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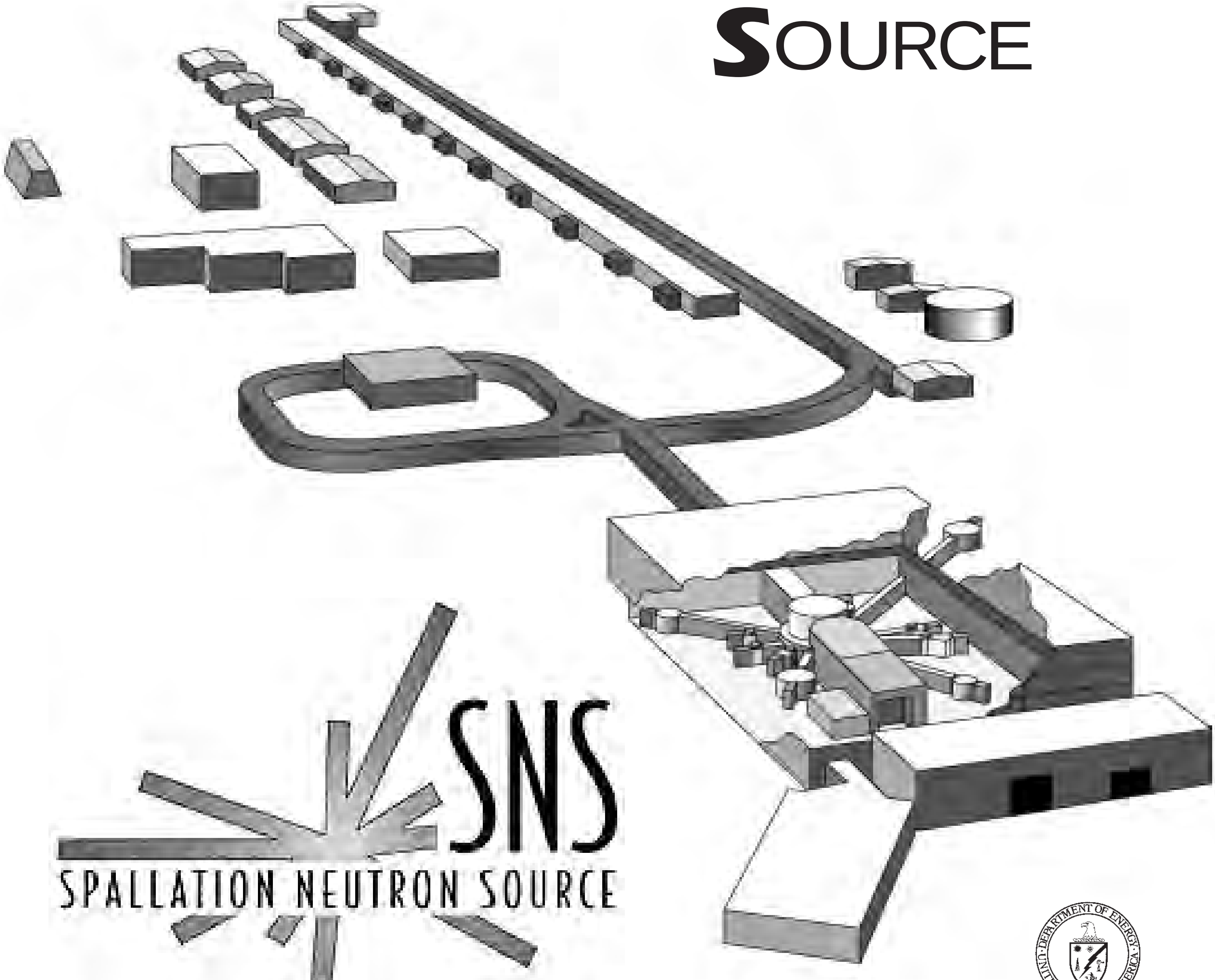
December 1998

DRAFT ENVIRONMENTAL IMPACT STATEMENT

Construction and Operation of the

SPALLATION NEUTRON SOURCE



SNS
SPALLATION NEUTRON SOURCE

U.S. Department
of Energy
Office of Science

DOE/EIS-0247

Construction and Operation of the Spallation Neutron Source Facility

Draft Environmental Impact Statement

U.S. Department of Energy
Office of Science

December 1998

COVER SHEET

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

TITLE:
Draft Environmental Impact Statement (DEIS), Construction and Operation of the Spallation Neutron Source (DOE/EIS-0247)

LOCATIONS OF ALTERNATIVE SITES:
Illinois, New Mexico, New York, and Tennessee.

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ABSTRACT:
DOE proposes to construct and operate a state-of-the-art, short-pulsed spallation neutron source comprised of an ion source, a linear accelerator, a proton accumulator ring, and an experiment building containing a liquid mercury target and a suite of neutron scattering instrumentation. The proposed Spallation Neutron Source would be designed to operate at a proton beam power of 1 megawatt. The design would accommodate future upgrades to a peak operating power of 4 megawatts. These upgrades may include construction of a second proton accumulator ring and a second target.

The U.S. needs a high-flux, short-pulsed neutron source to provide the scientific and industrial research communities with a much more intense source of pulsed neutrons for neutron scattering research than is currently available, and to assure the availability of a state-of-the-art facility in the decades ahead. This next-generation neutron source would create new scientific and engineering opportunities. In addition, it would help replace the neutron science capacity that will be lost by the eventual shutdown of existing sources as they reach the end of their useful operating lives in the first half of the next century.

This document analyzes the potential environmental impacts from the proposed action and the alternatives. The analysis assumes a facility operating at a power of 1MW and 4 MW over the life of the facility. The two primary alternatives analyzed in this EIS are: the proposed action (to proceed with building the Spallation Neutron Source) and the No-Action Alternative. The No-Action Alternative describes the expected condition of the environment if no action were taken. Four siting alternatives for the Spallation

Neutron Source are evaluated: Oak Ridge National Laboratory, Oak Ridge, TN, (preferred alternative); Argonne National Laboratory, Argonne, IL; Brookhaven National Laboratory, Upton, NY; and Los Alamos National Laboratory, Los Alamos, NM.

PUBLIC COMMENTS:

Comments on this Draft Environmental Impact Statement may be submitted during the public comment period, by writing to Mr. Wilfert at the above address, by directing a telephone call or facsimile message to the numbers indicated, or by e-mail. Comments may also be submitted at public meetings during the comment period. DOE will consider these public comments in its preparation of the Final Environmental Impact Statement.

SUMMARY

S 1.0 INTRODUCTION

The U.S. Department of Energy (DOE) proposes to construct and operate an accelerator-based research facility called the Spallation Neutron Source (SNS). This facility would provide the U. S. scientific community with a neutron source having greater intensity, power, and instrumentation than existing neutron sources. It would augment the research capabilities of current reactor-based neutron sources, satisfy current and future demand for research neutrons, lead to new scientific and technological discoveries, and meet international technological and economic challenges.

DOE has identified four siting alternatives for the proposed SNS. These are as follows:

- Oak Ridge National Laboratory (ORNL) Alternative (Preferred Alternative), Oak Ridge, Tennessee.
- Los Alamos National Laboratory (LANL) Alternative, Los Alamos, New Mexico.
- Argonne National Laboratory (ANL) Alternative, Argonne, Illinois.
- Brookhaven National Laboratory (BNL) Alternative, Upton, New York.

This summary provides a synopsis of the main text of the Environmental Impact Statement (EIS) for construction and operation of the SNS. The EIS complies with the requirements of the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321 et seq.); the President's Council on Environmental Quality (CEQ) regulations (40 CFR 1500-1508); and the DOE regulations for implementing the NEPA requirements (10 CFR 1021). The EIS presents the public and DOE decision-makers with a balanced and objective analysis of the potential environmental effects that would result from implementing the proposed action and alternative actions. The summary of the EIS covers the following subjects: (1) purpose and need for agency action, (2) proposed action and alternatives, (3) descriptions of siting alternatives for the proposed action, (4) areas of controversy, and (5) environmental consequences.

S 1.1 PURPOSE AND NEED FOR AGENCY ACTION

The U.S. needs a high-flux, short-pulsed neutron source to provide its scientific and industrial research communities with a much more intense source of pulsed neutrons for neutron scattering research than is currently available. This source would assure the availability of a state-of-the-art neutron research facility in the U.S. in the decades ahead. This facility would be used to conduct research in areas such as materials science, condensed matter physics, the molecular structure of biological materials, properties of polymers and complex fluids, and magnetism. In addition to creating new scientific and engineering opportunities, this next generation neutron source would help to replace the capacity that will be lost by the eventual shutdown of existing sources in the first half of the next century as they reach the end of their useful operating lives.

The neutron science community has long recognized the need for both high-intensity, pulsed (accelerator-based) neutron sources and continuous (reactor-based) neutron sources. The two types of sources are complementary. For many scattering techniques, having neutrons available in a series of pulses is preferable to having them in a continuous beam. In addition, pulsed sources can generally produce pulsed beams with a much higher peak intensity than those available from comparable sized reactor-based sources. This enables scientists to carry out a number of important flux-limited experiments. In recent years, steady improvements in accelerator technology have made it possible to design and construct sources that can produce even more intense neutron pulses. A next-generation neutron source with a proton beam power of 1 MW would initially produce pulses with a neutron intensity more than five times higher than those obtainable from today's best operational spallation source, Isis, in the United Kingdom.

A valuable feature of a pulsed spallation neutron source is the ability to tune the beam of neutrons for particular experiments (the time-of-flight technique). Each pulse of neutrons from the proposed SNS would contain neutrons with a range of energies. The energy level of the neutrons could be determined by noting the length of time it takes for the neutron to travel from the source to the detectors. The high-energy (faster) neutrons would reach the sample ahead of the medium-energy neutrons, and the lowest-energy (slower) neutrons would reach the sample last. Because the neutron with varying energies would be spread out over time as they reach a test specimen, the researcher could tune the neutron beam by selecting the energy level of interest by simply turning the detectors on and off at the appropriate time. Time-of-flight techniques enable the collection of many data points for each pulse of neutrons reaching the sample. Experience has shown that neutron pulses lasting approximately 1 Φs (one millionth of a second), each with a pulse occurring from 10 to 60 times per second, are optimal.

There are approximately 20 major neutron sources worldwide that produce neutron beams for materials research. Although these facilities are primarily located at large government-owned science laboratories, small research teams based at universities, research institutes, and industrial laboratories typically carry out neutron scattering experiments at these centers. The majority of users require recurrent, short-term access to the facilities, often for no more than a few days at a time. The research carried out at these sources contributes to the scientific and technological infrastructure in their regions and also contributes toward their industrial competitiveness.

Based on the conclusions of the Organization for Economic Cooperation and Development (OECD) Neutron Science Working Group,[1] which has studied this topic since 1996, there is a growing disparity between the worldwide need for neutron scattering research and the availability of facilities (reactor and spallation sources) to meet these needs. It was estimated that as the oldest sources continue to age, only about one-third of the present sources would remain available by 2010. The next generation neutron sources are then needed not only to create new scientific and engineering opportunities but also to replace out-dated capacity. In the U.S., the shortfall in neutron scattering resources compared with growing research demand and the lag in experimental capabilities compared with newer and more extensively upgraded foreign facilities have been

[1] OECD 1998, *OECD Megascience Forum: Neutron Sources Working Group*, Document available from DOE-HQ database (DRAFT NSWGREP13.DOC), May.

major concerns for over ten years. As stated most recently in the Kohn[2] and Russell[3] panel reports, the present U.S. sources are inadequate to meet the needs of the American scientific community, both in terms of flux and availability. The current generation of neutron sources in the U.S. has lower neutron beam intensities, lower operating powers, and less advanced measuring instruments, when compared to what is currently technologically feasible and desirable.

Given the long lead time from starting conceptual design to the commissioning of a new source (at least 10 years), decisions on new facilities are necessary in the next few years and certainly before 2005. Access to European and Japanese neutron sources by U.S. researchers and manufacturers is difficult, unreliable, and costly. The logistics of scheduling time and configuring instrumentation to conduct specialized experiments are prohibitive because of the commuting distances to these facilities. Because of its proprietary nature, much of the research desired by U.S. industry simply cannot be carried out at foreign facilities.

Scientific discoveries and the new technologies derived from neutron scattering research have contributed significantly to the development of new products for sale in the international marketplace. These include the following: better magnetic materials for recording tapes and computer hard drives; improved engine parts; better oil additives; light-weight, durable plastics; metallic glasses; semiconductors; optical systems; higher-strength magnets for electric generators and motors; thin films; pressure-sensitive adhesives; improved detergent and emulsification products; and new drugs. Because of the longstanding relationship between basic science and the world of business, scientific and technological advances like these have become major drivers of national economic progress and competitiveness among the industrialized nations of the world. The same type of relationship has developed between basic science and national defense. Since the end of World War II, the U.S. has used scientific discoveries to develop and sustain military capabilities that surpass those of potential international adversaries. These important relationships will continue into the foreseeable future.

Without future investments in major new science facilities, such as the proposed SNS, the nation's economic strength and competitiveness in the world economy, its national defense posture, and the health of its people may be jeopardized as the newest and best related technological developments are made overseas. The construction of a next-generation spallation neutron source in the U.S. would go far in providing a competitive edge for the nation in the physical, chemical, materials, biological, and medical sciences.

A next-generation, high-flux, short-pulsed neutron source is needed to:

[2] DOE 1993, *Neutron Sources for America's Future/Report of the Basic Energy Sciences Advisory Committee Panel on Neutron Sources*, DOE/ER-0576P, January, Washington, D.C.

[3] DOE 1996, *DOE Report of the BESAC on Neutron Source Facility Upgrades and the Technical Specification for the Spallation Neutron Source*, "Panel on Research Reactor Upgrades," chair, R. Birgeneau; "Panel on Spallation Source Upgrades," chair, G. Aeppli; "Panel on Next-Generation SNS," chair, T. Russell, March (unpublished, available from DOE).

- Satisfy the future needs of U.S. researchers in neutron scattering science for pulsed-neutron sources with much higher intensity, more comprehensive instrumentation, better experimental flexibility, and greater potential for future upgrades than those offered by existing U.S. facilities.
- Facilitate new scientific discoveries and develop cutting-edge technologies.
- Augment the capabilities of reactor-based neutron sources.
- Replace research capacity that will be lost by the shutdown of some existing neutron sources early in the next century.

S 1.2 PROPOSED ACTION AND ALTERNATIVES

The proposed action is the specific way DOE is proposing to meet the need for a new neutron source. This EIS assesses the environmental impacts that would result from implementing the proposed action at one of four alternative sites in different areas of the nation. It also assesses the environmental impacts that would result from the no-action alternative. Under the no-action alternative, DOE would not build the SNS at all. This section describes the proposed action, summarizes how the four siting alternatives for the proposed action were selected, identifies these siting alternatives, and describes the no-action alternative. It also discusses technological alternatives to the proposed action that were considered but eliminated from detailed analysis in this EIS.

S 1.2.1 PROPOSED ACTION

The proposed action is to construct and operate a state-of-the-art, short-pulse spallation neutron source comprising an ion source, a linear accelerator (linac), a proton accumulator ring, a liquid mercury target, and a set of neutron scattering instrumentation. This facility, called the SNS, would be designed to operate at a proton beam power of 1 MW and would be economically upgradable in the future to 4 MW (refer to Figures S 1.2.1-1 and S 1.2.1-2). The scope of these upgrades over the operating life of the facility is envisioned to encompass the following chronological stages:

1. Adding a second target station with its own set of instrumentation (space for this is included in the facility footprint analyzed in the EIS).
2. Increasing the proton beam power to 2 MW by doubling the ion source output.
3. Increasing the proton beam power to 4 MW by adding a second ion source, modifying the linac, and adding a second proton accumulator ring (space for the upgrades is included in the facility footprint, and the impacts of constructing and operating a 4-MW facility are analyzed in this EIS).

The implementation of these upgrades would depend largely on the availability of funding and cannot be predicted at this time. For the sake of completeness, however, this EIS analyzes the effects from the SNS facility as it would be originally built at 1 MW, as well as those corresponding to its fully upgraded configuration of 4 MW. DOE will review the adequacy of its NEPA coverage for this project as each upgrade is proposed.

The following site shape and dimensions would be essentially the same for all four of the siting alternatives evaluated in this EIS. The proposed SNS would occupy a hammer-shaped area of land containing approximately 110 acres (45 ha). Its maximum length would be approximately

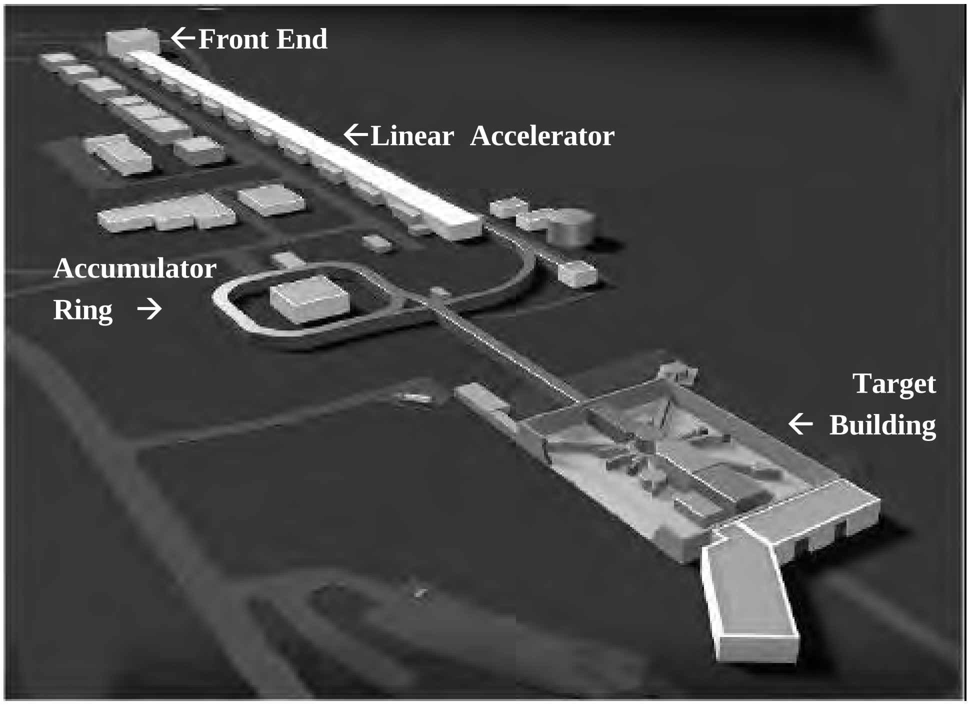

Figure S 1.2.1-1. Artist's conceptual drawing of the completed 1 MW SNS.

4,000 ft (1,219 m), and its maximum width would be approximately 1,100 ft (335 m). At the initial SNS operating power of 1 MW, this site would contain 15 permanent buildings, including the front end, linac tunnel, Klystron building, proton accumulator ring, target building, and several facility support buildings (refer to Figure S 1.2.1-2). These buildings would cover about 6 acres (2.4 ha) of land, and their interior areas would total 364,942 ft^2 (33,903 m^2). The front end and linac tunnel would total approximately 2,000 ft in length. The linac tunnel and adjacent, parallel Klystron building would have a total width of approximately 120 ft (37 m). The initial proton accumulator ring would be about the size of two football fields laid side-to-side. The target building would measure approximately 280 ft (85 m) by 200 ft (61 m). The dimensions of the research support wing on the target building would be about 170 ft (52 m) by 60 ft (18 m). If the SNS is eventually upgraded to an operating power of 4 MW, a second proton accumulator ring and target building with the same dimensions would be added to the facility (refer to Figure S 1.2.1-2). The two-proton accumulator rings and the target buildings would be separated by respective distances of approximately 500 ft (152 m) and 270 ft (82 m).

The proposed SNS facility would produce subatomic particles called neutrons to be used in research. The production of neutrons would begin by using the linac to accelerate hydrogen atoms containing an extra electron. Then, all the electrons would be stripped off as the high energy protons enter the accumulator ring where protons are concentrated. These protons would then be directed to a target of liquid mercury. The high-energy protons would strike the mercury in the target to break-off or spall (hence the term "spallation") neutrons from its molecules. Traveling at a high rate of speed, the neutrons would be passed through a material to slow them down. Finally, the neutrons would be directed through beam tubes to experiment

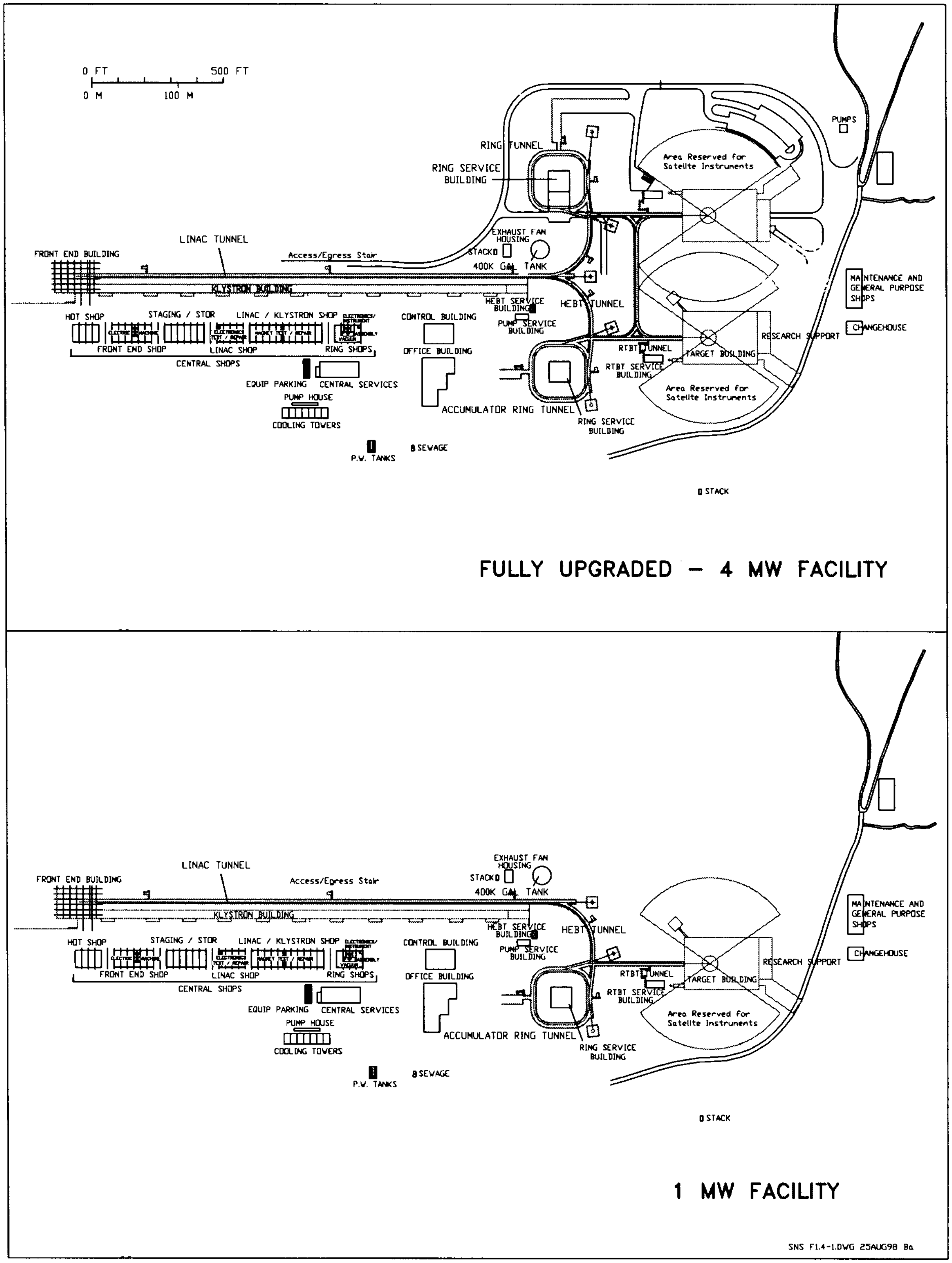

Figure S 1.2.1-2. Footprint of SNS accelerator components.

stations where research would be done on test materials. These neutrons would penetrate deeply beneath the surfaces of such materials to reveal their innermost characteristics.

S 1.2.2 SITING ALTERNATIVES FOR THE PROPOSED ACTION

DOE used a systematic process to select suitable alternative sites for the proposed action. The site-selection process began by identifying four major site exclusion criteria. When these criteria were defined, the process continued in two major phases. Phase 1 focused on using the exclusion criteria and other factors to identify several reasonable siting locations for the SNS at the national level. Phase 2 focused on identifying a specific alternative site for the SNS at each of these locations.

Specific SNS project requirements were used to develop the site exclusion criteria. These criteria were as follows:

- A site with a minimum area of 110 acres (45 ha) and a rectilinear shape to accommodate the length of the proposed linear accelerator and possible future expansion of the facility.
- A one-mile (1.6-km) buffer zone around the proposed SNS site to restrict uncontrolled public access and to insulate the public from the consequences of a postulated accident at the facility.
- Proximity and availability of an adequate electric power source. The regional power grid must be able to supply 40 MW of power during periods of operation. The site must be within one quarter to one mile (0.4 to 1.6 km) of existing transmission lines to minimize collateral construction impacts and costs. (It should be noted that the 40-MW power requirement was an early estimate that has since been increased to 62 MW for an SNS with a 1-MW beam and 90 MW for an SNS with a 4-MW beam.)
- Presence of existing neutron science programs and infrastructure to provide a pool of neutron science expertise and experience to meet mission goals. The site must have major facilities and programs utilizing neutron scattering techniques.

The logical universe of Phase 1 siting locations was identified and classified by DOE according to three categories: (1) existing DOE sites; (2) DOE acquisition and development of other federal property or a new, privately owned site; or (3) joint use of a nonfederal site (i.e., an academic facility). Using the exclusion criteria in combination with economic, legal, political, and public policy factors, DOE eliminated the siting locations in the second and third categories from consideration. At this point, a decision was made to limit site selection to the remaining category of existing DOE sites. Thirty-nine DOE facilities were carried forward as the universe of potential siting locations for the SNS. These 39 facilities were reviewed against the exclusion criteria. Failure of a facility to meet any of these criteria resulted in its elimination. As a result of this process, DOE identified four reasonable alternative facility locations for the SNS. These facility locations were ORNL, LANL, ANL, and BNL.

In Phase 2 of the site-selection process, each of the four national laboratories conducted its own systematic site-selection process to identify a specific site for the proposed SNS. These processes focused primarily on laboratory lands and involved the identification and evaluation of several alternative sites at each laboratory. Site-selection criteria included project requirements, environmental protection considerations, and other factors. DOE applied these criteria to the alternative sites to identify one specific site for the proposed SNS at each national laboratory.

The SNS EIS assesses the environmental impacts that would result from implementing the proposed action on each of the selected sites at the four national laboratories. These siting alternatives and their locations are as follows:

- ORNL Alternative (Preferred Alternative), Oak Ridge, Tennessee.
- LANL Alternative, Los Alamos, New Mexico.
- ANL Alternative, Argonne, Illinois.
- BNL Alternative, Upton, New York.

The preferred siting alternative for construction and operation of the proposed SNS is the ORNL Alternative. This alternative would allow DOE to take advantage of the highly trained scientific and technical staff at ORNL and the experience gained during development of the conceptual design for the Advanced Neutron Source.

The siting alternatives and the characteristics of the existing environment at each site are described in Section S 1.3 of this summary.

S 1.2.3 NO-ACTION ALTERNATIVE

This alternative describes continuation of the current (status quo) situation with U.S. neutron sources into the future, if the proposed action is not implemented. The no-action alternative would be to continue using existing neutron science facilities in the U.S. without construction and operation of the SNS.

S 1.2.4 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS

Several different methods for producing high-power, short-pulse beams of protons with a beam energy in the 1-GeV power range were evaluated during conceptual design of the proposed SNS. However, DOE eliminated these design alternatives from detailed analysis in this EIS for technical reasons that would prevent them from fulfilling the purpose and need for DOE action. These design alternatives and the reasons for their elimination from detailed analysis are as follows:

- **Partial-Energy Linac and a Rapid-Cycling Synchrotron.** The partial-energy linac and a rapid-cycling synchrotron is a well understood, proven accelerator technology. However, three significant drawbacks to this approach make it unsuitable for meeting the purpose and need for DOE action. First, upgrading the facility with even modest upgrades would be a major construction project entailing the building of a second booster synchrotron to reach the proton energy necessary for the higher beam power. Second, it has limited flexibility for accommodating different pulse frequencies. Finally, it lacks the flexibility to satisfy current and probable future research needs.

- **Full-Energy Superconducting Linac with an Accumulator Ring.** The superconductivity technology incorporated into this alternative is quite mature for fabricating magnets and constructing several radio-frequency linacs. However, the existing examples of superconducting linacs are designed for electron beams that operate in a continuous wave mode, as opposed to the pulsed operation required of the next-generation neutron source. To date, anticipated problems involving pulsed operation with superconducting linacs have been identified and characterized, but they have not yet been resolved.

- **Induction Linac, Either Full-Energy or Injecting a Fixed-Frequency Alternating Gradient Accelerator.** The induction linac offers the attractive possibility of producing very short pulses of very high current without the need for an accumulator or synchrotron ring. However, no existing induction linac has accelerated protons to the energies required of the next-generation neutron source. The costs associated with designing one would be greater than for options utilizing rings, and the reliability of the high-power switches for the required service life is viewed as problematic.

  The fixed-frequency alternating gradient accelerator component of the induction linac presents some attractive features. Its most notable feature is the ability to efficiently accelerate high-current beams injected by a radio frequency linac or, most intriguingly, by an induction linac. However, as is the case with the induction linac, no fixed-frequency alternating gradient accelerator has been built in the range of performance required to meet the purpose and need for DOE action. This technology is not viewed as mature enough to be technically viable at this time.

S 1.3 DESCRIPTIONS OF SITING ALTERNATIVES

This section describes the four siting alternatives for the proposed action. Each description includes the location of an alternative site and a brief summary of existing environmental conditions on and in the vicinity of the site. These descriptions are intended to provide a brief look at each alternative site without providing a comprehensive level of detail, which would be beyond the reasonable scope of a summary. Such detail is provided in Chapter 4 of this EIS.

S 1.3.1 ORNL ALTERNATIVE (PREFERRED ALTERNATIVE)

The preferred alternative would be to construct and operate the SNS at ORNL on the DOE Oak Ridge Reservation (ORR). The ORR is located in and around the city of Oak Ridge, Tennessee, and it contains three major facilities: ORNL, the Y-12 Plant, and the East Tennessee Technology Park (ETTP). It occupies 34,516 acres (13,974 ha) of land in Roane and Anderson counties. The location of the proposed SNS site on the ORR is shown in Figure S 1.3.1-1.

The proposed SNS site extends along a long but fairly wide and gently sloping ridge top with a broad saddle area at its eastern end. This area of Chestnut Ridge is planned for the target station and would require a minimum of excavation.

The linac and accumulator ring tunnels would be notched into the south side of the ridge using cut-and-fill techniques, providing economical construction and effective radiation shielding strategies.

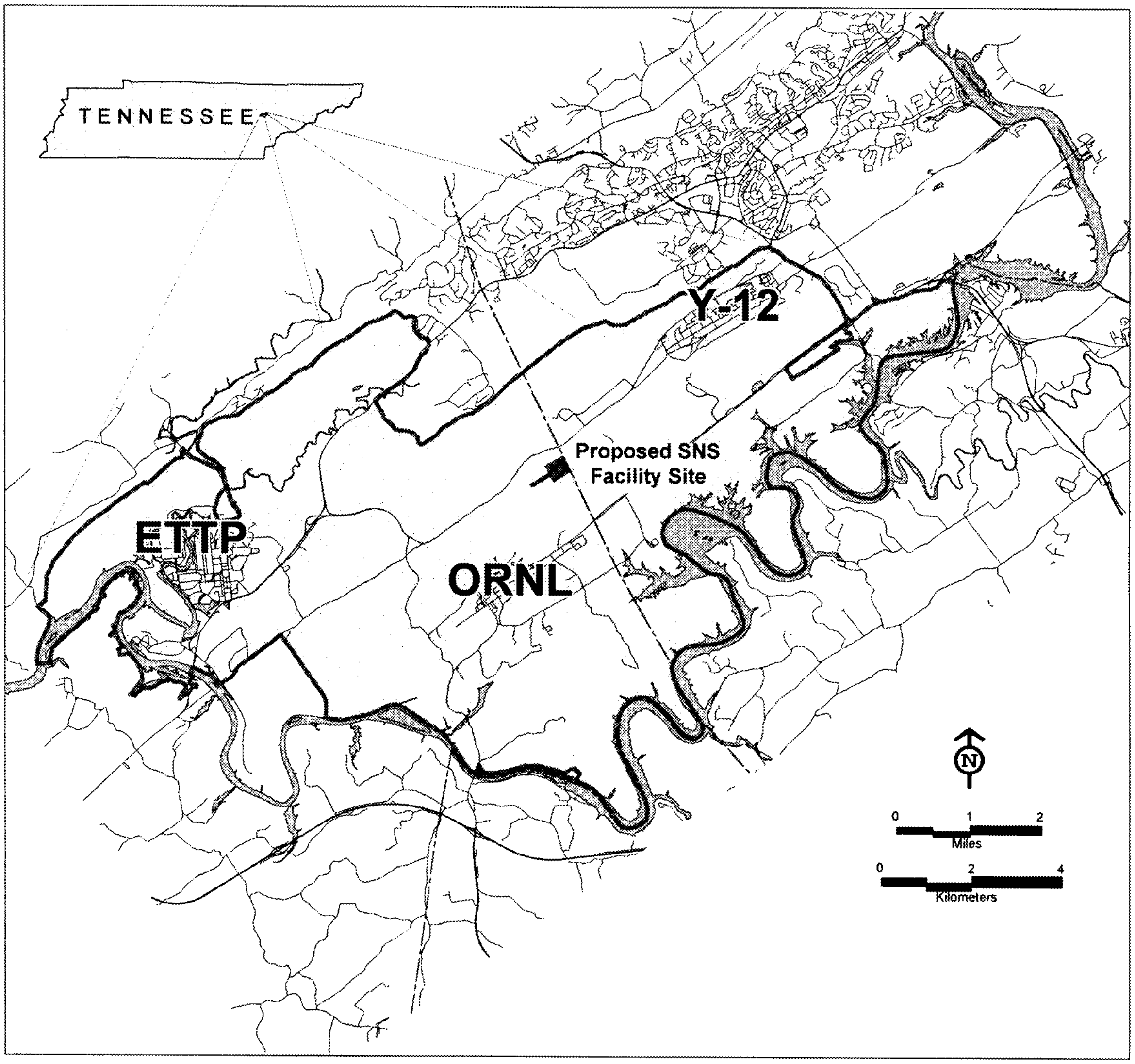

Figure S 1.3.1-1. Proposed SNS site on the ORR.

Land Cover: Over half of the proposed site is covered with a mixed hardwood forest composed of red oak, white oak, chestnut oak, poplar, and hickory. Approximately 20 percent of the site is covered with loblolly pines, the majority of which were planted in the 1940s and 1950s. Approximately 20 percent of the site is labeled as "beetle kill cut over," indicating that trees in these areas have been cut to reduce southern pine beetle infestation. The remaining 10 percent of the vegetative cover is old field scrub, which consists of first growth plant species on fields no longer used for agricultural purposes.

Protected Species: Ten protected plant species are recognized as potentially occurring within the proposed SNS site. Pink lady's slipper and American ginseng exist at three locations very near the site. Pink lady's slipper is a state-endangered species because of commercial exploitation. American ginseng is a state special concern species because of commercial exploitation.

Cultural Resources: No cultural resources eligible for listing on the National Register of Historic Places (NRHP) are known to exist on the proposed SNS site or in its immediate vicinity. No traditional cultural properties (TCPs) of special sensitivity or concern to the Eastern Band of the Cherokee are known to exist on the proposed SNS site or at other locations on the ORR. Because the SNS design team has not established all areas where construction or improvement of utility corridors and roads would be necessary to support the SNS, some of these areas have not been surveyed for cultural resources. The design team would establish these areas to avoid known cultural resources, and the areas would be surveyed prior to the initiation of SNS construction activities.

Land Use: The current land use category on the proposed SNS site is Mixed Research/Future Initiatives (land available for environmental research and future DOE development). The site is undeveloped land located entirely within the ORR National Environmental Research Park (NERP) and the buffer zone for the Walker Branch Watershed environmental research area.

Surface Water: The SNS site at ORNL is located entirely within the drainage basin of White Oak Creek. The headwaters of White Oak Creek begin immediately south of the site.

Wetlands: Seven wetland areas exist within the White Oak Creek watershed in the vicinity of the SNS site. An eighth wetland area is located in the riparian zone of Bear Creek South Tributary 4 and downslope from the proposed SNS site.

Groundwater: An unconfined groundwater table exists at depths approaching 100 ft (30 m) or more.

S 1.3.2 LANL ALTERNATIVE

The proposed SNS site at LANL is located on the Pajarito Plateau near Los Alamos, New Mexico. It lies on the east-central edge of the Jemez Mountains. The plateau is formed by an apron of volcanic sedimentary rocks and is dissected into a number of narrow mesas by southeast-trending canyons. The proposed SNS site would be located within a portion of the LANL reservation called Technical Area (TA)-70. TA-70 is located on a mesa flanked by Ancho Canyon 0.27 mi (0.47 km) to the southwest and a small unnamed canyon an equal distance to the northeast. To the southeast, the Rio Grande River flows through nearby White Rock Canyon at a distance of approximately 1.2 mi (1.9 km) from the proposed SNS site. Elevations within the proposed SNS site area range from 6,410 ft (1,954 m) to 6,490 ft (1,978 m). The location of the proposed SNS site at LANL is shown in Figure S 1.3.2-1.

Land Cover: The vegetation in the area of the proposed SNS site is dominated by piñon-juniper woodlands with scattered juniper savannas. Additionally, much of the land in and bordering the adjacent canyons is bare rock. Overstory plant species include piñon and one-seed juniper. Scattered grasses, primarily blue grama, shrubs, and forbs, are found in the understories.

Protected Species: No such species were identified during a surveillance survey of the proposed SNS site.

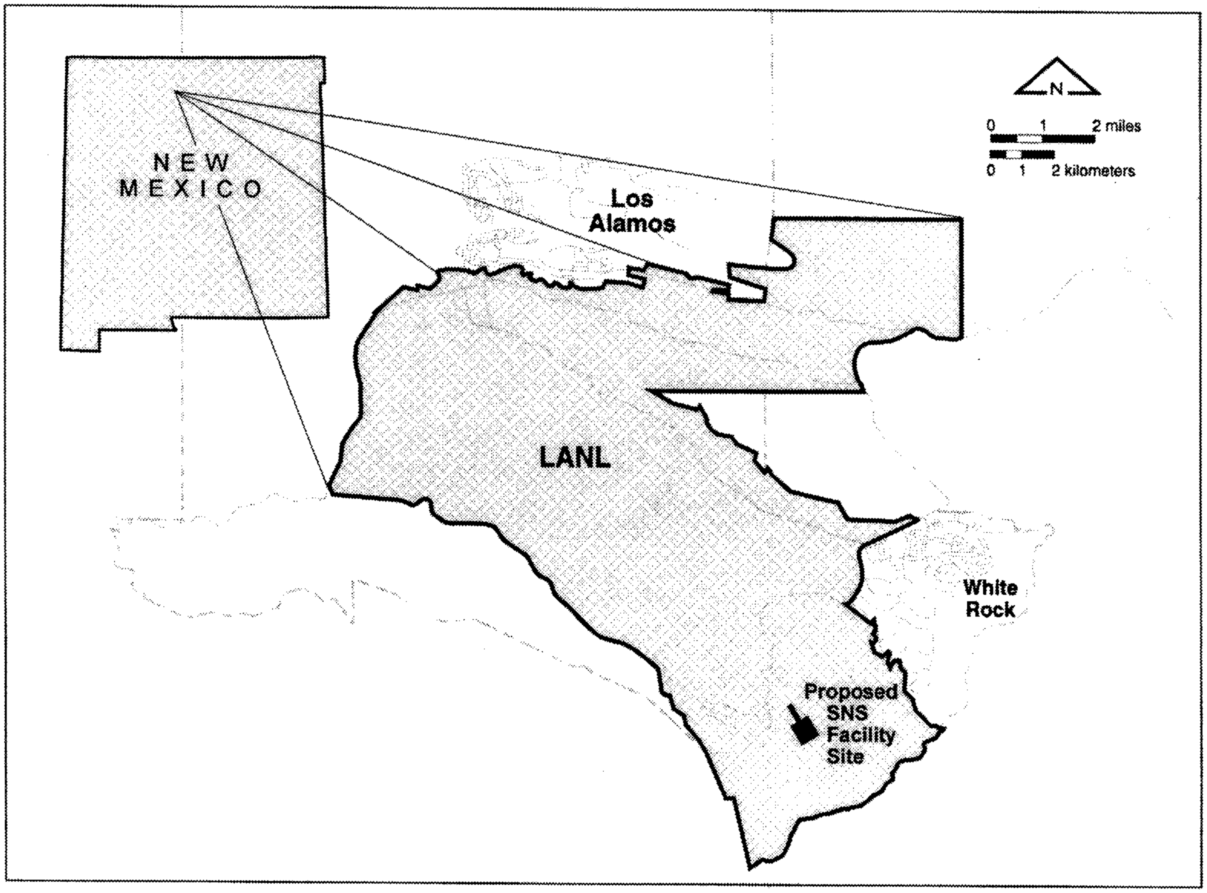

Figure S 1.3.2-1. Proposed SNS site at LANL.

Cultural Resources: Five prehistoric archaeological sites eligible for listing on the NRHP have been identified within the 65 percent of the SNS site and an adjacent buffer zone that have been surveyed for cultural resources. The remaining 35 percent will be surveyed prior to the initiation of construction-related activities, if this site is selected for construction of the proposed SNS. The DOE Albuquerque Operations Office has consulted with Native American tribes and Hispanic groups about the occurrence of TCPs on and in the vicinity of LANL land. Prehistoric archaeological sites and water resources have been identified as TCPs. However, these groups have not been consulted about the occurrence of other specific TCPs on and adjacent to the proposed SNS site. This would be done if the site is selected for construction of the SNS. Because the SNS design team has not decided where construction or improvement of utility corridors, roads, and ancillary structures would be necessary to support the SNS, these areas have not been surveyed for cultural resources. The design team would establish these areas to avoid known cultural resources, and the areas would be surveyed prior to the beginning of SNS construction activities.

Land Use: The current land use category on the proposed SNS site is Environmental Research/Buffer (available for environmental research and used as a buffer zone for LANL operations). The proposed SNS site is undeveloped open space in a remote area of the laboratory.

Surface Water: No perennial stream exists at the proposed site.

Wetlands: No wetlands exist at the proposed site.

Groundwater: The main aquifer is the primary water supply for the Los Alamos County area and could be considered a sole-source aquifer. The aquifer occurs at a depth of over 800 ft (244 m) below the ground surface.

S 1.3.3 ANL ALTERNATIVE

The proposed SNS site at ANL would lay on gently rolling land in the Des Plaines River Valley of DuPage County, Illinois, about 27 mi (43 km) southwest of downtown Chicago. Surrounding ANL on all sides is the Waterfall Glen Nature Preserve, a 2,040-acre (826-ha) greenbelt forest preserve owned by the Forest Preserve District of DuPage County, Illinois. The principal stream on ANL land is Sawmill Creek, which runs through the eastern portion of the laboratory and drains southward into the Des Plaines River. About 1 m (1.6 km) south of ANL are the Des Plaines River, the Chicago Sanitary and Ship Canal, and the Illinois Waterway. The location of the proposed SNS site at ANL is shown in Figure S 1.3.3-1.

Land Cover: The predominant vegetation community on the proposed SNS site is open grassland consisting of scattered areas of old-field and intermittently mowed areas. The dominant grass species in both mowed and unmowed areas are nonnative species commonly found on disturbed soils at ANL. Scrub-shrub communities in early successional stages occur in the southwestern and southeastern portions of the proposed SNS site. These communities, which have remained relatively undisturbed in the past decade, consist of open grassland species and low shrubs that form scattered clumps of vegetation.

Protected Species: No such species were identified during a surveillance survey of the proposed SNS site.

Cultural Resources: No prehistoric or historic cultural resources are located on the proposed SNS site, but one prehistoric site (11DU207) is located adjacent to the proposed SNS site. The NRHP eligibility of this site has not been assessed by ANL. No TCPs are known to occur on the proposed SNS site. Because the SNS design team has not decided areas where construction or improvement of utility corridors, roads, and ancillary structures would be necessary to support the SNS, these areas have not been surveyed for cultural resources. The design team would establish these areas to avoid known cultural resources, and the areas would be surveyed prior to the beginning of SNS construction activities.

Land Use: The current land use categories on the proposed SNS site are Ecology Plot Nos. 6, 7, and 8 (undeveloped with no current ecological research); Support Services (old 800 Area developments); and Open Space (undeveloped). The proposed SNS site contains four active environmental restoration sites requiring additional characterization and/or remediation. Another eight sites are located relatively near or adjacent to the proposed SNS site.

Surface Water: Surface water drainage at ANL flows in a southerly direction toward the Des Plaines River, approximately 0.6 km (2,000 ft) to the south. Within ANL, Sawmill Creek flows

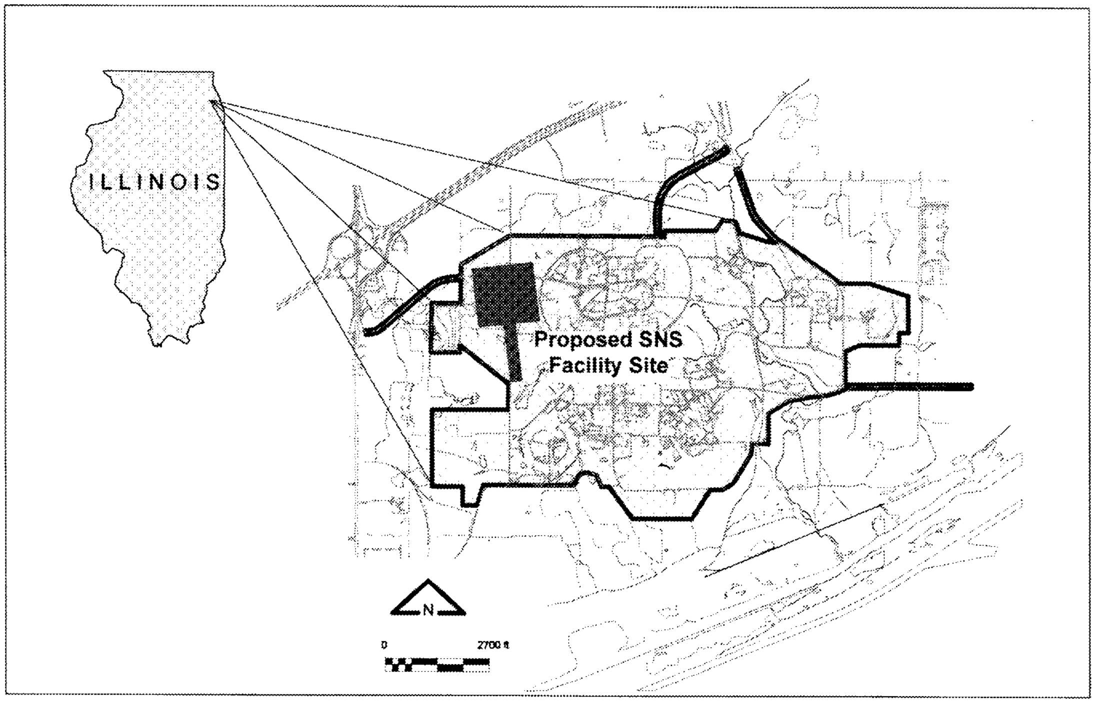

Figure S 1.3.3-1. Proposed SNS site at ANL.

to the south through the eastern edge of the reservation and discharges into the Des Plaines River channel. Two intermittent branches of Freund Brook flow from west to east, draining the interior portion of the reservation and ultimately flowing into Sawmill Creek.

Wetlands: A variety of wetland types occur in and around the proposed SNS site. About 3.4 acres (1.4 ha) of these wetlands occur within the site footprint. Most of these wetlands have been disturbed to some degree in the past. However, they continue to retain wetlands value such as wildlife habitat and flood control.

Groundwater: Groundwater in the area surrounding the proposed SNS site is segmented into three layered hydrogeological groups. Beginning at the ground surface, these layers are: glacial deposits of Pleistocene Age, shallow bedrock of Silurian Age, and deeper bedrock aquifers of Ordovician Age. Groundwater from the Silurian and Ordovician aquifers has been used for the ANL drinking water supply until recently. Since 1997, the laboratory's water resources have been obtained from Lake Michigan. This shift in potable water sources occurred as part of a widespread water distribution service change in the suburban areas near ANL. It was not related to actual or perceived pollution of groundwater by DOE operations at the laboratory.

S 1.3.4 BNL ALTERNATIVE

The proposed SNS site is located in the north-central portion of BNL. BNL is located in Suffolk County on Long Island, New York, in a section of the oak-chestnut forest region of the Atlantic Coastal Plain physiographic province.

It shares many of the same coastal features common to the barrier islands of Massachusetts, New Jersey, and coastal regions as far south as Cape Hatteras, North Carolina. The location of the proposed SNS site at BNL is shown in Figure S 1.3.4-1.

Land Cover: The southern portion of the proposed SNS site consists of a stand of white pine, apparently planted during the 1930s under a Civilian Conservation Corps project. Communities composed of planted white pine are common in Suffolk County. Self-sown pitch pine is scattered within this area. The understory vegetation consists of huckleberry with lesser amounts of blueberry, but it is sparse due to shade and pine needle litter. Occasional oaks are found along the edges of the firebreaks and lanes in this area.

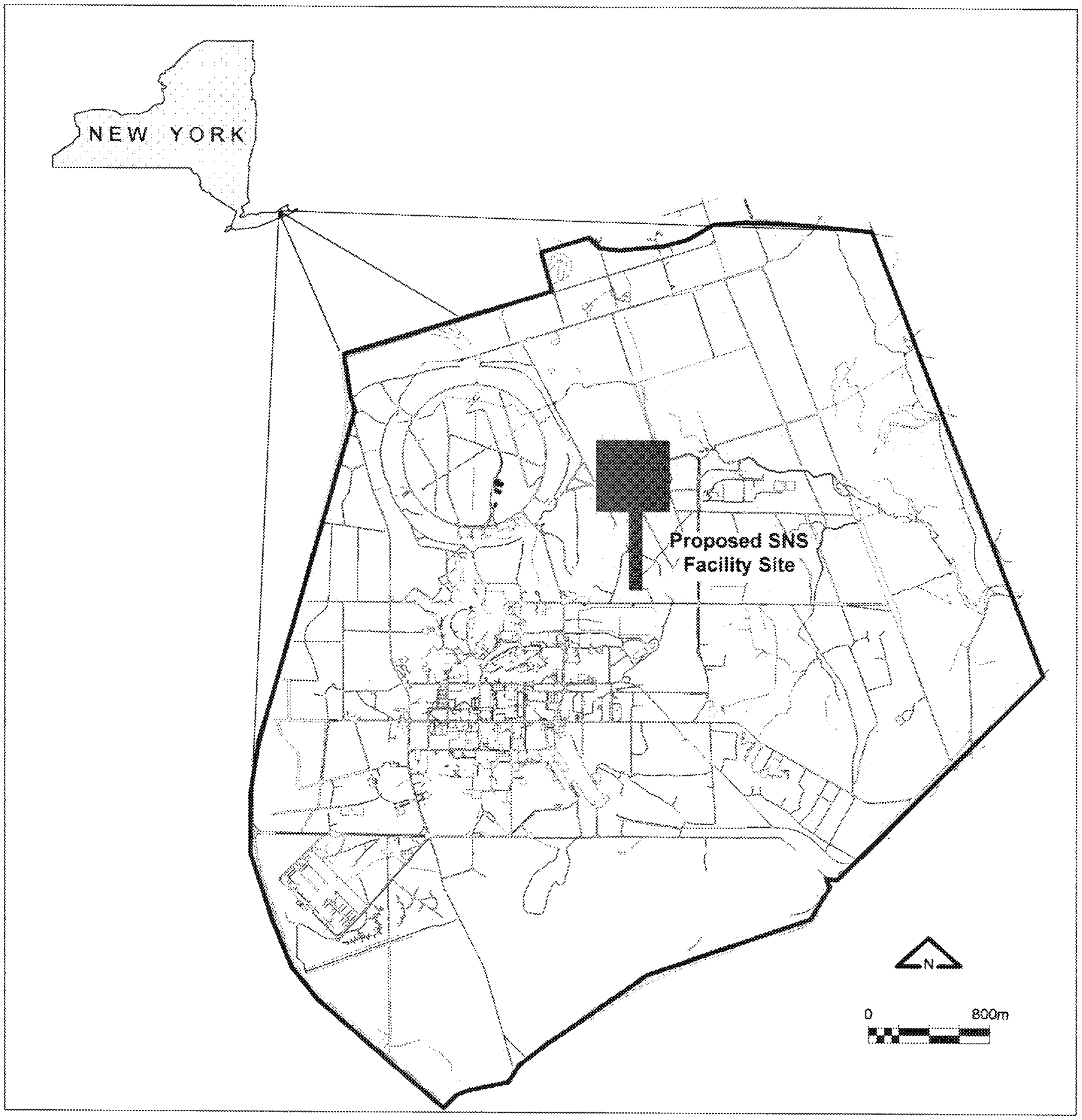

Figure S 1.3.4-1. Proposed SNS site at BNL.

Protected Species: The northwest portion of the proposed SNS site approaches wetlands associated with the Peconic River. This area may be suitable habitat for the tiger salamander and the spotted salamander. Both are listed as special concern species by the state of New York. Thirteen species of plants found at BNL are officially listed as "protected plants" by the state of New York. Three of these species—spotted wintergreen, bayberry, and swamp azalea—have been found on the proposed SNS site.

Cultural Resources: No prehistoric archaeological sites have been identified on or adjacent to the proposed SNS site at BNL. However, four historic earthen features (Stations 2, 4, 8, and 10), which may have been used for trench warfare training at Camp Upton during World War I, were identified on the proposed SNS site. Camp Upton is a former U.S. Army facility that previously occupied BNL land.

These features are potentially eligible for listing on the NRHP. No TCPs are known to occur on or adjacent to the proposed SNS site. Because the SNS design team has not decided areas where construction or improvement of utility corridors, roads, and ancillary structures would be necessary to support the SNS, these areas have not been surveyed for cultural resources. The design team would establish these areas to avoid known cultural resources, and the areas would be surveyed prior to the beginning of SNS construction activities.

Land Use: The current land use category on the proposed SNS site is Open Space. The entire site is largely undeveloped land.

Surface Water: The Peconic River flows through the northern portion of BNL. It was designated as a Wild and Scenic River by the state of New York in 1986 because it represented the last significant undeveloped river within the Long Island Pine Barrens area. The northeast corner of the proposed SNS site is approximately 300 ft (91 m) from the river. The headwaters of the Peconic River are located approximately 0.75 mi (1.2 km) to the west of BNL and exit the laboratory to the east.

Wetlands: Three wetlands are located in the vicinity of the proposed SNS site at BNL. These wetlands are associated with the upper reaches of the Peconic River. The Peconic River is protected under the New York Freshwater Wetlands Program and is classified as a Class I wetland.

Groundwater: BNL, and the proposed SNS site, are underlain by the Upper Glacial aquifer, Magothy aquifer, and Lloyd aquifer. The drinking water supply for Long Island comes from the Upper Glacial aquifer, a sole source aquifer characterized by high hydraulic conductivity. BNL overlies a deep-flow, groundwater-recharge zone for Long Island. Horizontal groundwater flow at BNL and the proposed SNS site are generally to the south and southeast.

S 1.4 AREAS OF CONTROVERSY

The CEQ NEPA regulations (40 CFR 1502.12) require the EIS to identify controversial issues raised by government agencies and the public. No such issues are associated with the LANL and ANL Alternatives. However, three controversial issues are associated with implementation of the proposed action on the SNS sites at ORNL and BNL. These issues are as follows:

1. DOE-Oak Ridge Operations (ORO) has actively sought public input on the future use of ORR land. An Oak Ridge citizens advisory organization, the End-Use Working Group, has drafted land use guidelines for recommendation to DOE-ORO. One of the draft guidelines recommends the siting of additional DOE facilities on brownfield sites instead of greenfield sites. Brownfield sites are previously contaminated and/or developed areas, whereas greenfield sites are natural, undeveloped areas. The proposed SNS site at ORNL is a 110-acre (45-ha) tract of undeveloped forest land. The selection of this greenfield site for the proposed SNS was a subject of some controversy during the Oak Ridge public scoping meetings for the EIS.

2. The Walker Branch Watershed is a major research area located approximately 0.75 mi (1.2 km) east of the proposed SNS site at ORNL. It is one of the few sites in the world characterized by long-term, intensive environmental studies. Environmental monitoring and ecological research projects in the area are being conducted by the National Oceanic and Atmospheric Administration/Atmospheric Turbulence and Diffusion Division (NOAA/ATDD) and the ORNL Environmental Sciences Division (ESD). The proposed SNS site is located within a buffer zone designed to protect research in the watershed. NOAA/ATDD and ORNL-ESD have expressed concerns that pollutant emissions from the nearby SNS may adversely affect their environmental monitoring and research projects.

3. The Spent Fuel Pool associated with the High-Flux Beam Reactor at BNL has gradually leaked water contaminated with radioactive tritium. The leakage has migrated through soil to the Upper Glacial groundwater aquifer beneath BNL. Currently, it is horizontally confined to an area within the laboratory boundaries. The Upper Glacial aquifer is the sole source of drinking water for most Long Island residents. Area residents have expressed deep concern about this controversial event and the potential for additional radioactive contamination of the aquifer from facilities such as the proposed SNS.

In this EIS, the analysis of potential environmental consequences resulting from the proposed action considers each of these issues. The analytical results pertinent to these issues are summarized under the Impacts on Water Resources and Impacts on Land Use headings in the table at the end of Section S 1.5.2 of this Summary.

S 1.5 ENVIRONMENTAL CONSEQUENCES

Environmental consequences are the potential effects that the proposed action would have on various aspects of the existing environment on and in the vicinity of the proposed SNS sites at ORNL, LANL, ANL, and BNL. They also include the effects that the no-action alternative would have on the existing environment. The aspects of the existing environment that could be affected are geology and soils, water resources (surface water and groundwater), air quality, noise, ecological resources, socioeconomics, cultural resources, land use, human health, infrastructure (transportation and utilities), and waste management.

S 1.5.1 SUMMARY OF ENVIRONMENTAL IMPACTS FROM THE ALTERNATIVES

This section provides a summary of the important environmental effects that would result from implementing the proposed action at each of the four SNS siting alternatives and from implementing the no-action alternative. These effects are described in terms of the various aspects of the existing environment that might be expected to change over time as a result of their implementation. This summary is based on the detailed environmental effects identified and described in Chapter 5 of this EIS.

These important effects, along with the other potential environmental effects identified during the assessment of environmental consequences, are also presented in a tabular format in Section S 1.5.2. This comparative format shows how particular aspects of the existing environment would be affected by all of the evaluated alternatives.

S 1.5.1.1 ORNL Alternative

During operation of the SNS, leaching of neutron-activated soil in the shielding berm for the linac tunnel could result in localized contamination of groundwater with radionuclides. As a result of limited migration and rapid decay of unstable radionuclides, an exceedance of drinking water limits for a human receptor would be highly unlikely.

Construction of the SNS would result in the partial encroachment of one small wetland [2.7 acres (1.1 ha)], probable encroachment and subsequent destruction of two small wetland areas [0.12 acres (0.05 ha)], and increased runoff and siltation to another wetland [1.6 acres (0.65 ha)].

A number of beneficial socioeconomic effects would result from construction and operation of the proposed SNS. Design and construction employment on the proposed SNS would peak in fiscal year (FY) 2002 during construction of the 1-MW facility. Based on the results of economic modeling, an estimated 1,499 direct, indirect, and induced jobs would be created, and the unemployment rate may potentially decrease from 3.2 to 3.0 percent. Operation of the proposed SNS at the 4-MW power level would result in substantial regional spending for operator salaries, supplies, utilities, and administrative support. The 4-MW operations would result in a maximum of 1,704 direct, indirect, and induced jobs. Approximately $68.7 million in local wages, $7.5 million in business taxes, and $75.9 million in personal income would result from these operations. The rate of unemployment may potentially decrease from 3.2 to 3.0 percent. The beneficial effects from operations at 1 MW would be similar to but slightly less than those from operations at 4 MW.

The NOAA/ATDD is conducting the TDFCMP in the Walker Branch Watershed (refer to Section S 1.4). In addition, the ORNL-ESD is conducting ecological research projects in this area. The TDFCMP is monitoring the continuous exchange of CO_2, H_2O vapor, and energy between the deciduous forest in this area and the atmosphere. During construction of the proposed SNS, emissions of CO_2 from construction vehicles could affect the TDFCMP and one long-term ORNL ecological research project in the watershed. The potential effects on research would be loss of CO_2 monitoring data quality and the comparability of data over time. During SNS operations, stack emissions of CO_2 from natural gas-fired boilers in the SNS heating system would similarly affect the

TDFCMP and one ORNL ecological research project. Continued future emissions of CO_2 from the SNS stacks would result in such effects on the TDFCMP and could affect two ORNL research projects. During operations, emissions of H_2O vapor from the SNS cooling towers may affect the TDFCMP and two ORNL research projects with a loss of data quality and comparability over time. Continued future operation of the SNS could result in H_2O vapor effects on the TDFCMP and eight ORNL research projects. Continued operations may also affect strategic ORNL ecological research initiatives. Once again, the effects would be loss of data quality and comparability over time. DOE is considering the mitigation of effects on the TDFCMP by moving the current NOAA/ATDD monitoring tower to a different location or constructing a new tower at this different location. The installation of electric heat pumps instead of natural gas boilers is being considered to eliminate most operational CO_2 emissions from the proposed SNS.

The general public living in the vicinity of the ORR would be exposed to low levels of airborne radioactive emissions from operation of the proposed SNS. For operation at the 1-MW power level, the maximally exposed individual (MEI) would receive an annual radiation dose of 0.40 mrem, or 4 percent of the 10-mrem limit (40 CFR 61). For operation at the 4-MW power level, the MEI would receive an annual dose of 1.5 mrem, or 15 percent of the limit. The results of the mathematical model used to estimate the effects to the population surrounding ORNL show that operating the proposed SNS at the 1-MW power level for 10 years and the 4-MW power level for 30 years would cause 0.2 latent cancer fatalities in the general population.

S 1.5.1.2 LANL Alternative

The proposed SNS could affect the groundwater at LANL. Sustained pumping of groundwater from the main aquifer (functionally a sole source aquifer) to serve SNS operations could eventually lower the water levels in nearby wells and adversely affect productivity of the aquifer. Considering the projected 40-year lifecycle of the proposed SNS, sustained pumping over this many years added to possible increases in water demand by LANL and the local population could have a cumulative impact on aquifer productivity. Additionally, during operation of the SNS, leaching of neutron-activated soil in the shielding berm for the linac tunnel could result in localized contamination of groundwater. As a result of a low infiltration rate and great depth to groundwater [820 ft (250 m)], migrating radionuclides would decay to low concentrations before reaching the groundwater. Therefore, compared to the other siting alternatives, it is least likely that human receptors in the vicinity of LANL would be affected by contaminated groundwater in excess of safe drinking water limits.

The maximally exposed individual is a hypothetical member of the public assumed to live at the boundary of the DOE-owned land for 8,760 hours per year and to produce their entire food supply at this location. For the ORNL alternative, this is the boundary of the Oak Ridge Reservation. For the LANL, ANL, and BNL alternatives, this is the boundary of the laboratory.

The offsite population consists of all individuals residing outside the ORR boundary within 50 mi (80 km) of the site and is assumed to be present for 8,760 hr/yr.

A number of beneficial socioeconomic effects would result from construction and operation of the proposed SNS. Design and construction employment on the proposed SNS would peak in FY 2002 during construction of the 1-MW facility. Based on the results of economic modeling, an estimated 1,447 direct, indirect, and induced jobs would be created, and the unemployment rate may potentially decrease from 6.6 to 5.8 percent. Operation of the proposed SNS at the 4-MW power level would result in substantial regional spending for operator salaries, supplies, utilities, and administrative support. The 4-MW operations would result in a maximum of 1,486 direct, indirect, and induced jobs. Approximately $66.8 million in local wages, $7.6 million in business taxes, and $71.4 million in personal income would result from these operations. The rate of unemployment may potentially decrease from 6.6 to 5.8 percent. The beneficial effects from operations at 1 MW would be similar to but slightly less than those from operations at 4 MW.

Sixty-five percent of the proposed SNS site and an adjacent buffer zone have been surveyed for cultural resources. Five prehistoric archaeological sites eligible for listing on the NRHP have been identified within this area. During construction of the proposed SNS, all five sites would be destroyed by site preparation activities. If any more eligible sites are located within the 35 percent that has not been surveyed, they would also be destroyed by site preparation activities. If this site were chosen for construction of the proposed SNS, the remaining 35 percent would be surveyed and assessed for specific effects prior to the initiation of construction activities. These effects on prehistoric resources would be mitigated by data recovery.

No historic resources have been identified within the 65 percent survey area on and adjacent to the proposed SNS site. However, any NRHP-eligible historic sites, structures, or features that might occur within the 35 percent that has not been surveyed would be destroyed by site preparation activities. These effects on historic resources would be mitigated by data recovery.

During construction of the proposed SNS, site preparation activities would destroy five TCPs, all prehistoric archaeological sites. These sites are located within the 65 percent cultural resource survey area on and adjacent to the proposed SNS site. If any prehistoric archaeological sites are located within the 35 percent that has not been surveyed, these TCPs would also be destroyed. With respect to cumulative impacts on TCPs, the proposed action and expansion of the Low-Level Waste Disposal Facility into Zones 4 and 6 in TA-54 would destroy a total of 20 prehistoric archaeological sites. Because some American Indian tribal groups consider water resources to be TCPs, the previously described radionuclide contamination of groundwater and the reduction in aquifer productivity would also be important effects on TCPs. Because the specific identities and locations of other onsite TCPs are not known, potential effects on such specific resources are uncertain. If the LANL Alternative is selected by DOE, the remaining 35 percent of the proposed SNS site would be surveyed and assessed for cultural resources effects prior to the initiation of construction activities. Similarly, additional consultations on the locations of site-specific TCPs would be held with Hispanic and tribal groups.

Construction and operation of the proposed SNS would have effects on land use with respect to recreational and visual resources. The public use of TA-70 hiking trails near the proposed SNS site may end or be restricted during construction of the SNS and throughout its operational life cycle. Landscape views in the vicinity of the proposed SNS site would be changed from natural piñon-juniper woodlands to industrial development. The SNS facilities would be visible from points on the proposed SNS site, State Route 4, the access road to the proposed SNS site, and hiking trails in TA-70. Because other lighted facilities are not present in the immediate area, the SNS facilities would be highly visible at night. They would not be visible, however, from the nearby community of White Rock and popular public use areas in Bandelier National Monument.

The general public living in the vicinity of LANL would be exposed to low levels of airborne radioactive emissions from operation of the proposed SNS. For operation at the 1-MW power level, the MEI would receive an annual radiation dose of 0.47 mrem, or 4.7 percent of the 10-mrem limit. For operation at the 4-MW power level, the MEI would receive an annual dose of 1.8 mrem, or 18 percent of the limit. The results of the mathematical model used to estimate the effects to the population surrounding LANL show that operating the proposed SNS at the 1-MW power level for 10 years and the 4-MW power level for 30 years would cause 0.2 latent cancer fatalities in the general population.

Effects on utility infrastructure would result from implementing the proposed action on the SNS site at LANL. The electrical power system serving LANL is inadequate to supply the 62-MW and 90-MW power demands of the proposed SNS, and it is potentially unreliable because of its age. Supplying the SNS would require a new power line to the SNS site, new regional and multistate power grid configurations, and possibly a site-specific SNS power generation station. Because the distribution systems for other utilities do not extend to the site, a considerable investment would be necessary to build the required infrastructure. From a cumulative impacts perspective, the addition of SNS demands for power and water to future demands by LANL and the local population would exceed the capacity of existing distribution systems and require additional infrastructure.

S 1.5.1.3 ANL Alternative

The proposed action would have effects on floodplain areas that occur on the SNS site at ANL. The eastern edge of the proposed SNS footprint would encroach on the 100-year floodplain of an unnamed tributary of Sawmill Creek. In addition, the southern tip of the linac tunnel would be constructed within the 100-year floodplain of Freund Brook. These floodplain locations would pose at least some risk of flooding during construction of the SNS. Filling and stabilization, drainage pattern alterations, and man-made drainage features would be implemented as part of SNS construction to minimize potential effects from flooding during SNS operations.

Operations at the proposed SNS could have effects on groundwater at ANL. The leaching of neutron-activated soil in the shielding berm for the linac tunnel may result in localized contamination of groundwater with radionuclides. A shallow aquifer not used as a source of potable water lies beneath the proposed SNS site at a depth of 65 ft (20 m). Aquifers that are sources of potable water occur at a depth of 165 ft (50 m). The geological formations overlying the potable aquifers would retard the downward migration of groundwater contaminated with radionuclides. For example, groundwater movement through the saturated zone of the Wadsworth Till, a complex mixture of silts, clays, and sand, is only about 3 ft/yr (0.9 m/yr). However, the accurate prediction of migration rates and the potential for aquifer contamination with radionuclides would be difficult because of the complexity of these deposits.

Construction on the proposed SNS and the now completed and operating Advanced Photon Source (APS) would have a cumulative impact on terrestrial wildlife at ANL. The total area of land cleared for these two projects would be approximately 160 acres (65 ha). Clearing 15 percent of the undeveloped land at ANL would decrease the terrestrial wildlife inhabiting ANL land. Population levels would be decreased by an amount generally proportional to the amount of habitat lost. Although no rare animals would be affected, fallow deer, an important game species in the area, would be affected.

Construction of the proposed SNS would have an effect on some wetland areas at ANL. Approximately 3.5 acres (1.4 ha) of wetlands would be destroyed by construction activities. This is about 20 percent of the wetlands on and in the vicinity of the proposed SNS site and about 7 percent of the jurisdictional wetlands on ANL property.

A number of beneficial socioeconomic effects would result from construction and operation of the proposed SNS. Design and construction employment on the proposed SNS would peak in FY 2002 during construction of the 1-MW facility. Based on the results of economic modeling, an estimated 1,795 direct, indirect, and induced jobs would be created. Because of the very large regional population, no decrease in the regional unemployment rate would be expected. Operation of the proposed SNS at the 4-MW power level would result in substantial regional spending for operator salaries, supplies, utilities, and administrative support. The 4-MW operations would result in a maximum of 1,776 direct, indirect, and induced jobs. Approximately $82.9 million in local wages, $8.7 million in business taxes, and $91.2 million in personal income would result from these operations. The rate of unemployment may potentially decrease from 5.2 to 5.1 percent. The beneficial effects from operations at 1 MW would be similar to but slightly less than those from operations at 4 MW.

A prehistoric archaeological site (11DU207) is located adjacent to the proposed SNS site. ANL has not assessed the NRHP eligibility of this site, which may be disturbed or destroyed by construction activities. If the proposed SNS site were chosen for construction of the SNS, an assessment of eligibility would be performed prior to the initiation of construction activities. If it is determined that 11DU207 is a prehistoric cultural resource, the effects would be mitigated by avoidance, if possible, or data recovery.

Cumulative impacts on undeveloped land would result from constructing the SNS and APS at ANL. The SNS and now operational APS would introduce development to approximately 160 acres (65 ha) of undeveloped ANL land. This would reduce the already limited area of undeveloped ANL land available for development by about 15 percent. The SNS and APS would reduce land in the current Open Space land use category by 145 acres (59 ha). This would reduce the already limited area of Open Space land available for development by about 15 percent.

The proposed SNS site is located in close proximity to the west perimeter of ANL, which is adjacent to the Waterfall Glen Nature Preserve. During construction and operations, the SNS facilities could potentially interfere with natural views from interior points within the nature preserve, especially on the west side during late autumn, winter, and early spring. The currently operating APS is also located near the west ANL perimeter and just south of the proposed SNS site. With regards to cumulative impacts, the proposed SNS and APS could degrade natural views from interior points within the west side of the Waterfall Glen Nature Preserve.

The general public living in the vicinity of ANL would be exposed to low levels of airborne radioactive emissions from operation of the proposed SNS. For operation at the 1-MW power level, the MEI would receive an annual radiation dose of 3.2 mrem, or 32 percent of the 10-mrem limit. For operation at the 4-MW power level, the MEI would receive an annual dose of 12 mrem. This dose exceeds the 10-mrem limit. However, as presented in the ANL report, *Argonne National Laboratory—East Site Environmental Report for Calendar Year 1996*, the MEI at a location actually occupied by people from existing operations at ANL is very low, only 0.021 mrem. Since the dose of 12 mrem projected for SNS operations at 4 MW is based on a hypothetical individual much closer to the facility, ANL would remain in compliance with the addition of emissions from the proposed SNS facility. The results of the mathematical model used to estimate the effects to the population surrounding ANL show that operating the proposed SNS at the 1-MW power level for 10 years and the 4-MW power level for 30 years would cause 0.2 latent cancer fatalities in the general population.

Construction of the SNS would have effects on transportation at ANL. The main access to ANL from the west is via Westgate Road, and a portion of Westgate Road lies within the proposed SNS site. Construction of the SNS would eliminate the use of this segment of road as an access corridor to the laboratory as a whole. This would require infrastructure construction to reroute approximately 1 mi (1.6 km) of Westgate Road to the north around the SNS site.

S 1.5.1.4 BNL Alternative

The leaching of neutron-activated soil in the shielding berm for the linac tunnel may result in localized contamination of groundwater with radionuclides. The sole source aquifer that provides potable water to the large population of Long Island lies only 20 ft (6.1 m) below the land surface on the SNS site. In addition, the soils on the site are primarily composed of quartz sand. Because these soils have a high permeability that can approach 17 ft/yr (5.2 m/yr), they have little ability to retard the migration of contaminated groundwater. Thus, among the four siting alternatives for the proposed action, this alternative has the greatest potential for increasing radionuclide concentrations in an aquifer that produces potable water. At another BNL facility, the Advanced Gradient Synchrotron (AGS), only two radionuclides (^{3}H and ^{22}Na) have sufficient half-life duration to pose a contamination problem for groundwater. Calculated dilution of these radionuclides in groundwater reduces exposure estimates for offsite receptors to below levels of concern. If comparable dilution factors can be applied to radionuclides from the SNS, then concentrations at levels of concern would not be transported to offsite receptors. With respect to cumulative impacts on groundwater at BNL, the Relativistic Heavy Ion Collider

(RHIC) is located about 656 ft (200 m) west of the proposed SNS site. Because of their close proximity, the potential exists for the comingling of radionuclides from the SNS and RHIC in groundwater. Once again, these effects would apply primarily to groundwater beneath BNL, and effects on offsite receptors would be minimal.

A number of beneficial socioeconomic effects would result from construction and operation of the proposed SNS. Design and construction employment on the proposed SNS would peak in FY 2002 during construction of the 1-MW facility. Based on the results of economic modeling, an estimated 1,481 direct, indirect, and induced jobs would be created, and the unemployment rate may potentially decrease from 3.4 to 3.3 percent. Operation of the proposed SNS at the 4-MW power level would result in substantial regional spending for operator salaries, supplies, utilities, and administrative support. The 4-MW operations would result in a maximum of 1,551 direct, indirect, and induced jobs. Approximately $41.6 million in local wages, $10.3 million in business taxes, and $80.5 million in personal income would result from these operations. The rate of unemployment may potentially decrease from 3.4 to 3.2 percent. The beneficial effects from operations at 1 MW would be similar to but slightly less than those from operations at 4 MW.

A number of earthen features have been identified on the proposed SNS site at BNL. They are located at four cultural resources survey stations (Stations 2, 4, 8, and 10). These features, all potentially eligible for listing on the NRHP, may have been associated with World War I trench warfare training at Camp Upton, a U.S. military installation that previously occupied BNL land. These features would be destroyed by SNS construction activities such as site preparation. The effects would be mitigated by data recovery.

The general public living in the vicinity of BNL would be exposed to low levels of airborne radioactive emissions from operation of the proposed SNS. For operation at the 1-MW power level, the MEI would receive an annual radiation dose of 0.91 mrem, or 9 percent of the 10-mrem limit. For operation at the 4-MW power level, the MEI would receive an annual dose of 3.4 mrem, or 34 percent of the limit. The results of the mathematical model used to estimate the effects to the population surrounding BNL show that operating the proposed SNS at the 1-MW power level for 10 years and the 4-MW power level for 30 years would cause 0.2 latent cancer fatalities in the general population.

S 1.5.1.5 No-Action Alternative

None of the environmental effects from implementing the proposed action would occur under the no-action alternative because the proposed SNS would not be constructed at any of the four alternative sites or at any other site. For example, no undeveloped land would be used for development, no soils or groundwater would become radioactively contaminated, no wetland areas would be taken by construction activities, and no endangered or threatened species would be affected. No beneficial effects would be realized in the form of increased income and jobs.

DOE implementation of the no-action alternative would have no effects on existing, reactor-based neutron sources. None of the existing, reactor-based sources would be discontinued as a result of implementing the no-action alternative or the proposed action. This would be a result of the major technological differences between reactor-based neutron sources and accelerator-based sources such as the proposed SNS. Because of these basic differences, each technology is best suited to exploring different scientific opportunities.

Because of high and ever-increasing demand for access to neutron science facilities, existing U.S. facilities would increasingly fail to meet domestic experimentation demand under the no-action alternative. A longstanding lag in U.S. experimental capabilities behind those of foreign nations with more extensively upgraded neutron science facilities would continue to widen.

S 1.5.2 Tabular Summary of Environmental Impacts

Table S 1.5.2-1 contains a comprehensive summary of the potential environmental impacts that may result from the proposed action, as implemented through the four siting alternatives, and the no-action alternative. The table covers environmental impacts, which are presented according to internal headings that correspond to the major impacts analysis subheadings in Chapter 5 of this EIS. Under the other internal headings, this table covers impacts on long-term productivity of the environment and cumulative impacts. Unless otherwise indicated, the impacts of a 4-MW facility are given. Where there are substantial differences in impacts, data are given for both 1 MW and 4 MW.

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Table S 1.5.2-1 Comparison of impacts among alternatives.

Category **Page**

Table S 1.5.2-1. Comparison of impacts among alternatives.

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
1a. Impacts on Geology and Soils (Construction)				
No effects from seismicity.				No effects from seismicity.
Erosion and siltation during construction. Minimal effects on soils or site stability.				No effects on soils or site stability.
1b. Impacts on Geology and Soils (Operations)				
The soil in the berm used to shield the linac tunnel would be subject to neutron activation caused by a small portion of particles (hydrogen ions) escaping from the particle beam as it travels down the linac. An estimated total of 3.09 E05 Ci of radioactive isotopes would be generated in the soil berm by neutron activation over the life of the facility. The maximum design beam loss rate is 1.0 E-09 amps per meter of linac. This design limit is the same for all linac beam power levels, hence soil activation would be the same at both 1 and 4 MW. For the analysis of potential effects, the beam loss is assumed to be 10.0 E-09. The total curies (3.09 E05) is based on this conservative limit.				No effects on soils.
No effects from seismicity or on site stability because of design to meet known seismic hazards at ORNL.	No effects from seismicity or site stability because of design to meet known seismic hazards at LANL.	No effects from seismicity or site stability because of design to meet known seismic hazards at ANL.	No effects from seismicity or site stability because of design to meet known seismic hazards at BNL.	No effects from seismicity.
2a. Impacts on Water Resources (Construction)				
No effects on floodplains. Minimal increase in run-off and siltation from improvements to Chestnut Ridge Road.	No effects on floodplains.	Construction in very small areas on the 100-year floodplains (<5 acres) of an unnamed tributary of Sawmill Creek and Freund Brook.	No effects on floodplains.	No effects on floodplains.
Minimal effects on surface water (see Impact 1a).				No effects on surface water.
2b. Impacts on Water Resources (Operations)				
No effects on floodplains.				No effects on floodplains.
Overall effects expected to be minimal. Discharges to surface water would increase average base flow by 50%, (continued on next page)	Overall effects expected to be minimal. Discharges to surface water would result in channel erosion in (continued on next page)	Overall effects expected to be minimal. Discharges to surface water would increase base flow, resulting in (continued on next page)	Overall effects expected to be minimal. Discharges to surface water would increase base flow, resulting in (continued on next page)	No effects on surface water resources.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
2b. Impacts on Water Resources (Operations) — continued				
resulting in increased stream velocity and channel erosion in White Oak Creek. Minimal effects from biocides and antiscaling agents relative to flow. Slight increase (4%) in radionuclide flux over White Oak Dam.	intermittent TA-70 drainages. Most flow would infiltrate soil before reaching Rio Grande River. Minimal effects from biocides and antiscaling agents relative to flow.	increased stream velocity and channel erosion in an unnamed tributary of Sawmill Creek. Minimal effects from biocides and antiscaling agents relative to flow.	increased stream velocity and channel erosion in the headwaters of the Peconic River. Most flow would infiltrate the subsurface in the river channel before reaching the BNL boundary. Minimal effects from biocides and antiscaling agents relative to flow.	
Potential localized increase in groundwater radionuclide concentrations (at a depth of 100 ft or more) due to leaching of neutron-activated soil in the shielding berm for the linac tunnel. Three radionuclides would equal or exceed the 10 CFR Part 20 limit (shown in parentheses) at 10 m away from the site: ^{14}C 4.4 E-04 µCi/cc (3E-04 µCi/cc), ^{22}Na 5.5 E-05 µCi/cc (6 E-06 µCi/cc), and ^{54}Mn 3.0 E-05 µCi/cc (3 E-05 µCi/cc).	Pumping may lower water levels in nearby wells and affect productivity of main aquifer. Potential localized increase in groundwater radionuclide concentrations due to leaching of neutron-activated soil in the shielding berm for the linac tunnel. Groundwater effects would be least likely at LANL because of low infiltration rate and greater depth [820 ft (250 m)] to main aquifer.	Potential localized increase in groundwater radionuclide concentrations due to leaching of neutron-activated soil in the shielding berm for the linac tunnel. A potable groundwater aquifer lies at a depth of 165 ft (50 m). The downward rate of water movement through the saturated zone of the Wadsworth Till is only 3.0 ft/yr (0.9 m/yr). High clay content of the till would retard radionuclide migration, but accurate prediction of migration rates and potential for aquifer contamination would be difficult because of the complex deposits.	Highest potential for increase in groundwater radionuclide concentrations due to leaching of neutron-activated soil in the shielding berm for the linac tunnel. The sole source aquifer for Long Island would lie only 20 ft (6.1 m) below the SNS. High permeability of the soils [17 ft/yr (5.2 m/yr)] would allow higher levels of radionuclides in the aquifer in the immediate vicinity of the SNS. Exceedance of drinking water limits for a human receptor at an off-site location would be unlikely.	No effects on groundwater resources.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
3a. Impacts on Climate and Nonradiological Air Quality (Construction)				
Temporary increases in suspended particulates (PM_{10}) during work hours (10-hr day). Primarily fugitive dust from vegetation clearing, excavation, and land contouring.				No effects on nonradiological air quality.
3b. Impacts on Climate and Nonradiological Air Quality (Operations)				
No effects on local or regional climate.				No effects on local or regional climate.
Combustion of natural gas would emit air pollutants, CO_2, CO, NO_2, and PM_{10}, limited by NAAQS. Off-site levels of pollutants would all be less than 20% of the NAAQS limit. Diesel back-up generators would only run in an emergency. Effects on nonradiological air quality would be expected to be minimal.	Combustion of natural gas would emit air pollutants, CO_2, CO, NO_2, and PM_{10}, limited by NAAQS. Off-site levels of pollutants would all be less than 5% of the NAAQS limit. Diesel back-up generators would only run in an emergency. Effects on nonradiological air quality would be expected to be minimal.	Combustion of natural gas would emit air pollutants, CO_2, CO, NO_2, and PM_{10}, limited by NAAQS. Off-site levels of pollutants would all be less than 5% of the NAAQS limit. Diesel back-up generators would only run in an emergency. Effects on nonradiological air quality would be expected to be minimal.	Combustion of natural gas would emit air pollutants, CO_2, CO, NO_2, and PM_{10}, limited by NAAQS. Off-site levels of pollutants would all be less than 5% of the NAAQS limit. Diesel back-up generators would only run in an emergency. Effects on nonradiological air quality would be expected to be minimal.	No effects on nonradiological air quality.
4a. Impacts on Noise Levels (Construction)				
Short-term increase in noise to continuous moderate levels (approximate average level of 86 dBA). Effects on humans and wildlife would be minimal because of distances (more than 400 ft) from sources, natural barriers, and worker hearing protection.				No effects on noise levels.
4b. Impacts on Noise Levels (Operations)				
Elevated continuous noise levels from cooling towers, compressors, and ventilation fans/blowers (approximate average level of 86 dBA). Minimized with landscape barriers. Periodically increased traffic noise. Minimal overall noise effects to human and wildlife populations.				No effects on noise levels.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
5a. Impacts on Ecological Resources (Construction)				
Removal of vegetation from 110 acres (45 ha) of land (less than 0.5% of the total forested area of the ORR) would result in increased forest fragmentation. This would have a minimal effect on terrestrial wildlife movement because a forested path along Chestnut Ridge would be retained. Only a portion of the ridge and ORR would be affected.	Removal of vegetation from 110 acres (45 ha) of land. Minimal effects on wildlife movement or the roosting, feeding, and reproduction of birds because 90% of TA-70 would remain undeveloped.	Removal of vegetation from 110 acres (45 ha) of land partially developed in the past. This would result in a long-term reduction of wildlife habitat and populations on the SNS site and in adjacent areas. These effects would be minimal because the species that would be involved are neither rare nor game species and other habitat exists in the region.	Removal of vegetation from 110 acres (45 ha) of land would displace wildlife to surrounding areas. This displacement may exceed carrying capacity in these areas, resulting in a small but permanent population reduction for one or more species. The proposed site lies within the Compatible Growth Area of the Pine Barrens. The 110 acres represent less than 20% of the Pine Barrens Protection Area.	No effects on terrestrial resources.
Construction would temporarily disturb wildlife occupying areas adjacent to the proposed site. This could result in emigration of some sensitive species from the surrounding area.				No effects on terrestrial resources.
Construction of the SNS would encroach on two small wetlands, with a combined area of 0.12 acres. A third, forested wetland, with an area of 1.6 acres, may receive increased runoff and siltation during construction activities. This wetland contains two plant species that are uncommon in Tennessee. There would be minimal effects on four additional (continued on next page)	No effects on wetlands within the SNS site or in TA-70 because there are no wetlands on or in the vicinity of the proposed site.	Approximately 3.5 acres (1.4 ha) of wetlands would be destroyed by construction. DOE would consult on plans to mitigate their loss. Temporary, minor effects to other wetlands surrounding the proposed site during construction.	There are no wetlands within the proposed SNS site. Minimal effects on Peconic River wetlands from runoff and sedimentation because of implementing runoff and erosion control measures.	No effects on wetlands.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
5a. Impacts on Ecological Resources (Construction) — continued				
small wetlands located outside of the construction area. Appropriate mitigation measures, including wetland replacement or enhancement and control of surface runoff, would be employed to minimize effects to these wetlands.				
Minimal effects on aquatic resources from increased runoff and sediment loading in White Oak Creek due to runoff and erosion control measures. Minimal effects on cool water fish (banded sculpin and blacknose dace) habitat from vegetation clearing and associated solar radiation increase of water temperature in White Oak Creek, because of leaving a 100- to 200-ft (30- to 60-m) uncleared vegetation buffer zone along the creek for shade.	No effects on aquatic resources. There are no aquatic resources on or in the vicinity of the proposed site.	Minimal effects on aquatic resources, particularly bottom-dwelling fauna, from increased runoff and sediment loading in Freund Brook, because of establishing a 100- to 200-ft (30- to 60-m) uncleared vegetation buffer zone along the brook and implementing erosion control measures.	Minimal effects on aquatic resources from increased runoff and sediment loading in the Peconic River, because of establishing a minimum 300-ft (91-m) uncleared vegetation buffer zone between the SNS site and the river and implementing erosion control measures.	No effects on aquatic resources.
Minimal effects on threatened and endangered (T&E) plant species due to implementation of protective measures. No T&E or other (continued on next page)	Minimal effects on American peregrine falcon and bald eagle population from small reductions in non-nesting habitat. No T&E plant (continued on next page)	No protected species were identified on the proposed SNS site. Therefore, no effects on T&E or other protected species.	Minimal effects on state-protected plant species identified on the SNS site due to implementation of protective measures. No (continued on next page)	No effects on T&E or other protected species.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
5a. Impacts on Ecological Resources (Construction) — continued				
protected animal species were identified within the proposed footprint of the SNS.	species were identified on the SNS site.		T&E or other protected animal species were identified on the SNS site.	
5b. Impacts on Ecological Resources (Operations)				
During operations, runoff from the site would be directed to the sediment retention basin; thus increased runoff to wetlands in the vicinity of the site would be expected to be minimal.	Minimal effects on wetlands in arroyos of Ancho Canyon and unnamed canyon to the northeast because cooling water flow could not reach these areas, except possibly during a heavy rain event.	During operations, runoff from the site would be directed to the sediment retention basin; thus increased runoff to wetlands in the vicinity of the site would be expected to be minimal.	During operations, runoff from the site would be directed to the sediment retention basin; thus increased runoff to wetlands in the vicinity of the site would be expected to be minimal.	No effects on wetlands.
Minimal effects on aquatic resources in the headwaters area of White Oak Creek. Cooling water and runoff from the proposed site would be collected in the sediment retention basin. Discharge to White Oak Creek would be south of Bethel Valley Road. If necessary, the cooling tower blowdown would be dechlorinated. The retention basin would allow for reduction in the temperature of the water prior to discharge in White Oak Creek. Only minimal effects to aquatic resources (continued on next page)	No effects on aquatic resources.	Biotic communities in Sawmill Creek may change as a result of increased flow from cooling water and runoff discharged into it from the sediment retention basin. These effects on aquatic resources would be minimal because the temperature of the discharge would be reduced to ambient temperature in the sediment retention basin.	No effects on aquatic resources in the upper reaches of the Peconic River because cooling water and runoff in the sediment retention basin would be released to the river near the current Sewage Treatment Plant outfall. Downstream flow increase would be less than a routine rain event, resulting in minimal effects to aquatic resources. If necessary, the cooling tower blowdown would be dechlorinated. The retention basin could allow for reduc-tion in the temperature of the (continued on next page)	No effects on aquatic resources.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
5b. Impacts on Ecological Resources (Operations) — continued				
downstream from the discharge point would be expected.			water prior to discharge to the Peconic River. Only minimal effects to aquatic resources would be expected.	
Minimal effects on T&E plant species due to implementation of protective measures. No T&E or other protected animal species were identified on the proposed SNS site. Two plants protected by the State of Tennessee, pink lady's slipper and American ginseng, were found in areas adjacent to the proposed site.	No T&E plant species were identified on the proposed SNS site. Minimal effects on American peregrine falcon and bald eagle populations because their use of the SNS site area would be less likely after development.	No known T&E or other protected species at ANL would be affected.	Minimal effects on state-protected plant species identified on the proposed SNS site due to implementation of protective measures. No T&E or other protected animal species were identified on the proposed SNS site.	No effects on T&E or other protected species.
6a. Impacts on Socioeconomics (Construction)				
Peak construction workforce of 578 workers would occur during construction of the 1-MW facility. Approximately 25% of workers may come from outside the Region of Influence (ROI). Based on experience with past major construction projects, most in-migrating workers would not relocate their families. However, if all in-migrating workers brought (continued on next page)	Peak construction workforce of 578 workers would occur during construction of the 1-MW facility. Approximately 25% of workers may come from outside the ROI. Based on experience with past major construction projects, most in-migrating workers would not relocate their families. However, if all in-migrating workers brought families into (continued on next page)	Peak construction workforce of 578 workers would occur during construction of the 1-MW facility. Approximately 25% of workers may come from outside the ROI. Based on experience with past major construction projects, most in-migrating workers would not relocate their families. However, if all in-migrating workers brought families (continued on next page)	Peak construction workforce of 578 workers would occur during construction of the 1-MW facility. Approximately 25% of workers may come from outside the ROI. Based on experience with past major construction projects, most in-migrating workers would not relocate their families. However, if all in-migrating workers brought families into (continued on next page)	No effects on regional population growth.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
6a. Impacts on Socioeconomics (Construction) — continued				
families into the area, the regional population would increase by approximately 0.01%. This would have minor effects on housing and regional community services.	the area, the regional population would increase by approximately 0.02%. This would have minor effects on housing and regional community services.	into the area, the regional population would increase by approximately 0.01%. This would have minor effects on housing and regional community services.	the area, the regional population would increase by approximately 0.01%. This would have minor effects on housing and regional community services.	
Design and construction employment would peak in FY 2002 during construction of the 1-MW facility. Based on modeling of regional economics, there would be an estimated 1,499 new jobs created, including direct, indirect, and induced jobs. Unemployment rate may potentially decrease from 3.2 to 3.0%.	Design and construction employment would peak in FY 2002 during construction of the 1-MW facility. Based on modeling of regional economics, there would be an estimated 1,447 new jobs created, including direct, indirect, and induced jobs. Unemployment rate may potentially decrease from 6.6 to 5.8%.	Design and construction employment would peak in FY 2002 during construction of the 1-MW facility. Based on modeling of regional economics, there would be an estimated 1,795 new jobs created, including direct, indirect, and induced jobs Because of the very large regional population, no decrease in the regional unemployment rate would be expected.	Design and construction employment would peak in FY 2002 during construction of the 1-MW facility. Based on modeling of regional economics, there would be an estimated 1,481 new jobs created, including direct, indirect, and induced jobs. Unemployment rate may potentially decrease from 3.4 to 3.3%.	No economic benefit.
6b. Impacts on Socioeconomics (Operations)				
Workforce for operation of the proposed SNS would be 250 persons for the 1-MW facility and 375 for the 4-MW facility. Regional population growth of approximately 0.01% due to worker in-migration would (continued on next page)	Workforce for operation of the proposed SNS would be 250 persons for the 1-MW facility and 375 for the 4-MW facility. Regional population growth of approximately 0.03% due to worker in-migration would (continued on next page)	Workforce for operation of the proposed SNS would be 250 persons for the 1-MW facility and 375 for the 4-MW facility. Regional population growth of approximately 0.01% due to worker in-migration would (continued on next page)	Workforce for operation of the proposed SNS would be 250 persons for the 1-MW facility and 375 for the 4-MW facility. Regional population growth of approximately 0.01% due to worker in-migration would (continued on next page)	No effects on regional socioeconomics.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
6b. Impacts on Socioeconomics (Operations) — continued				
have minor effects on housing and regional community services.	have minor effects on housing and regional community services.	have minor effects on housing and regional community services.	have minor effects on housing and regional community services.	
Operation of the proposed SNS at 4 MW would result in substantial regional spending for operator salaries, supplies, utilities, and administrative support. Operation of the proposed SNS would result in a maximum of 1,704 direct, indirect, and induced jobs. Operations would result in approximately $68.7 million in local wages, $7.5 million in business taxes, and $75.9 million in personal income. Unemployment rate may potentially decrease from 3.2 to 3.0%. The effects of operation of the proposed SNS at the 1-MW power level would be similar but slightly less than the 4-MW case.	Operation of the proposed SNS at 4 MW would result in substantial regional spending for operator salaries, supplies, utilities, and administrative support. Operation of the proposed SNS would result in a maximum of 1,486 direct, indirect, and induced jobs. Operations would result in approximately $66.8 million in local wages, $7.6 million in business taxes, and $71.4 million in personal income. Unemployment rate may potentially decrease from 6.6 to 5.8%. The effects of operation of the proposed SNS at the 1-MW power level would be similar but slightly less than the 4-MW case.	Operation of the proposed SNS at 4 MW would result in substantial regional spending for operator salaries, supplies, utilities, and administrative support. Operation of the proposed SNS would result in a maximum of 1,776 direct, indirect, and induced jobs. Operations would result in approximately $82.9 million in local wages, $8.7 million in business taxes, and $91.2 million in personal income. Unemployment rate may potentially decrease from 5.2 to 5.1%. The effects of operation of the proposed SNS at the 1-MW power level would be similar but slightly less than the 4-MW case.	Operation of the proposed SNS at 4 MW would result in substantial regional spending for operator salaries, supplies, utilities, and administrative support. Operation of the proposed SNS would result in a maximum of 1,551 direct, indirect, and induced jobs. Operations would result in approximately $71.6 million in local wages, $10.3 million in business taxes, and $80.5 million in personal income. Unemployment rate may potentially decrease from 3.4 to 3.2%. The effects of operation of the proposed SNS at the 1-MW power level would be similar but slightly less than the 4-MW case.	No economic benefits.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
6b. Impacts on Socioeconomics (Operations) — continued				
Operation of the proposed SNS would not cause high and/or adverse impacts to any of the surrounding populations. Therefore, there would not be a disproportionate risk of significantly high and adverse impact to minority and low-income populations.				The No-Action alternative would not cause high and/or adverse impacts to any of the surrounding populations. Therefore, there would not be a disproportionate risk of significantly high and adverse impact to minority and low-income populations.
7a. Impacts on Cultural Resources (Construction)				
No effects on prehistoric resources. No prehistoric cultural resources have been identified on or in the vicinity of the proposed SNS site.	Five prehistoric archaeological sites within the 65% survey area at the SNS site and eligible for listing on the NRHP would be destroyed by site preparation activities. In the unsurveyed area of the proposed SNS site, any prehistoric sites listed on or eligible for listing on the NRHP could also be destroyed by site preparation. If this site were chosen for construction of the SNS, the remaining 35% would be surveyed and assessed for specific effects prior to the initiation of construction activities. Effects on (continued on next page)	Prehistoric site 11DU207, adjacent to the proposed SNS site, may be disturbed or destroyed by construction activities. ANL has not assessed the NRHP eligibility of site 11DU207. If this site were chosen for construction of the SNS, an assessment of eligibility would be performed prior to the initiation of construction activities. If it is determined that a cultural resource would be affected, the effects would be mitigated by avoidance, if possible, or data recovery.	No effects on prehistoric resources. No prehistoric No effects on prehistoric resources. No prehistoric cultural resources have been identified on or in the vicinity of the proposed SNS site.	No effects on prehistoric resources.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
7a. Impacts on Cultural Resources (Construction) — continued				
	prehistoric archaeological sites would be mitigated by data recovery.			
No effects on historic resources. No historic cultural resources have been identified on or in the vicinity of the proposed SNS site.	No effects on historic resources within the surveyed 65% of the SNS site and buffer zone because no such resources have been identified in these areas. Site preparation activities in the unsurveyed area of the proposed SNS site would destroy any historic sites, structures, or features listed on or eligible for listing on the NRHP. If this site were chosen for construction of the SNS, the 35% area would be surveyed and assessed for specific effects prior to the initiation of construction activities. Effects would be mitigated by data recovery.	No effects on historic resources. Historic Period (A.D. 1600–present in the ANL area) buildings and features in the 800 Area on the proposed SNS site would be destroyed by site preparation activities. However, they are less than 50 yrs old and are not considered to be historic cultural resources.	A number of earthen features (potentially NRHP-eligible) at Stations 2, 4, 8, and 10 on the SNS site may have been associated with World War I trench warfare training at Camp Upton. They would be destroyed by construction activities. Effects would be mitigated by data recovery.	No effects on historic resources.
No effects on traditional cultural properties (TCPs). No TCPs identified on or in the vicinity of the proposed SNS site.	Five TCPs (prehistoric archaeological sites) within 65% survey area at SNS site would be destroyed by site preparation activities. If any prehistoric archaeological sites are located within the unsurveyed 35% of the SNS	No effects on TCPs. No TCPs identified on or in the vicinity of the proposed SNS site.	No effects on TCPs. No TCPs identified on or in the vicinity of the proposed SNS site.	No effects on TCPs.

(continued on next page)

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
7a. Impacts on Cultural Resources (Construction) — continued				
	site, these TCPs would also be destroyed. Because specific identities and locations of other on-site TCPs are not known, potential effects on such specific resources are uncertain.			
7b. Impacts on Cultural Resources (Operations)				
No effects on prehistoric or historic resources. Operational activities would be largely confined to the SNS site. No prehistoric or historic cultural resources have been identified on or in the vicinity of the proposed SNS site.	No effects on prehistoric or historic resources. Operational activities would be largely confined to the SNS site. No prehistoric archaeological sites would be present on the site after construction. No historic cultural resources have been identified on the proposed SNS site.	No effects on prehistoric or historic resources. Operational activities would be largely confined to the SNS site. No prehistoric or historic cultural resources have been identified on the proposed SNS site.	No effects on prehistoric or historic resources. Operational activities would be largely confined to the SNS site. No prehistoric cultural resources have been identified on or in the vicinity of the proposed SNS site. No historic cultural resources would be present on the site after construction.	No effects on prehistoric or historic resources.
No effects on TCPs. No TCPs identified on or in the vicinity of the proposed SNS site.	American Indian tribal groups have identified water resources (surface water and groundwater) as TCPs. See Impacts 2b and 10b for operational effects on these TCPs. Because specific identities and locations of on-site TCPs are not known, potential operational effects on such specific resources are uncertain.	No effects on TCPs. No TCPs identified on or in the vicinity of the proposed SNS site.	No effects on TCPs. No TCPs identified on or in the vicinity of the proposed SNS site.	No effects on TCPs.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
8a. Impacts on Land Use (Construction)				
Introduce large-scale development to the proposed SNS site, utility corridors, and new rights-of-way. Considering that about 64% of the 34,516 acres (13,794 ha) of ORR land is undeveloped, this would be a minimal overall effect. A greenfield site is proposed because no brownfield sites that meet SNS requirements are available.	Introduce large-scale development to the proposed SNS site, utility corridors, and new rights-of-way. Considering the 16,000 acres (6,478 ha) of undeveloped land at LANL, the effect on undeveloped laboratory lands as a whole would be minimal.	Displace the remaining support services operations in the 800 Area. Demolition of the three remaining 800 Area buildings. These would be minimal effects. Introduce large-scale development to Open Space areas due to limited ANL land. Increase the pace of remediation on numerous Solid Waste Management Units (SWMUs) within the proposed SNS site. A beneficial effect would be use of a partial brownfield site for constructing the SNS.	Introduce large-scale development to the proposed SNS site, utility corridors, and new rights-of-way. Considering the large amounts of Open Space land at BNL, the effects would be minimal.	No effects on current land use.
The National Oceanic and Atmospheric Administration/ Atmospheric Turbulence and Diffusion Division (NOAA/ATDD) is conducting the Temperate Deciduous Forest Continuous Monitoring Program (TDFCMP) in the Walker Branch Watershed [0.75 mi. (1.2 km)] east of the proposed SNS site. This long-term program is monitoring the continuous exchange of CO_2, (continued on next page)	No effects on the use of land by environmental research projects. Land on and in the vicinity of the SNS site is not being used for environmental research projects, and none are planned.	No effects on the use of land by environmental research projects. Land on and in the vicinity of the SNS site is not being used for environmental research projects, and none are planned. The ecology plots at ANL are areas of land potentially suitable for ecological research, but little, if any, actual ecological research has ever been conducted in these areas. Currently, there are no on- (continued on next page)	No effects on the use of land by environmental research projects. Land on and in the vicinity of the SNS site is not being used for environmental research projects, and none are planned.	No effects on the use of land by environmental research projects.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
8a. Impacts on Land Use (Construction) — continued				
H_2O vapor, and energy between the deciduous forest and atmosphere. CO_2 from construction vehicles could affect the TDFCMP and one long-term ORNL ecological research project in the Walker Branch Watershed. Potential effects would be loss of CO_2 data quality and data comparability over time.		Going or planned ecological projects in Ecology Plots 6, 7, and 8 on the proposed SNS site.		
Potential limitations on future use of the proposed SNS site and land areas adjacent to it.				No effects on future land use.
Reduce the area of ORR land open to recreational deer hunting by 110 acres (45 ha). Effect would be minimal because about 26,406 acres (10,735 ha) would still be open to hunting.	Potential restriction or end of public hiking trail use near the SNS site in TA-70.	No reasonably discernible effects on parks, preserves, and recreational resources. The effects from the proposed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics that support park, nature preserve, and recreational land uses outside ANL and within the laboratory boundaries.	No reasonably discernible effects on parks, preserves, and recreational resources. The effects from the proposed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics that support park, nature preserve, and recreational land uses in the vicinity of BNL.	No effects on parks, preserves, or recreational resources.
The proposed SNS would come into view only along the upper reaches of the Chestnut Ridge Road and southwest road accesses to the proposed SNS site. This (continued on next page)	Change views in SNS site area from piñon-juniper woodlands to industrial development. SNS facilities visible to public from points on State Route 4, access road (continued on next page)	Potential interference of SNS facilities with natural views from interior points in the Waterfall Glen Nature Preserve, especially on the west side during late autumn, (continued on next page)	Most visual panoramas in the area around BNL and within the laboratory contain features indicative of development. The proposed action would add the SNS (continued on next page)	No effects on visual resources.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
8a. Impacts on Land Use (Construction) — continued				
effect would be minimal because these roads would be traveled primarily by DOE and ORNL personnel, construction workers, and service providers. It would not be visible to the public from land-based vantage points outside the ORR, most points on the ORR, or frequently traveled roads such as Bear Creek Road and Bethel Valley Road. No established visual resources on the ORR would include the proposed SNS.	to proposed SNS site, the site, and hiking trails in TA-70. Highly visible at night—absence of other lighted facilities. Not visible from White Rock and popular public use areas in Bandelier National Monument.	winter, and early spring. This would result from the close proximity of the proposed SNS site to the west ANL perimeter, which is adjacent to the nature preserve.	facilities to this visual environment, and they would be compatible with it. This effect on visual resources would be minimal.	
8b. Impacts on Land Use (Operations)				
Land use change from Mixed Research/Future Initiatives to Institutional/Research.	Change in current land use from Environmental Research/Buffer to Experimental Science.	Change in current land use from Ecology Plots (Nos. 6, 7, and 8), Support Services, and Open Space to a programmatic land use category specific to SNS operations or Programmatic Mission-Other Areas.	Change in current land use from Open Space to Commercial/Industrial.	No effects on current land use.
CO_2 from SNS stacks would adversely affect TDFCMP (NO_x minimal) and one ORNL research project in the Walker Branch Watershed. (continued on next page)	No effects on the use of land by environmental research projects. Land on and in the vicinity of the proposed SNS site is not being used for (continued on next page)	No effects on the use of land by environmental research projects. Land on and in the vicinity of the proposed SNS site is not being used for (continued on next page)	No effects on the use of land by environmental research projects. Land on and in the vicinity of the proposed SNS site is not being used for (continued on next page)	No effects on the use of land by environmental research projects.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
8b. Impacts on Land Use (Operations) — continued				
H_2O vapor from cooling towers may affect the TDFCMP and two ORNL research projects. Effects would be loss of data quality and data comparability over time.	environmental research projects, and none are planned.	environmental research projects, and none are planned.	environmental research projects, and none are planned.	
No effects on DOE zoning (SNS operations compatible). Through a DOE process called Common Ground and a citizen stakeholder group referred to as the End Use Working Group, citizens in the Oak Ridge area have developed future ORR land use recommendations for DOE. Use of the proposed SNS site for the proposed action would be at variance with recommended Common Ground zoning of the site for Conservation Area Uses. It would also be at variance with a draft End Use Working Group advisory to use brownfield sites for new DOE facilities. A greenfield site is proposed for the SNS because no brownfield sites that meet project requirements are available.	No effects on DOE zoning (SNS operations compatible).	The SNS operations would be at variance with Support Services, Ecology Plot No. 8, and Open Space zoning on the SNS site. However, a guiding principle behind ANL zoning is the expansion of other land uses into the Ecology Plots and Open Space. The amount of Support Services land used would be negligible.	The SNS operations would be at variance with Open Space zoning on the SNS site. However, a guiding principle behind BNL zoning is expansion of other land uses into Open Space. Operation of the SNS would probably result in an eventual change in end use zoning of the SNS site and adjacent land from predominantly Open Space to Commercial/ Industrial.	No effects on zoning for future land use.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
8b. Impacts on Land Use (Operations) — continued				
Future adverse CO_2 effects on the TDFCMP and two ORNL research projects. Minimal No_x effects from SNS stacks. Potential future H_2O vapor effects on the TDFCMP and eight ORNL research projects. Potential future effects on strategic ORNL ecological research initiatives. Effects would be loss of data quality and data comparability over time.	No future uses of SNS site and vicinity land for environmental research are planned. As a result, effects on specific future research projects cannot be assessed.	No future uses of SNS site and vicinity land for environmental research are planned. The ecology plots at ANL are areas of land potentially suitable for ecological research, but little, if any, actual ecological research has ever been conducted in these areas. There are no planned environmental research projects in the portions of Ecology Plots 6, 7, and 8 adjacent to the proposed SNS site. As a result, effects on specific future research projects cannot be assessed.	No future uses of SNS site and vicinity land for environmental research are planned. As a result, effects on specific future research projects cannot be assessed.	No effects on the future use of land by environmental research projects.
Potential limitations on future use of the proposed SNS site and land areas adjacent to it.				No effects involving future land use limitations.
Continued restriction of recreational deer hunting on 110-acre (45-ha) SNS site. Effect would be minimal because about 26,406 acres (10,735 ha) would still be open to hunting.	Continued restriction or end of public hiking trail use near the SNS site in TA-70.	No reasonably discernible effects on parks, preserves, and recreational resources. The effects from the pro-posed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics that support park, nature preserve, and recreational land uses outside ANL and within the laboratory boundaries.	No reasonably discernible effects on parks, preserves, and recreational resources. The effects from the proposed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics that support park, nature preserve, and recreational land uses in the vicinity of BNL.	No effects on parks, preserves, or recreational resources.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
8b. Impacts on Land Use (Operations) — continued				
The proposed SNS would come into view only along the upper reaches of the Chestnut Ridge Road and southwest road accesses to the proposed SNS site. This effect would be minimal because these roads would be traveled primarily by DOE personnel, SNS employees, service providers, and visitors to the SNS facilities, including visiting scientists. It would not be visible to the public from land-based vantage points outside the ORR, most points on the ORR, and frequently traveled roads such as Bear Creek Road and Bethel Valley Road. No established visual resources on the ORR would include the proposed SNS.	Change views in proposed SNS site area from piñon-juniper woodlands to industrial development. SNS facilities visible to public from points on State Route 4, access road to proposed SNS site, the site, and hiking trails in TA-70. Highly visible at night—absence of other lighted facilities. Not visible from White Rock and popular public use areas in Bandelier National Monument.	Potential interference of SNS facilities with natural views from interior points in the Waterfall Glen Nature Preserve, especially on the west side during late autumn, winter, and early spring. This would result from the close proximity of the proposed SNS site to the west ANL perimeter, which is adjacent to the nature preserve.	Most visual panoramas in the area around BNL and within the laboratory contain features indicative of development. The proposed action would add the SNS facilities to this visual environment, and they would be compatible with it. This effect on visual resources would be minimal.	No effects on visual resources.
9a. Impacts on Human Health (Construction)				
Based on rates for general industrial construction accidents, 110 potential occupational injuries but less than 1 fatality are predicted.	Based on rates for general industrial construction accidents, 110 potential occupational injuries but less than 1 fatality are predicted.	Based on rates for general industrial construction accidents, 110 potential occupational injuries but less than 1 fatality are predicted.	Based on rates for general industrial construction accidents, 110 potential occupational injuries but less than 1 fatality are predicted.	No effects on human health.

(continued on next page)

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
9a. Impacts on Human Health (Construction) — continued				
		Due to the preferred location of the SNS within the 800 Area SWMU, construction activities may expose workers to organic compounds and possibly radioactive materials.		
9b. Impacts on Human Health (Operations)				
Minimal effects on the health of workers or the public. For operation at 1-MW power, the maximally exposed individual (MEI) would receive an annual radiation dose of 0.40 mrem, or 4% of the 10-mrem limit (40 CFR Part 61). For operation at 4-MW power, the MEI would receive an annual dose of 1.5 mrem, or 15% of the limit. Operation of the SNS at 1-MW power for 10 years and at 4-MW power for 30 years would result in 0.2 latent cancer fatalities (LCFs) in the off-site population attributable to the SNS.	Minimal effects on the health of workers or the public. For operation at 1-MW power, the MEI would receive an annual radiation dose of 0.47 mrem, or 4.7% of the 10-mrem limit (40 CFR Part 61). For operation at 4-MW power, the MEI would receive an annual dose of 1.8 mrem, or 18% of the limit. Operation of the SNS at 1-MW power for 10 years and at 4-MW power for 30 years would result in 0.09 LCFs in the off-site population attributable to the SNS.	Minimal effects on the health of workers or the public. For operation at 1-MW power, the MEI would receive an annual radiation dose of 3.2 mrem, or 32% of the 10-mrem limit (40 CFR Part 61). For operation at 4-MWpower, the MEI would receive an annual dose of 12 mrem, or 120% of the limit. Operation of the SNS at 1-MW power for 10 years and at 4-MW power for 30 years would result in 1.3 LCFs in the off-site population attributable to the SNS.	Minimal effects on the health of workers or the public. For operation at 1-MW power, the MEI would receive an annual radiation dose of 0.91 mrem, or 9.1% of the 10-mrem limit (40 CFR Part 61). For operation at 4-MWpower, the MEI would receive an annual dose of 3.4 mrem, or 3.4% of the limit. Operation of the SNS at 1-MW power for 10 years and at 4-MW power for 30 years would result in 1.2 LCFs in the off-site population attributable to the SNS.	No effects on human health.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
9b. Impacts on Human Health (Operations) — continued				
Potential effects on off-site population for combined operations at 1- and 4-MW power. Potential effects on off-site population predicted to maximally exposed individual for initial 1-MW and upgraded 4-MW operations — 0.2 excess LCFs over 40 years.	Potential effects on off-site population for combined operations at 1- and 4-MW power. Potential effects on off-site population predicted to maximally exposed individual for initial 1-MW and upgraded 4-MW operations — 0.09 excess LCFs over 40 years.	Anticipated effects on off-site population for combined operations at 1- and 4-MW power. Potential effects on off-site population predicted to maximally exposed individual for initial 1-MW and upgraded 4-MW operations — 1.3 excess LCFs over 40 years.	Anticipated effects on off-site population for combined operations at 1- and 4-MW power. Potential effects on off-site population predicted to maximally exposed individual for initial 1-MW and upgraded 4-MW operations — 1.2 excess LCFs over 40 years.	No effects on human health.
No observable effects on workers or public from mercury emissions. Mercury levels would be approximately 100,000 times less than OSHA and NIOSH recommendations and the EPA reference concentration for members of the public.				No effects on human health.
9c. Impacts on Human Health (Accidents)				
Extremely unlikely that workers would be exposed to levels of direct radiation that could induce radiation effects. The SNS shield design would be such that with a high-consequence, low-probability design-basis accident, the dose to a maximally exposed individual would be 1 rem in an uncontrolled area and 25 rem for a worker in a controlled area.				No impacts on health.
No effects expected at 1 MW. At 4 MW, only "beyond-design-basis" accident estimated to occur less than once per 1,000,000 years would induce 31 excess LCFs in off-site population.	No effects expected.	No effects expected at 1 MW. At 4 MW, LCFs expected in off-site population for three accident scenarios: one "beyond-design-basis" accident (120 LCFs) occurring less than once per 1,000,000 years; one extremely unlikely accident (2.7 LCFs) occurring between once per 10,000 and once per 1,000,000 years; and one anticipated accident (2.1 LCFs).	No effects expected at 1 MW. At 4 MW, LCFs expected in off-site population for three accident scenarios: one "beyond-design-basis" accident (85 LCFs) occurring less than once per 1,000,000 years; one extremely unlikely accident (1.9 LCFs) occurring between once per 10,000 and once per 1,000,000 years; and one anticipated accident (1.6 LCFs).	No effects on human health.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
10a. Impacts on Support Facilities and Infrastructure (Construction)				
Traffic on ORNL access roads would increase approximately 7%. The estimated peak construction workforce of 578 employees would be expected to add approximately 466 daily round trips and 10 material/service trucks to the total ORNL traffic of 7,810 vehicle trips. Effects on traffic could include increased general congestion on existing access roads to the ORR.	Traffic on LANL access roads would increase approximately 7%. The estimated peak construction workforce of 578 employees would be expected to add approximately 466 daily round trips and 10 material/ service trucks to the total LANL traffic of 6,980 vehicle trips. The access route, State Highway 4, to the proposed site is a relatively lightly traveled road. Construction traffic would increase traffic on this road by approximately 45%. State Highway 4 also provides access to Bandelier National Monument. This increase in traffic would increase the general congestion on this road.	Approximately 1 mile (1.6 km) of the existing Westgate Road would have to be relocated to the north in order to circumvent the SNS site and replace the existing Westgate Road access to ANL. Traffic on ANL access roads would increase approximately 7%. The estimated peak construction workforce of 578 employees would be expected to add approximately 466 daily round trips and 10 material/ service trucks to the total ANL traffic of 6,290 vehicle trips. Construction traffic would affect the composition and speed of the traffic, resulting in an increase in the general congestion on existing access roads.	Traffic on BNL access roads would increase approximately 16%. The estimated peak construction workforce of 578 employees would be expected to add approximately 466 daily round trips and 10 material/service trucks to the projected total BNL traffic of 2,500 vehicle trips. Because of the condition of the access roads to BNL, this increase is not considered significant.	No effects on support facilities and infrastructure.
10b. Impacts on Support Facilities and Infrastructure (Operations)				
Operation of the proposed SNS at 4 MW would add 305 daily round trips and 3 service trucks per day, or a 5% increase over current traffic levels. Effects on (continued on next page)	Operation of the proposed SNS at 4 MW would add 305 daily round trips and 3 service trucks per day, or a 4% increase over current traffic levels. Effects on. (continued on next page)	Operation of the proposed SNS at 4 MW would add 305 daily round trips and 3 service trucks per day, or a 5% increase over current traffic levels. Effects on (continued on next page)	Operation of the proposed SNS at 4 MW would add 305 daily round trips and 3 service trucks per day, or a 12% increase over current traffic levels. Effects on (continued on next page)	No effects on support facilities and infrastructure.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
10b. Impacts on Support Facilities and Infrastructure (Operations) — continued				
traffic could increase general congestion on existing access roads to the ORR.	traffic could increase general congestion on existing access roads to LANL.	traffic could increase general congestion on existing access roads to ANL.	traffic could increase general congestion on existing access roads to BNL. Because of the condition of the access roads to BNL, this increase is not considered significant.	
Existing electrical service is adequate for the proposed 1-MW SNS and the 4-MW upgrade. Existing transmission lines would be extended approximately 3000 ft. Environmental effects of construction the electrical feeder would be negligible.	The existing electrical power system at LANL does not have adequate capacity to meet the demands of the proposed SNS. Meeting these demands would require a 115-kV transmission line from the east side of the site. Additional required efforts could include new power grid configurations and an SNS site-specific power generation station.	The existing electrical power system at ANL has sufficient capacity for the proposed SNS operating at 1-MW power. However, there is not sufficient capacity at ANL for the 4-MW SNS. Sufficient power is available from Commonwealth Edison. Approximately 6,600 ft of new 138-kV transmission line would be constructed to connect the proposed SNS to an adequate substation. The transmission line would be constructed in developed areas, so environmental effects would be minimal.	Existing electrical service at BNL is adequate for the proposed 1-MW SNS. However, in order to accommodate the 4-MW facility, a new 69-kV transmission line would be required extending to the Long Island Lighting Company's (LILCO's) 138-kV grid. The length of this line would be approximately 1 mile and would parallel the existing 69-kV line. All upgrades would occur within existing utility corridors; therefore, environmental effects would be minor.	No effects on electrical service.
The existing steam supply at ORNL is adequate to meet the needs of the proposed SNS. If the decision is made to use ORNL steam, approximately 2 miles of (continued on next page)	Steam is not available at or in the vicinity of the proposed SNS site. The facility would include steam generation.	The existing steam supply at ANL is adequate to meet the needs of the proposed SNS. If the decision is made to use ANL steam, approximately 1,500 ft of steam line would (continued on next page)	The existing steam supply at BNL is adequate to meet the needs of the proposed SNS. If the decision is made to use BNL steam, approximately 4,000 ft of steam line would (continued on next page)	No effects on the steam supply.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
10b. Impacts on Support Facilities and Infrastructure (Operations) — continued				
steam line would be constructed. Much of the construction would be on previously disturbed land. Environmental effects would be expected to be minimal.		be constructed, crossing developed land. Environmental effects would be expected to be minimal.	be constructed, crossing developed land. Environmental effects would be expected to be minimal.	
The existing East Tennessee Natural Gas 22-in. gas main has adequate capacity to supply the proposed SNS. Approximately 5,000 ft of new gas line would be constructed along Chestnut Ridge Road, the main access road to the proposed site. This would encroach on 0.12 acres of palustrine emergent wetlands.	There is adequate capacity from the existing natural gas system at LANL to meet the needs of the proposed SNS. However, there are no existing gas lines in the vicinity of the proposed site. An expansion of the natural gas infrastructure would be necessary.	There is adequate capacity from the existing natural gas system at ANL to meet the needs of the proposed SNS. The natural gas system at ANL is scheduled to be upgraded in FY 1999. A high-pressure gas main is located near the proposed site. Modifications necessary to accommodate the proposed SNS could be accomplished during the scheduled upgrade.	There is sufficient capacity in the existing natural gas system at BNL to meet the needs of the proposed SNS. Approximately 4,000 ft of new gas line would be constructed, primarily across developed land. Environmental effects would be expected to be minimal.	No effects on natural gas system.
The existing 24-in. water main located adjacent to the proposed site has adequate capacity to supply water to the SNS.	The domestic water system at LANL can not meet the projected demands for LANL, including the proposed SNS and the surrounding communities. Accommodating the proposed SNS would require extensive upgrades to the delivery system, including new water mains, lift stations and storage tanks.	The domestic water system at ANL has sufficient capacity to meet the needs of the proposed SNS. In addition, ANL has a non-potable laboratory water supply the could be used for cooling tower makeup.	The domestic water system at BNL has sufficient capacity to meet the needs of the proposed SNS.	No effects on the domestic water system.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
10b. Impacts on Support Facilities and Infrastructure (Operations) — continued				
The existing sewage treatment plant at ORNL has adequate capacity to treat wastes from the proposed SNS.	The existing sewage treatment plant at LANL has sufficient capacity to treat wastes from the proposed SNS. The plant is several miles from the proposed site. Sanitary sewage would have to be trucked to the treatment plant or a small package plant included in the SNS facilities.	The existing sewage treatment plant at ANL has adequate capacity to treat wastes from the proposed SNS.	The existing sewage treatment plant at BNL has adequate capacity to treat wastes from the proposed SNS.	No effects on sewage treatment.
11a. Impacts on Waste Management (Construction and Operations)				
Hazardous Wastes Treatment No hazardous waste treatment facilities at ORNL. Storage Projected generation, excluding SNS, 1998–2040: 160 m^3/yr. Total capacity available for SNS wastes: 139 m^3/yr. Amount generated by SNS: 40 m^3/yr. (continued on next page)	**Hazardous Wastes** Treatment No hazardous waste treatment facilities at LANL. Storage Projected generation, excluding SNS, 1998–2040: 942 m^3/yr. Total capacity available for SNS wastes: Not applicable. Amount generated by SNS: 40 m^3/yr. (continued on next page)	**Hazardous Wastes** Treatment No hazardous waste treatment facilities at ANL. Storage Projected generation, excluding SNS, 1998–2040: 115 m^3/yr. Total capacity available for SNS wastes: Not applicable. Amount generated by SNS: 40 m^3/yr. (continued on next page)	**Hazardous Wastes** Treatment No hazardous waste treatment facilities at BNL. Storage Projected generation, excluding SNS, 1998–2040: 100 drums/yr. Total capacity available for SNS wastes: Not applicable. Amount generated by SNS: 200 drums (40 m^3)/yr. (continued on next page)	**Hazardous Wastes**

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
11a. Impacts on Waste Management (Construction and Operations) — continued				
Hazardous Wastes (cont'd) <u>Conclusion</u> No effect on hazardous waste storage facilities would be anticipated because DOE has contracts in place for disposal of wastes as generated.	**Hazardous Wastes (cont'd)** <u>Conclusion</u> No effect on hazardous waste storage facilities would be anticipated because DOE has contracts in place for disposal of wastes as generated.	**Hazardous Wastes (cont'd)** <u>Conclusion</u> No effect on hazardous waste storage facilities would be anticipated because DOE has contracts in place for disposal of wastes as generated.	**Hazardous Wastes (cont'd)** <u>Conclusion</u> No effect on hazardous waste storage facilities would be anticipated because DOE has contracts in place for disposal of wastes as generated.	**Hazardous Wastes (cont'd)** <u>Conclusion</u>: No effects on hazardous waste facilities.
Low-Level Radioactive Wastes <u>Treatment</u> Projected generation, excluding SNS, 1998–2040: 282,000 m^3/yr (7.45E07 gal/yr). Total capacity available for SNS wastes: 423,920 m^3/yr (1.12E08 gal/yr). Amount generated by SNS: 16,400 m^3/yr (4.33E06 gal/yr). <u>Conclusion</u> No effects on low-level radioactive waste (LLW) treatment facilities would be anticipated. (continued on next page)	**Low-Level Radioactive Wastes** <u>Treatment</u> Projected generation, excluding SNS, 1998–2040: 21,880 m^3/yr (5.78E06 gal/yr). Total capacity available for SNS wastes: 4,600 m^3/yr (1.22E06 gal/yr). Amount generated by SNS: 16,400 m^3/yr (4.33E06 gal/yr). <u>Conclusion</u> Treatment facilities do not have the capacity to treat all of the LLW from the proposed SNS. LLW with accelerator-produced tritium would not meet the waste (continued on next page)	**Low-Level Radioactive Wastes** <u>Treatment</u> Projected generation, excluding SNS, 1998–2040: 413,000 m^3/yr (1.09E08 gal/yr). Total capacity available for SNS wastes: 1.00E06 m^3/yr (2.64E08 gal/yr). Amount generated by SNS: 16,400 m^3/yr (4.33E06 gal/yr). <u>Conclusion</u> No effects on LLW treatment facilities would be anticipated. Tritium discharge would increase from 0.75 Ci/yr to 40 Ci/yr. (continued on next page)	**Low-Level Radioactive Wastes** <u>Treatment</u> Projected generation, excluding SNS, 1998–2040: 190 m^3/yr (50,000 gal/yr). Total capacity available for SNS wastes: 300 m^3/yr (70,000 gal/yr). Amount generated by SNS: 16,400 m^3/yr (4.33E06 gal/yr). <u>Conclusion</u> SNS volume exceeds capacity. Wastes can be processed at a higher rate. Additional treatment capacity may be necessary. (continued on next page)	**Low-Level Radioactive Wastes** <u>Conclusion</u> No effects on LLW facilities.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
11a. Impacts on Waste Management (Construction and Operations) — continued				
Low-Level Radioactive Wastes (cont'd)	**Low-Level Radioactive Wastes (cont'd)** acceptance criteria for the existing LLW treatment facility (RLWTF TA-50). However, a new facility is under construction that will accept these wastes.	**Low-Level Radioactive Wastes (cont'd)**	**Low-Level Radioactive Wastes (cont'd)**	**Low-Level Radioactive Wastes (cont'd)**
Storage Projected generation, excluding SNS, 1998–2040: 2,520 m^3/yr. Total capacity available for SNS wastes: Limited storage available; long-term storage would not be necessary because contracts are in place that would allow for disposal of waste. Amount generated by SNS: 1,026 m^3/yr.	Storage Facilities are present on-site for treatment and disposition; therefore, long-term storage facilities for LLW are not necessary at LANL.	Storage Projected generation, excluding SNS, 1998–2040: 232 m^3/yr. Total capacity available for SNS wastes: 30 m^3 Amount generated by SNS: 1,026 m^3/yr.	Storage Projected generation, excluding SNS, 1998–2040: 283 m^3/yr. Total capacity available for SNS wastes: 270 m^3/yr. Amount generated by SNS: 1,026 m^3/yr.	
Conclusion Additional storage capacity may be necessary to accommodate SNS wastes; however, long-term storage		Conclusion Additional storage capacity may be necessary to accommodate SNS wastes; however, long-term storage	Conclusion Additional storage may be necessary to accommodate SNS wastes; however, long-term storage would not be	Conclusion No effects on LLW facilities.
(continued on next page)	(continued on next page)	(continued on next page)	(continued on next page)	(continued on next page)

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
11a. Impacts on Waste Management (Construction and Operations) — continued				
Low-Level Radioactive Wastes (cont'd) would not be necessary because DOE has contracts in place for disposal of wastes as generated. Disposal No LLW disposal at ORNL.	**Low-Level Radioactive Wastes (cont'd)** Disposal Projected generation, excluding SNS, 1998–2040: 2,500 m^3/yr. Total capacity available for SNS wastes: 35,000 m^3/yr. Amount generated by SNS: 1,026 m^3/yr. Conclusion No effect on LLW disposal facilities would be anticipated.	**Low-Level Radioactive Wastes (cont'd)** would not be necessary because DOE has contracts in place for disposal of wastes as generated. Disposal No LLW disposal at ANL.	**Low-Level Radioactive Wastes (cont'd)** necessary because DOE has contracts in place for disposal of wastes as generated. Disposal No LLW disposal at BNL.	**Low-Level Radioactive Wastes (cont'd)**
Mixed Wastes Treatment No mixed waste treatment facilities at ORNL. (continued on next page)	**Mixed Wastes** Treatment No mixed waste treatment facilities at LANL. (continued on next page)	**Mixed Wastes** Treatment Projected generation rate, excluding SNS, 1998–2040: 215 m^3/yr. Total capacity available for SNS wastes: Not Applicable. (continued on next page)	**Mixed Wastes** Treatment No mixed waste treatment facilities at BNL. (continued on next page)	**Mixed Wastes** (continued on next page)

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
11a. Impacts on Waste Management (Construction and Operations) — continued				
Mixed Wastes (cont'd)	**Mixed Wastes (cont'd)**	**Mixed Wastes (cont'd)** Amount generated by SNS: 18 m^3/yr. Conclusion Design capacity is much greater than anticipated volumes. If necessary, permitted volumes could be increased.	**Mixed Wastes (cont'd)**	**Mixed Wastes (cont'd)**
Storage Projected generation rate, excluding SNS, 1998–2040: 20 m^3/yr. Total capacity available for SNS wastes: Not applicable. Amount generated by SNS: 18 m^3/yr.	Storage Projected generation rate, excluding SNS, 1998–2040: 622 m^3/yr. Total capacity available for SNS wastes: Not applicable. Amount generated by SNS: 18 m^3/yr.	Storage Projected generation rate excluding SNS, 1998–2040: 215 m^3/yr. Total capacity available for SNS wastes: Not applicable. Amount generated by SNS: 18 m^3/yr.	Storage Projected generation rate, excluding SNS, 1998–2040: 2 m^3/yr. Total capacity available for SNS wastes: Not applicable. Amount generated by SNS: 18 m^3/yr.	
Conclusion No effect on mixed waste storage facilities would be anticipated because DOE has contracts in place for disposal of wastes as generated.	Conclusion No effect on mixed waste storage facilities would be anticipated because DOE has contracts in place for dis-posal of wastes as generated.	Conclusion No effect on mixed waste storage facilities would be anticipated because DOE has contracts in place for disposal of wastes as generated.	Conclusion No effect on mixed waste storage facilities would be anticipated because DOE has contracts in place for disposal of wastes as generated.	Conclusion No effect on mixed waste facilities.
All laboratories have waste certification processes in place to assure LLW and mixed wastes sent to off-site disposal facilities meet the waste acceptance criteria (WAC) of the facility. Because of the uncertainty of the composition of the LLW and mixed waste generated by the SNS, the waste may not meet the current WAC. Pretreatment of the waste at the SNS may be necessary. DOE may have to amend the licenses at the current disposal facilities to allow acceptance of wastes from the SNS.				

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
11a. Impacts on Waste Management (Construction and Operations) — continued				
Sanitary Wastes Treatment Projected generation rate, excluding SNS, 1998–2040: 300,000 gal/day. Total capacity available for SNS wastes: 42,000 gal/day. Amount generated by SNS: 25,900 m^3/yr (18,000 gal/day). Conclusion No effect on sanitary waste treatment. Disposal Projected generation rate, excluding SNS, 1998–2040: 7,645 m^3/yr. Total capacity available for SNS wastes: 1,090,000 m^3/yr. Amount generated by SNS: 1,350 m^3/yr.	**Sanitary Wastes** Treatment Projected generation rate, excluding SNS, 1998–2040: 692,827 m^3/yr. Total capacity available for SNS wastes: 368,000 m^3/yr. Amount generated by SNS: 25,900 m^3/yr (18,000 gal/day). Conclusion No effect on sanitary waste treatment. Disposal Projected generation rate, excluding SNS, 1998–2040: 5,453 m^3/yr. Total capacity available for SNS wastes: Not applicable. Sanitary wastes would be disposed of in off-site landfills. Amount generated by SNS: 1,350 m^3/yr.	**Sanitary Wastes** Treatment Projected generation rate, excluding SNS, 1998–2040: 350,000 gal/day. Total capacity available for SNS wastes: 150,000 gal/day. Amount generated by SNS: 25,900 m^3/yr. (18,000 gal/day). Conclusion No effect on sanitary waste treatment. Disposal Projected generation rate, excluding SNS, 1998–2040 not provided. Total capacity available for SNS wastes: Not applicable. Sanitary wastes would be disposed of in off-site landfills. Amount generated by SNS: 1,350 m^3/yr.	**Sanitary Wastes** Treatment Projected generation rate, excluding SNS, 1998–2040: 800,000 gal/day. Total capacity available for SNS wastes: 1.5 million gal/day. Amount generated by SNS: 25,900 m^3/yr (18,000 gal/day). Conclusion No effect on sanitary waste treatment. Disposal Projected generation rate, excluding SNS, 1998–2040: 1,700 tons/yr. Total capacity available for SNS wastes: Not applicable. Sanitary wastes are disposed of in off-site landfills. Amount generated by SNS: 1,350 m^3/yr.	**Sanitary Wastes** Conclusion No effect on sanitary waste facilities.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
11a. Impacts on Waste Management (Construction and Operations) — continued				
Sanitary Wastes (cont'd) <u>Conclusion</u> No effect anticipated.	**Sanitary Wastes (cont'd)** <u>Conclusion</u> No effect anticipated. Sanitary wastes would be disposed of in off-site landfills.	**Sanitary Wastes (cont'd)** <u>Conclusion</u> No effect anticipated. Solid sanitary wastes would be disposed of in off-site landfills.	**Sanitary Wastes (cont'd)** <u>Conclusion</u> No effect anticipated. Solid sanitary wastes would be disposed of in off-site landfills.	**Sanitary Wastes (cont'd)** <u>Conclusion</u> No effect on sanitary waste facilities.
12a. Impacts on Long-Term Productivity of the Environment (Operations)				
Localized effects on groundwater productivity would occur at the ORNL SNS site but not on the corresponding watershed.	Sustained use of groundwater by the SNS over time could lower water levels in wells and reduce long-term main aquifer productivity.	Localized effects on groundwater productivity would occur at the ANL SNS site but not on the corresponding watershed.	Localized effects on groundwater productivity would occur at the BNL SNS site but not on the corresponding watershed.	No effects on groundwater productivity.
Permanent commitment of 110 acres (45 ha) of forested land to the SNS. This represents less 0.5% of the forested area on the ORR.	Permanent commitment of 110 acres (45 ha) of piñon-juniper habitat to the SNS. This represents approximately 10% of the piñon-juniper habitat in TA-70.	Permanent commitment of 110 acres (45 ha) of land to the SNS. A large portion of this land has been previously disturbed.	Permanent commitment of 110 acres (45 ha) of land to the SNS. This represents less than 2% of the legally established Pine Barrens Protection Area. The proposed SNS site is entirely within the Compatible Growth Area.	No effects on the long-term productive potential of land.
13a. Cumulative Impacts (Construction and Operations)				
The proposed action would contribute to cumulative impacts through localized radionuclide contamination of groundwater.				This proposed action would not contribute to cumulative impacts involving radionuclide contamination of groundwater.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
13a. Cumulative Impacts (Construction and Operations) — continued				
The potential cumulative impact of incremental emissions would be evaluated and permitted on a case-by-case basis by the state and federal air quality agencies at the appropriate juncture in order to protect public health and welfare.				This alternative would not contribute to cumulative impacts on incremental emissions.
No cumulative impacts are predicted for noise.				This alternative would not contribute to cumulative impacts on noise.
The proposed action would not contribute to cumulative impacts on terrestrial resources.	The proposed action would not contribute to cumulative impacts on terrestrial resources.	Clearing 15% of the undeveloped land at ANL for the SNS and APS would significantly decrease the terrestrial wildlife inhabiting ANL. Except for fallow deer, no rare or important game animals would be affected.	The proposed action would not contribute to cumulative impacts on terrestrial resources.	This alternative would not contribute to cumulative impacts on terrestrial resources.
Cumulative impacts on wetlands would be minimal.				This alternative would not contribute to cumulative impacts on wetlands.
No cumulative impacts are anticipated on aquatic resources.				This alternative would not contribute to cumulative impacts on aquatic resources.
Cumulative impacts on protected species would be expected to be minimal.				This alternative would not contribute to cumulative impacts on protected species.
The activities at ORNL account for only about 7% of the employment, wage and salary, and business activities of the area. Cumulative impacts of SNS on the (continued on next page)	The activities at LANL account for about one-third of the employment, wage and salary, and business activities of the area. Some positive benefits would occur in the (continued on next page)	The activities at ANL account for much less than 1% of the employment, wage and salary, and business activities of the area. Cumulative impacts of SNS (continued on next page)	The activities at BNL account for much less than 1% of the employment, wage and salary, and business activities of the area. Cumulative impacts of SNS (continued on next page)	No cumulative impacts on the economy, housing, and community infrastructure.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
13a. Cumulative Impacts (Construction and Operations) — continued				
economy, housing, and community infrastructure would be minimal.	form of new jobs but cumulative impacts of SNS on the economy, housing, and community infrastructure would be minimal overall.	on the economy, housing, and community infrastructure would be minimal.	on the economy, housing, and community infrastructure would be minimal.	
There would be no cumulative impacts involving environmental justice issues.				This alternative would not contribute to cumulative impacts involving environmental justice issues.
The proposed action would not contribute to cumulative impacts on prehistoric cultural resources.	Twenty prehistoric archaeological sites in the 65% surveyed area would be destroyed by construction of the proposed SNS and expansion of LLW Disposal Facility in TA-54. The potential contribution of the other 35% of the proposed SNS site cannot be accurately assessed. If the proposed SNS site is chosen for construction of the SNS, this area would be surveyed and assessed for cumulative impacts on prehistoric cultural resources prior to construction.	Prehistoric site 40DU207, adjacent to the proposed SNS site, may be disturbed or destroyed by SNS construction. ANL has not assessed the NRHP eligibility of this site. Site 40DU189 on the Advanced Photon Source (APS) site was once thought to be potentially NRHP-eligible, but it was later determined to not be a prehistoric cultural resource. If 40DU207 is a cultural resource, the proposed action, along with the APS project, would not contribute to cumulative impacts on prehistoric cultural resources at ANL because 40DU189 is not a prehistoric cultural resource.	The proposed action would not contribute to cumulative impacts on prehistoric cultural resources.	This alternative would not contribute to cumulative impacts on prehistoric cultural resources.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
13a. Cumulative Impacts (Construction and Operations) — continued				
The proposed action would not contribute to cumulative impacts on historic cultural resources.	Implementation of the proposed action within the 65% surveyed area at the proposed SNS site would not contribute to cumulative impacts on historic cultural resources. The potential contribution of the other 35% cannot be accurately assessed. If this site is chosen for construction of the proposed SNS, this area would be surveyed and assessed for cumulative impacts on historic cultural resources prior to construction.	The proposed action would not contribute to cumulative impacts on historic cultural resources.	The proposed action would not contribute to cumulative impacts on historic cultural resources.	This alternative would not contribute to cumulative impacts on historic cultural resources.
The proposed action would not contribute to cumulative impacts on TCPs.	Cumulative impacts on 20 prehistoric archaeological sites (all TCPs) destroyed by construction of the proposed SNS and expansion of LLW Disposal Facility in TA-54. If any prehistoric archaeological sites are located within the unsurveyed 35 percent of the proposed SNS site, these (continued on next page)	The proposed action would not contribute to cumulative impacts on TCPs.	The proposed action would not contribute to cumulative impacts on TCPs.	This alternative would not contribute to cumulative impacts on TCPs.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
13a. Cumulative Impacts (Construction and Operations) — continued				
	TCPs would also be destroyed during construction. Cumulative impacts on water resources are also impacts on TCPs (see related entries under this table heading). Because specific identities and locations of TCPs at sites of the proposed SNS and other analyzed actions are not known, cumulative impacts on such specific resources would be uncertain.			
The proposed action would contribute minimally to cumulative impacts on undeveloped ORR land.	The proposed action would contribute minimally to cumulative impacts on undeveloped LANL land.	The SNS and APS would introduce development to about 160 acres (65 ha) of undeveloped land. This would reduce the already limited area of undeveloped ANL land available for development by about 15%.	The proposed action would contribute minimally to cumulative impacts on undeveloped land at BNL.	This alternative would not contribute to cumulative impacts on undeveloped land.
The proposed action would contribute minimally to cumulative impacts on areas of ORR land in current use categories.	The proposed action would contribute minimally to cumulative impacts on areas of LANL land in current use categories.	The SNS and APS would reduce Open Space land at ANL by 145 acres (59 ha). This would further reduce the already limited area of Open Space ANL land available for development by about 15%.	The proposed action would contribute minimally to cumulative impacts on areas of BNL land in current use categories.	This alternative would not contribute to cumulative impacts on areas of land in current use categories.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
13a. Cumulative Impacts (Construction and Operations) — continued				
The proposed action, CERCLA Waste Disposal Facility, Parcel ED-1, and JINS would reduce the environmental research potential of 981 acres (391 ha) of National Environmental Research Park (NERP) land on the ORR. This cumulative impact would be minimal because only 4.5% of the NERP land on the ORR would be affected. The cumulative impacts of these actions on environmental research projects are uncertain.	The proposed action, construction of a new LLW disposal facility in TA-67, and construction of a new road to support pit production would reduce the environmental research potential of 177 acres (72 ha) of NERP land. This cumulative impact would be Minimal because only 0.6% of the NERP land at LANL would be affected. The land on and in the vicinity of the proposed SNS site is not being used for environmental research projects. As a result, the proposed action would not contribute to cumulative impacts on uses of the land by environmental research projects. Because no future environmental research projects are planned for this land, cumulative impacts on specific future projects cannot be assessed.	No NERP land is present at ANL. Consequently, the proposed action would not reduce the environmental research potential of NERP land. The land on and in the vicinity of the proposed SNS site, including Ecology Plot Nos. 6, 7, and 8, is not being used by environmental research projects. As a result, the proposed action would not contribute to cumulative impacts on the use of land by such projects. Because no future environmental research projects are planned for this land, cumulative impacts on specific future projects cannot be assessed.	No NERP land is present at BNL. Consequently, the proposed action would not reduce the environmental research potential of NERP land. The land on and in the vicinity of the proposed SNS site is not being used by environmental research projects. As a result, the proposed action would not contribute to cumulative impacts on the use of land by such projects. Because no future environmental research projects are planned for this land, cumulative impacts on specific future projects cannot be assessed.	No cumulative impacts on NERP land or environmental research projects.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
13a. Cumulative Impacts (Construction and Operations) — continued				
The SNS and CERCLA Waste Management Facility [White Wing Scrap Yard (high-end scenario)] would be collectively at variance with Common Ground zoning for future use of their sites in Conservation Area Uses.	The proposed action would not contribute to cumulative impacts on zoning of land for future use.	The proposed action would not contribute to cumulative impacts on zoning of land for future use.	The proposed action would not contribute to cumulative impacts on zoning of land for future use.	This alternative would not contribute to cumulative impacts on zoning of land for future use.
The proposed action would contribute minimally to cumulative impacts on recreational land use but not at all on parks and preserves.				This alternative would not contribute to cumulative impacts on parks, preserves, or recreational land uses.
The proposed action would not contribute to cumulative impacts on visual resources.	The proposed action would not contribute to cumulative impacts on visual resources.	The proposed SNS and APS would degrade natural views from interior points within the west side of the Waterfall Glen Nature Preserve.	The proposed action would not contribute to cumulative impacts on visual resources.	This alternative would not contribute to cumulative impacts on visual resources.
Minimal cumulative radiological impacts on human health from normal ORNL and SNS operations.	Minimal cumulative radiological impacts on human health from normal LANL and SNS operations.	Potential for adverse radiological impacts on human health from normal ANL and SNS operations.	Potential for adverse radiological impacts on human health from normal BNL and SNS operations.	This alternative would not contribute to radiological impacts on human health.
Minor increases in traffic due to the proposed SNS project and development of Parcel ED-1 may minimally reduce the level of service on roads.	Minimal cumulative impacts on transportation.	Minimal cumulative impacts on transportation.	Minimal cumulative impacts on transportation.	This alternative would not contribute to cumulative impacts involving transportation.
Minimal cumulative impacts on electric power supply capabilities.	The power demand of the SNS, DAHRT facility, and continued LANL operations would exceed the delivery capacity of the electric power pool that serves the laboratory.	Adequate power is available, but new power lines would need to be installed.	Minimal cumulative impacts on electric power supply capabilities.	This alternative would not contribute to cumulative impacts on electric power supply capabilities.

Table S 1.5.2-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
13a. Cumulative Impacts (Construction and Operations) — continued				
Waste management facilities at ORNL have sufficient capacity to handle the waste volume projected for the period 1998–2040, including the wastes from the proposed SNS. Therefore, construction and operation would have a minimal contribution to cumulative impacts on waste management facilities.	Waste management facilities at LANL have sufficient capacity to handle the waste volume projected for the period 1998–2040, including the wastes from the proposed SNS. Therefore, construction and operation would have a minimal contribution to cumulative impacts on management facilities.	Waste management facilities at ANL have sufficient capacity to handle the waste volume projected for the period 1998–2040, including the wastes from the proposed SNS. Therefore, construction and operation would have a minimal contribution to cumulative impacts on waste management facilities.	Waste management facilities at BNL have sufficient capacity to handle the waste volume projected for the period 1998–2040, including the wastes from the proposed SNS. Therefore, construction and operation would have a minimal contribution to cumulative impacts on waste management facilities.	This alternative would not contribute to cumulative impacts on waste management.

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ACRONYMS AND ABBREVIATIONS

ADT	average daily trips
AEA	Atomic Energy Act
ANL	Argonne National Laboratory
ANS	Advanced Neutron Source
AOC	area of concern
APS	Advanced Photon Source
ARAP	Aquatic Resource Alteration Permit
ATDD	Atmospheric Turbulence and Diffusion Division
AWQS	Ambient Water Quality Standards
BESAC	Basic Energy Sciences Advisory Committee
BGRR	Brookhaven Graphite Research Reactor
BMAP	Biological Monitoring and Abatement Program
BNL	Brookhaven National Laboratory
BSR	biodiversity significance ranking
CAA	Clean Air Act
CCDTL	coupled-cavity drift-tube linac
CCL	coupled-cavity linac
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CHP	Central Heating Plant
CSF	Central Steam Facility
CWA	Clean Water Act
DCG	derived concentration guides
DNA	deoxyribonucleic acid
DOE	U.S. Department of Energy
DOE-AL	U.S. Department of Energy Albuquerque Operations Office
DOE-CH	U.S. Department of Energy Chicago Operations Office
DOE-ORO	U.S. Department of Energy Oak Ridge Operations Office
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
DTL	drift-tube linac
ECL	Environmental Conservation Law
EDE	effective dose equivalents
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESD	Environmental Sciences Division
ETNG	East Tennessee Natural Gas Company
ETTP	East Tennessee Technology Park

ACRONYMS AND ABBREVIATIONS - Continued

FR	*Federal Register*
FY	fiscal year
HEBT	high-energy beam transport
HEPA	high-efficiency particulate air (filter)
HFBR	High-Flux Beam Reactor
HFIR	High-Flux Isotope Reactor
HVAC	heating, ventilation, and air conditioning
ICRP	International Commission on Radiation Protection
IEPA	Illinois Environmental Protection Agency
ILCS	Illinois Compiled Statutes
IPNS	Intense Pulsed Neutron Source
JINS	Joint Institute for Neutron Science
K	hydraulic conductivity
LANL	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron Science Center
LCF	latent cancer fatalities
LEBT	low-energy beam transport
LILCO	Long Island Lighting Company
linac	linear accelerator
LLLW	liquid low-level radioactive waste
LLW	low-level radioactive waste
LMER	Lockheed Martin Energy Research Corporation
LMES	Lockheed Martin Energy Systems
LOS	level of service
MAP	Mitigation Action Plan
MEBT	medium energy beam transport
MEI	maximally exposed individual
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIOSH	National Institute of Occupational Safety and Health
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMEDAQB	New Mexico Environment Department Air Quality Bureau
NMSA	New Mexico Statutes Annotated
NMWQCC	New Mexico Water Quality Control Commission
NOAA	National Oceanic and Atmospheric Administration

ACRONYMS AND ABBREVIATIONS - Continued

NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NSC	National Safety Council
NSNS	National Spallation Neutron Source
NYSDEC	New York State Department of Environmental Conservation
NYSDWS	New York State Drinking Water Standards
OECD	Organization for Economic Cooperation and Development
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PGA	peak ground acceleration
PM_{10}	particulate matter (less than 10 microns in diameter)
PSD	prevention of significant deterioration
RCRA	Resource Conservation and Recovery Act
rf	radio-frequency
RfC	reference concentration
RFQ	radio-frequency quadrupole
RHIC	Relativistic Heavy Ion Collider
RMO	Reservation Management Organization
ROD	Record of Decision
ROI	region-of-influence
RTBT	ring-to-target beam transport
SDWA	Safe Drinking Water Act
SHPO	State Historic Preservation Officer
SNS	Spallation Neutron Source
SR	state road
STP	sewage treatment plant
SWMU	Solid Waste Management Unit
SWTP	Sanitary Wastewater Treatment Plant
TCPs	Traditional Cultural Properties
TCRR	Tennessee Compilation of Rules and Regulations
TDEC	Tennessee Department of Environment and Conservation
TDFCMP	Temperate Deciduous Forest Continuous Monitoring Program
TSCA	Toxic Substances Control Act
TSD	treatment, storage, or disposal
TVA	Tennessee Valley Authority

ACRONYMS AND ABBREVIATIONS - Continued

USACOE	U.S. Army Corp of Engineers
USC	United States Code
USDA	U.S. Department of Agriculture
USFS	United States Forest Service
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound
WAC	waste acceptance criteria

UNITS OF MEASURE

ac	Acre
bcf	billion cubic feet
Bq/L	Becquerels per liter
Btu/hr	British thermal units per hour
C	Celsius
cfm	cubic feet per minute
Ci	Curie
Ci/g	curies per gram
Ci/ml	curies per milliliter
cm	Centimeter
cm/yr	Centimeters per year
cm/s	Centimeters per second
dB	Decibel
dBA	decibel A-weighted
F	Fahrenheit
(fCi)/m^3	Femtocuries per cubic meter
ft	Feet
ft/d	feet per day
ft/mi	feet per mile
ft^2	square feet
ft^3	cubic feet
ft^3/hr	cubic feet per hour
ft^3/s	cubic feet per second
g	Grams
g/L	grams per liter
gal	Gallon
GeV	billion electron volts
gpd	gallons per day
gpm	gallons per minute
gwh	gigawatt hour
ha	Hectare
Hz	Hertz
in	Inch
K	Kelvin
keV	thousand electron volts
kv	Kilovolt
kg/ft^2	kilograms per square feet
Km	Kilometer
km^2	square kilometer
km/hr	Kilometers per hour
KPa	Kilopascal
KV	Kilovolt
L	Liter
Lb	Pound
lb/ft^2	pounds per square feet
lb/hr	pounds per hour
lpd	liters per day

UNITS OF MEASURE – Continued

lpm	liters per minute
lps	liters per second
M	meter
m^2	square meter
m^2/d	square meters per day
m^3	cubic meter
m^3/yr	cubic meters per year
MA	milliamperes
m/d	meters per day
MeV	million electron volts
mg/L	milligrams per liter
mg/ m^3	milligrams per cubic meter
Mgpd	million gallons per day
Mi	mile
mi^2	square mile
min	minute
ml	milliliter
mmhos	micro ohm^{-1}
mph	miles per hour
mrem	millirem (one thousandth of a rem)
mrem/yr	millirems per year
mR/y	millirads per year
m/s	meters per second
m^3/s	cubic meters per second
mSv	milliseivert
MW	megawatt
m/y	meters per year
pCi/g	picocuries (one trillionth of a curie) per gram
pCi/L	picocuries per liter
PCi/m^3	picocuries per cubic meter
Ppm	parts per million
Psig	pounds per square inch guage
R/hr	roentgen per hour
Rad/hr	rads per hour
Rem	roentgen equivalent man
Rem/yr	rems per year
S	second
Tns/yr	tons per year
µg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
µs	a millionth of a second
yd^3	cubic yards
yr	year

CHEMICALS AND ELEMENTS

Ag	silver
Al	aluminum
Ba	barium
Ca	calcium
Cd	cadmium
Cl	chlorine
CO	carbon monoxide
CO_2	carbon dioxide
Cr	chromium
Cu	copper
D_2O	deuterium
Fe	iron
H	hydrogen
H_20	water
HCl	hydrochloric acid
Hg	mercury
Mg	magnesium
Mn	manganese
Na	sodium
NH_4	ammonium
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
NO_3-N	nitrate--nitrogen
O_2	oxygen
P	phosphorus
Pb	lead
SiO_2	quartz
SO_2	sulfur dioxide
SO_4	sulfate
SO_x	oxides of sulfur
Zn	zinc

RADIONUCLIDES

Al-26	aluminum-26	^{26}Al
Am-241	americium-241	^{241}Am
Ar-37	argon-37	^{37}Ar
Ar-39	argon-39	^{39}Ar
Ar-41	argon-41	^{41}Ar
Be-7	beryllium-7	^{7}Be
Be-10	beryllium-10	^{10}Be
C-10	carbon-10	^{10}C
C-11	carbon-11	^{11}C
C-14	carbon-14	^{14}C
Ca-41	calcium-41	^{41}Ca
Cl-36	chlorine-36	^{36}Cl
Co-60	cobalt-60	^{60}Co
Cs-137	cesium-137	^{137}Cs
Fe-55	iron-55	^{55}Fe
H-3	tritium	^{3}H
I-122	iodine-122	^{122}I
I-125	iodine-125	^{125}I
K-40	potassium-40	^{40}K
Mn-53	manganese-53	^{53}Mn
Mn-54	manganese-54	^{54}Mn
N-13	nitrogen-13	^{13}N
N-15	nitrogen-15	^{15}N
Na-22	sodium-22	^{22}Na
O-14	oxygen-14	^{14}O
O-15	oxygen-15	^{15}O
Pu-238	plutonium-238	^{238}Pu
Pu-239	plutonium-239	^{239}Pu
Pu-240	plutonium-240	^{240}Pu
Pu-249	plutonium-249	^{249}Pu
Sr-89	strontium-89	^{89}Sr
Sr-90	strontium-90	^{90}Sr
Tc-99	technetium-99	^{99}TC
Te-123m	Tellurium-123m	^{123m}Te
U-234	uranium-234	^{234}U
U-235	uranium-235	^{235}U
U-238	uranium-238	^{238}U
Xe-127	xenon-127	^{127}Xe

METRIC CONVERSION CHART

To Convert into Metric			To Convert out of Metric		
If You Know	**Multiply By**	**To Get**	**If You Know**	**Multiply By**	**To Get**
Length					
Inches	2.54	Centimeters	Centimeters	0.3937	Inches
Feet	30.48	Centimeters	Centimeters	0.0328	Feet
Feet	0.3048	Meters	Meters	3.281	Feet
Yards	0.9144	Meters	Meters	1.0936	Yards
Miles	1.60934	Kilometers	Kilometers	0.6214	Miles
Area					
Square inches	6.4516	Square centimeters	Square centimeters	0.155	Square inches
Square feet	0.092903	Square meters	Square meters	10.7639	Square feet
Square yards	0.8361	Square meters	Square meters	1.196	Square yards
Acres	0.40469	Hectares	Hectares	2.471	Acres
Square miles	2.58999	Square kilometers	Square kilometers	0.3861	Square miles
Volume					
Fluid ounces	29.574	Milliliters	Milliliters	0.0338	Fluid ounces
Gallons	3.7854	Liters	Liters	0.26417	Gallons
Cubic feet	0.028317	Cubic meters	Cubic meters	35.315	Cubic feet
Cubic yards	0.76455	Cubic meters	Cubic meters	1.308	Cubic yards
Weight					
Ounces	28.3495	Grams	Grams	0.03527	Ounces
Pounds	0.45360	Kilograms	Kilograms	2.2046	Pounds
Short tons	0.90718	Metric tons	Metric tons	1.1023	Short tons
Temperature					
Fahrenheit	Subtract 32 then multiply by 5/9ths	Celsius	Celsius	Multiply by 9/5ths, then add 32	Fahrenheit

METRIC PREFIXES

Prefix	Symbol	Multiplication Factor
Exa-	E	1 000 000 000 000 000 000 = 10^{18}
Peta-	P	1 000 000 000 000 000 = 10^{15}
Tera-	T	1 000 000 000 000 = 10^{12}
Giga-	G	1 000 000 000 = 10^{9}
Mega-	M	1 000 000 = 10^{6}
Kilo-	K	1 000 = 10^{3}
Hecto-	H	100 = 10^{2}
Deca-	Da	10 = 10^{1}
Deci-	D	0.1 = 10^{-1}
Centi-	C	0.01 = 10^{-2}
Milli-	M	0.001 = 10^{-3}
Micro-	μ	0.000 001 = 10^{-6}
Nano-	N	0.000 000 001 = 10^{-9}
Pico-	P	0.000 000 000 001 = 10^{-12}
Femto-	F	0.000 000 000 000 001 = 10^{-15}
Atto-	A	0.000 000 000 000 000 001 = 10^{-18}

RADIOACTIVITY UNITS

Part of this report deals with levels of radioactivity that might be found in various environmental media. Radioactivity is a property; the amount of a radioactive material is usually expressed as "activity" in curies (Ci). The curie is the basic unit used to describe the amount of substance present, and concentrations are generally expressed in terms of curies per unit mass or volume. One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radionuclide that decays at the rate of 37 billion disintegrations per second. Disintegrations generally include emissions of alpha or beta particles, gamma radiation, or combinations of these.

RADIATION DOSE UNITS

The amount of ionizing radiation energy received by a living organism is expressed in terms of radiation dose. Radiation dose in this report is usually written in terms of effective dose equivalent and reported numerically in units of rem. Rem is a term that relates ionizing radiation and biological effect or risk. A dose of 1 millirem (0.001 rem) has a biological effect similar to the dose received from about a 1-day exposure to natural background radiation. A list of the radionuclides discussed in this document and their half-lives is included in Appendix F.

CHAPTER 1: INTRODUCTION

In the context of carrying out its mission to support continued U.S. leadership in science and technology, the Department of Energy (DOE) is proposing to construct and operate a major new scientific research facility, the Spallation Neutron Source (SNS). The proposed SNS is designed to be a world-class neutron scattering science user facility serving a broad national community of researchers from federal laboratories, academia, and private industry. It is anticipated that this facility would be used by 1,000 to 2,000 scientists and engineers annually and that it would help meet the nation's demand for research capabilities in neutron scattering science well into the next century. This chapter provides background information about neutron scattering science and associated research facilities, describes the environmental analysis process, introduces the proposed action and alternatives included in this Environmental Impact Statement (EIS), and describes how this document is organized.

1.1 BACKGROUND ON NEUTRON SCATTERING SCIENCE AND FACILITIES

Neutron scattering science is a specialized field of basic research having to do with using a subatomic particle, the neutron, as a means to probe and derive an understanding of the fundamental structure and behavior of matter. Among all types of radiation used to probe materials (including X-rays, protons, and electrons), neutrons are uniquely capable of penetrating deeply beneath the material's surface to reveal its innermost characteristics. In basic terms, this is accomplished by directing a beam of neutrons at a material sample, detecting the neutrons that are scattered from collisions with atomic nuclei within the sample, and measuring the angles of their scattering paths and their post-collision energies. From these data, scientists can determine a wide range of characteristics about how a solid or liquid material's molecules are structured and how they behave under various physical conditions.

Development of neutron scattering techniques as a means to analyze material properties was pioneered by U.S. scientists beginning in 1945 when the first nuclear reactors became available for research. This type of research eventually spread to Europe and Japan as neutron sources became available there. DOE (and its predecessor agencies) has served as the prime steward of this field throughout the entire course of its development. Two of the leaders in this field, Clifford Shull of the Massachusetts Institute of Technology and Bertram Brockhouse of McMaster University in Canada, were jointly awarded the 1994 Nobel Prize for Physics for their development of neutron diffraction and neutron spectroscopy, respectively. Diffraction refers to patterns followed by the scattered neutrons; these patterns are a direct result of the molecular structure of a material sample. The diffraction patterns can be used to understand how atoms in the molecules are arranged. This information can, in turn, be used to predict how a material will behave under various physical conditions (e.g., high temperature or extreme pressure). Spectroscopy involves measuring the energies of the scattered neutrons, which can be used to reveal information about the movements of atoms within a material sample (e.g., their individual and collective oscillations).

Neutron beams can be either continuous (steady streams of neutrons) or pulsed (short bursts of neutrons). Both types are used and are uniquely valued in neutron scattering research. Continuous beams can be easily generated by nuclear reactors, and reactor sources were used exclusively up through the 1970s for neutron scattering experiments. These reactors tend to be relatively small and specially designed for neutron research purposes, in contrast to those built for commercial power generation. Pulsed neutron beams can be optimally produced from short bursts of high energy protons or electrons from a particle accelerator impinging on a heavy metal target, such as tungsten, tantalum, or mercury, to generate bursts of neutrons through a nuclear process called spallation. Spallation occurs when an incoming high energy proton hits a heavy atomic nucleus and knocks one or more neutrons out of it (Figure 1.1-1). Other neutrons are "boiled off" as the bombarded nucleus heats up. For every proton striking the nucleus, 20 to 30 neutrons are expelled. The power of a spallation source is characterized by the power [in kilowatts (kW) or megawatts (MW)] of the proton beam coming from the accelerator and directed onto the target. The first pulsed spallation source was built at Argonne National Laboratory (ANL) and began operation in 1973.

Regardless of whether the neutron source is continuous or pulsed, the emerging neutrons must be slowed

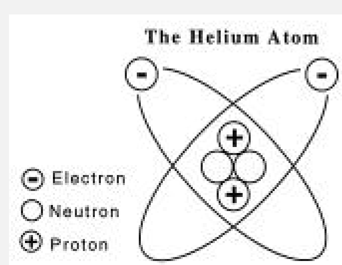
What Are Neutrons and What Can They Do?

Neutrons are one of the fundamental particles that make up matter. They were first identified in 1932 by Sir James Chadwick in England, for which he was awarded the 1935 Nobel Prize in Physics. This uncharged particle exists in the nucleus of a typical atom along with its positively charged counterpart, the proton. Protons and neutrons each have about the same mass, and both can exist as free particles apart from the atomic nucleus. In the universe, neutrons are abundant, making up more than half of all visible matter.

Neutrons traveling on their own can collide with the atomic nuclei of any material that they encounter and bounce off in a new direction, usually at a different speed or energy. This interaction is referred to as neutron scattering, which can be used to identify the positions of atoms in a molecule. It is especially good at locating light atoms such as hydrogen, carbon, and oxygen. Since these light atoms are prevalent in organic compounds, neutron scattering is a particularly effective means of studying biological materials. Because neutrons weakly interact with materials, they are highly penetrating and can be used to study bulky or highly complex samples, as well as samples inside thick-walled metal containers.

As an alternative to scattering, neutrons can be absorbed into a nucleus upon colliding with it. This can result in the formation of a nucleus of a different element, which can be either stable or radioactive. This is the process used to produce radioactive isotopes for medical applications such as implants for treating some forms of cancer. When neutrons are absorbed into the nuclei of certain heavy elements, such as uranium, those nuclei can be split apart. This is the fission process that occurs in a nuclear reactor, generating heat and producing more neutrons.

Lastly, another valuable feature of neutrons is that they are slightly magnetic, which makes them one of the best probes for the study of magnetic structure and magnetic properties of materials.



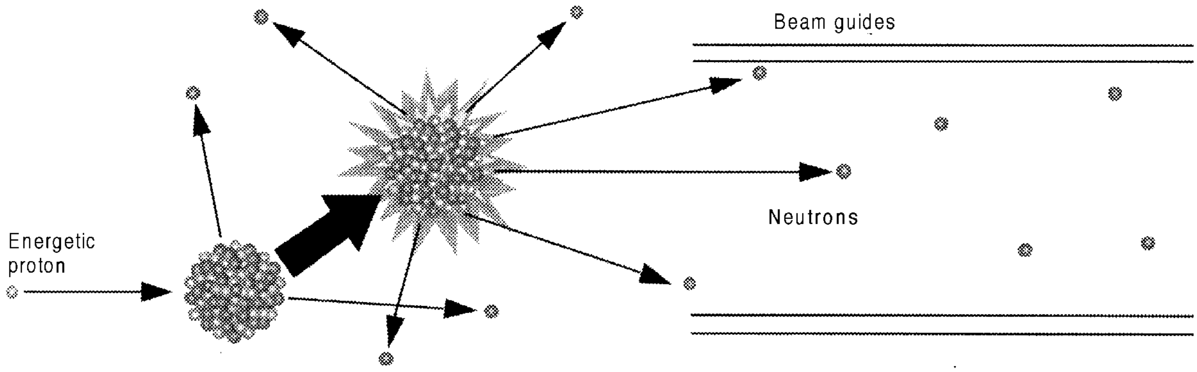


Figure 1.1-1. Neutron spallation process.

down, or moderated, to energies that are applicable to studying the kinds of materials chosen by the scientist conducting a particular experiment. This is usually accomplished by surrounding the reactor core or spallation target with a material containing hydrogen (e.g., water), which is most effective at slowing neutrons. The neutrons are then channeled in a beamline to an experiment station equipped with instruments capable of collecting and processing the desired kinds of information. Neutrons that are moderated to the energy or temperature of their surroundings are called thermal neutrons [0.002 to 0.1 electron volts (eV)], and those that slow down even further are termed cold neutrons (0.1 eV to 0.001 eV). In the late 1960s, neutron guides were developed for cold neutrons. These guides, which are evacuated glass channels with a metallic coating, can transport neutrons long distances with low losses. More recently, guides were developed for thermal neutrons. Guides for cold and thermal neutrons enable remote placement of instruments in buildings or rooms that are removed from the reactor core or the spallation target; such structures are called guide halls. The geometry involved in locating the instruments farther away from the neutron source allows more instruments to be installed, which makes the facility far more scientifically productive and flexible.

It is important to note that continuous and pulsed neutron sources are complementary and equally valuable as research tools. While many classes of experiments can be performed at some level with either type of source, there are some kinds of experiments that cannot be done with one or the other. For instance, with a pulsed source it is possible to achieve much higher neutron beam intensities (i.e., a greater number of neutrons per unit of time or higher flux) enabling deeper penetration into a material sample, and its pulsed nature permits time-of-flight analysis of the scattered neutrons. Time-of-flight analysis is based on the fact that each pulse contains neutrons with a range of energies, so neutrons of different energies can be separated by letting them run down a path of several meters. The highest energy neutrons reach the sample ahead of the rest, and because the neutron energies are spread out in time, the energy of an individual neutron is determined by its time-of-flight to the sample. Another area where pulsed sources are desirable is neutron scattering from samples subjected to very high pressures or very high magnetic fields that can be sustained only for brief periods of time. A reactor source is superior for performing experiments requiring cold neutrons, such as studying polymer dynamics. Apart from neutron scattering, reactors are better suited to conducting radiation damage studies and producing radioisotopes, both of which require neutron fluxes over large volumes. The neutron science community has expressed its view that both reactor and spallation neutron sources must remain available to support a strong, comprehensive U.S. neutron scattering research program (DOE 1993a).

Future advances in neutron scattering science and its applications depend to a large extent upon the number, technical capability, and research capacity of neutron sources available to the scientific research community. In addition to the previously mentioned distinction of continuous versus pulsed beams, the technical capability of a neutron source can be described by several other principal characteristics. Probably the most important is the flux or brightness of the neutron beam, and like a flashlight in a dark room, a high flux beam allows the researcher to look deeper inside a sample specimen and more clearly discern its structural features. Because neutrons only interact weakly with matter, most neutrons pass through a sample without producing a detectable interaction. As a result, experiments tend to be extremely flux-limited. This situation is further exacerbated because, unlike X-rays and charged particles, neutrons cannot be easily focused. The combination of weak interaction and focusing difficulties has driven the quest for higher-flux neutron sources. Existing spallation sources have produced beams with higher brightness than reactor-based sources, and unlike reactors, they have the potential to achieve even higher levels of brightness by employing even higher power proton accelerators. Lastly, pulsed sources can be characterized by their pulse repetition frequency (generally in the range of 10 to 100 Hertz). Research capacity can be characterized by the number of beamlines a facility has and the capability of their associated instrumentation, how many weeks per year it typically operates, and its operational reliability.

1.2 CURRENT AND FUTURE NEUTRON SOURCES

A worldwide scientific community, on the order of 6,000 scientists, presently uses approximately 20 major neutron sources worldwide, most of these being nuclear reactors and the remainder being spallation sources (see Table 1.2-1). Among the seven U.S. sources are five reactors: the High Flux Beam Reactor (HFBR) at Brookhaven National Laboratory (BNL), the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL), the Neutron Beam Split-Core Reactor (NBSR) at the National Institute of Standards and Technology (NIST), the Missouri University Research Reactor (MURR), and a smaller reactor at the Massachusetts Institute of Technology (MIT). The other two are pulsed spallation sources: the Intense Pulsed Neutron Source (IPNS) at ANL and the Los Alamos Neutron Science Center (LANSCE) at Los Alamos National Laboratory (LANL). All of these facilities except the smaller reactors at MIT, NIST, and MURR are supported by DOE, and all are currently in operation except HFBR. The HFBR has been shut down since 1997 to resolve issues related to a tritium leak into the groundwater from its spent fuel storage pool. A decision expected in June of 1999 on the future of HFBR will be made by DOE after completing an

Table 1.2-1. Present and future neutron sources worldwide.

Facility	Location	Type	Age (years)	Status
HIFAR	Australia	Reactor	40	Operating
HIFAR II	Australia	Reactor	NA	Planned replacement for existing HIFAR in 2005
Austron	Australia	Spallation	NA	Planned
Riso	Denmark	Reactor	39	Operating
IRF	Canada	Reactor	NA	Planned
ILL	France	Reactor	27	Operating; further instrument upgrades planned
Orphee	France	Reactor	18	Operating; further instrument upgrades planned
KFA	Germany	Reactor	36	Operating
KFA Replacement	Germany	Reactor	NA	Planned replacement for existing KFA reactor
Berlin	Germany	Reactor	7	Operating
FRM II	Germany	Reactor	NA	Under construction; operation planned for 2001
KENS	Japan	Spallation	18	Operating
JRR-3	Japan	Reactor	8	Operating
JHF	Japan	Spallation	NA	Project start and funding approved
NSRP	Japan	Spallation	NA	Planned
Petten	Netherlands	Reactor	37	Operating
IBR-2	Russia	Reactor	14	Operating; upgrades planned
PIK	Russia	Reactor	NA	Planned
IN-06	Russia	Spallation	NA	Planned
Studsvik	Sweden	Reactor	38	Operating
SINQ	Switzerland	Spallation	2	Operating (continuous; not pulsed)
ISIS	United Kingdom	Spallation	23	Operating; power upgrade planned (ISIS II)
ESS	Europe	Spallation	NA	Planned to be world's best spallation source (5 MW); R&D underway; site TBD
HFBR	USA (BNL)	Reactor	33	Shut down; decision to restart or remain shut down pending completion of an EIS
HFIR	USA (ORNL)	Reactor	32	Operating; cold source and instrument upgrades in progress; new guide hall proposed
IPNS	USA (ANL)	Spallation	17	Operating
LANSCE	USA (LANL)	Spallation	13	Operating; power upgrade in progress
NBSR	USA (NIST)	Reactor	29	Operating; upgraded (cold neutron research facility)
MURR	USA (U of MO)	Reactor	33	Operating
MIT	USA (MIT)	Reactor	40	Operating
SNS	USA (the Proposed Action)	Spallation	NA	Project authorized by Congress in FY 1999; initiating preliminary design

NA – Not applicable

Sources: DOE 1993a: 37–38; OECD 1998

PRACTICAL BENEFITS OF NEUTRON SCATTERING SCIENCE

Over the past 40 years, neutrons have become an increasingly essential tool in broad areas of the physical, chemical, and biological sciences, as well as in nuclear medicine and materials technology. In the latter area alone, neutron probes have made invaluable contributions to the understanding and development of many classes of new materials ranging from high temperature superconductors to polymers (plastics) — materials with enormous industrial applications and future potential.

Some specifics:

- In materials science, neutron scattering research can be used to study diffusion, crystal structures, impurity concentrations, and residual stresses in forgings, castings, and welds. Residual stress studies have been used to predict failure modes in critical structural components (e.g., aircraft engines) and to help design ways to avoid these failures.

- In condensed matter physics, neutron scattering has vastly improved our understanding of the static and dynamic aspects of glasses, liquids, amorphous solids, and phase behavior. This, in turn, has enabled the optimized design of a variety of useful materials: metallic glasses with unique mechanical and magnetic properties that make them the preferred choice for many industrial uses; amorphous semiconductors that have wide use in the electronics industry and solar energy conversion; molten salts that have important applications in electrochemical processes that are as wide ranging as plating of steel and waste treatment; integrated optical systems including lasers and fiber optic transmission channels; and thin films for use in various magnetic data storage systems.

- Neutron scattering, particularly with cold neutrons, is becoming increasingly important to the investigation of molecular structures in biological materials. This has opened new opportunities to obtain information crucial to understanding biological functions and processes. Neutrons are already being used to study the role of water and hydrogen bonds in enzyme reactivity and protein chemistry and to make major contributions to the design of new drugs to treat a wide range of medical conditions.

- Neutron research on polymers and other complex fluids has led to improved pressure-sensitive adhesives, better oil additives, light-weight durable plastics, and improved detergent and emulsification products. Measurement of real-time changes in scattering profiles caused by changes in an externally applied field (e.g., pressure, shear stress, temperature) is valuable to chemical manufacturers, who are interested in improving the design, control, and reliability of industrial manufacturing processes like extrusion, molding, and cold drawing.

- Neutron research on magnetism has led to the development of higher strength magnets for more efficient electric generators and motors and better magnetic materials for magnetic recording tapes, high density computer hard drives, and other information storage devices.

Although not obvious to most people, the benefits of applying scientific knowledge gained from neutron scattering research are all around us in the form of products that have markedly improved our standard of living. Thus, neutron science lies at the foundation of the ability of American industry to develop, produce, and market new or improved products vital to the future growth of our nation's economy.

Environmental Impact Statement, which is now being prepared.

In Europe, the leading neutron scattering research facilities are the Institut Laue-Langevin (ILL) reactor in Grenoble, France; the ISIS short-pulse spallation source at the Rutherford Appleton Laboratory in England; and the SINQ steady-state spallation source in Switzerland. Smaller reactors are also in operation in Australia, Canada, Denmark, France, Germany, the Netherlands, Russia, and Sweden. With its guide halls, ILL accommodates more instruments than the two largest U.S. reactor sources (HFIR and HFBR) combined. The ISIS and SINQ spallation sources are far more powerful than the best U.S. spallation source (LANSCE), although work is now underway to upgrade LANSCE to the same power level as ISIS. Germany is constructing a new reactor neutron source, FRM II, with world-class cold source capabilities roughly equal to those of ILL. It is scheduled to be completed and to enter operation within the next few years. Lastly, a joint European effort is in the early stages of design for a next-generation spallation source, the European Spallation Source (ESS).

The Japanese have a sizable neutron scattering program that is supported by a research reactor (JRR-3) and a relatively modest spallation source (KENS). The JRR-3 research center, commissioned approximately 6 years ago, represents a substantial investment (~$300 million in 1992 dollars), far more than all U.S. investments in neutron sources over the past decade. As will be described later, the Japanese government has also embarked on an ambitious plan to build two large spallation sources in the coming decade.

A study published by the European Science Foundation (European Science Foundation 1996) provided a forward look at the likely increase in worldwide demand for neutron scattering experimentation. It demonstrated that research using neutrons can be expected to grow in both traditional fields such as solid-state physics, materials science, and physical chemistry, and new and rapidly developing areas for neutron research such as biotechnology, drug design, engineering, and earth sciences. This will involve an increase in the complexity and sophistication of the scientific work rather than a mere growth in the number of experiments. In addition, the study confirmed that non-neutron tools for matter investigation (e.g., X-rays, electron beams) cannot be adequate substitutes for neutron beams.

Thus, the availability of neutron sources in the face of increasing demand is a global concern. In recognition of this, a Neutron Sources Working Group was established in January 1996 under the auspices of the Organization for Economic Cooperation and Development (OECD). This OECD Working Group, comprising government officials and scientists from 25 countries including the U.S., is investigating the refurbishment and upgrading of existing facilities, as well as the prospects for international collaboration on developing new instrumentation and new neutron sources. The group has concluded that by the year 2020, there could be a “neutron gap” caused by more than two-thirds of the world’s neutron sources reaching the end of their useful operating lives. It therefore recommended that new, advanced neutron sources be built in each of the three major user regions (Japan, Europe, and the U.S.). This is consistent with plans for next generation spallation sources that are already being planned for construction. Specifically, a consortium of European countries is designing a 5-MW short-pulse spallation source, the previously mentioned ESS; Austria has designed a 100-kW short-pulse spallation source, the Austron; and Japan has formally announced a plan to build a 600-kW short-pulse spallation source, the Japanese Hadron Facility (JHF), that will be progressively upgraded to 1.2 MW and is part of the high-energy physics Japanese Hadron Project. Japan is also planning another 1-MW spallation source that will be upgraded to 5 MW for nuclear technology development and neutron scattering. The construction of the proposed SNS in the U.S. would then complete the worldwide set of new neutron sources recommended by the OECD Working Group.

When compared with the global "neutron gap," the shortfall in our nation's neutron science capability is even more acute; this shortfall has been developing over the past two decades as a result of insufficient funding to invest in building new sources and upgrading existing facilities. It is clear from Table 1.2-1 and the preceding discussion that among the world's major neutron sources, those in the U.S. are older and becoming less capable than their foreign counterparts. Although there are modest efforts to upgrade and extend the useful life of these facilities (already underway at LANSCE and HFIR), a new neutron source has not been built in the U.S. in well over 10 years.

1.3 PROPOSED ACTION AND ALTERNATIVES ANALYZED

This section introduces DOE's proposed action and provides background information about the proposed neutron source. This section also introduces the alternatives analyzed in the EIS. Chapter 3 of this document provides a detailed description of the proposed action and alternatives.

1.3.1 THE PROPOSED ACTION

The proposed action is to construct and operate a state-of-the-art short-pulse spallation neutron source comprising an ion source, a linear accelerator (linac), a proton accumulator ring, and an experiment building containing a liquid mercury target and a suite of neutron scattering instrumentation. The proposed SNS facility would be designed to operate at a proton beam power of 1 MW and to be upgradable in the future (see Figure 1.3-1). The scope of these upgrades over the operating life of the facility is envisioned to encompass, in chronological stages:

1. Adding a second experiment building, including a second mercury target with its own suite of instrumentation (space for this is included in the facility footprint analyzed in this EIS).

2. Increasing the proton beam power to 2 MW by doubling the ion source output.

3. Increasing the proton beam power to 4 MW by adding a second ion source, modifying the linac, and adding a second proton storage ring (again, space for the upgrades is included in the facility footprint analyzed in this EIS).

The implementation of these upgrades would depend largely on availability of future funding. DOE would perform further NEPA review if and when the decision to upgrade the facility is made. For the sake of completeness, however, this EIS analyzes the impacts of the SNS facility

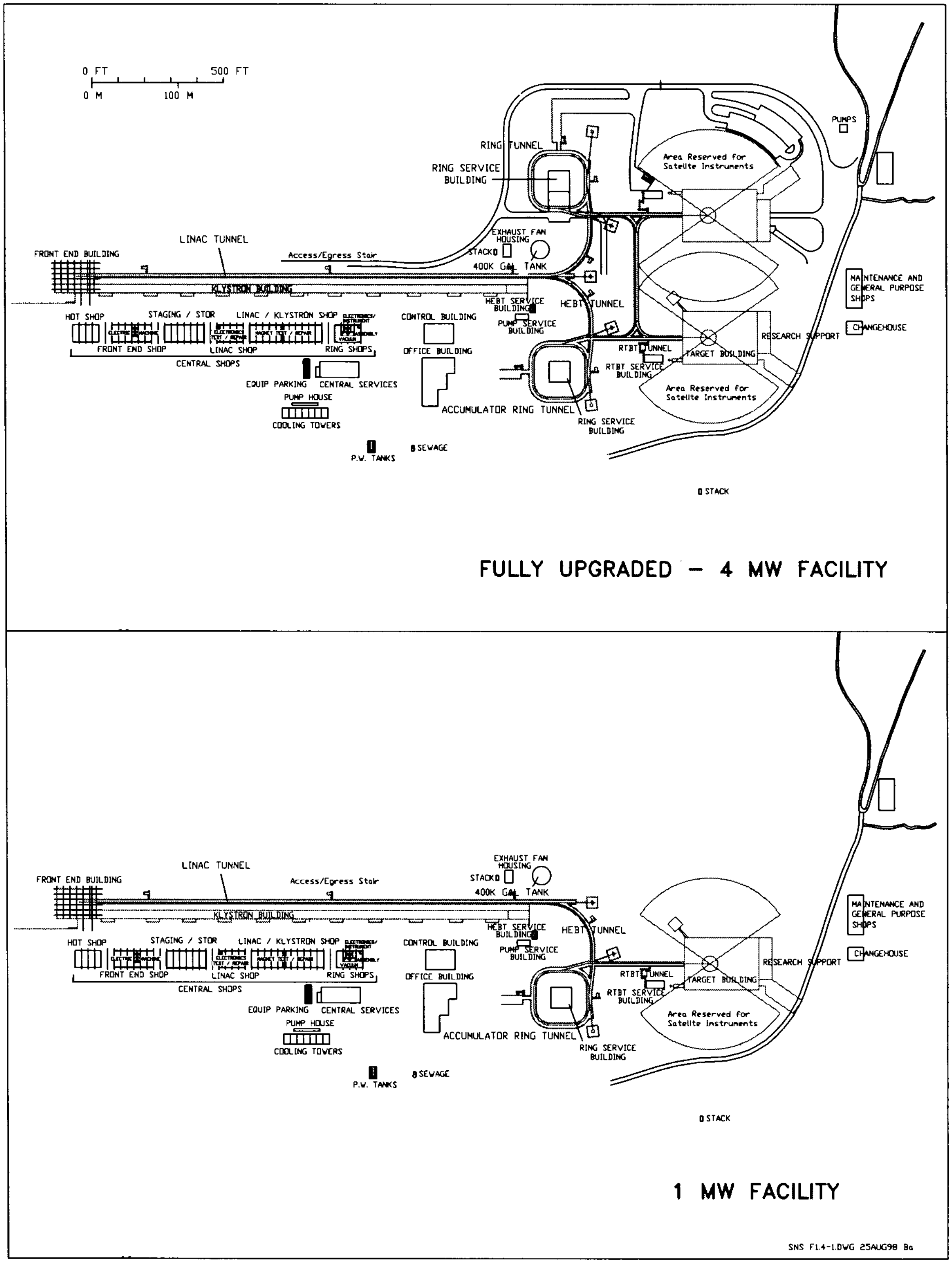


Figure 1.3-1. Site plan for SNS.

as it would originally be built as well as those corresponding to its fully upgraded configuration. The proposed action does not include decommissioning of the proposed facility. The fate of the SNS beyond its 40-year life span has not been determined. When the decision is made to decommission the facilities, a detailed decontamination and decommissioning plan along with the appropriate NEPA documentation would be prepared.

1.3.2 BASIS OF PROPOSED ACTION

DOE has been charged with the responsibility for planning, constructing, and operating the major scientific user facilities to provide special research capabilities (*Energy Policy Act of 1992*; Public Law 102-486, Section 2203). This is in recognition of the fact that these kinds of facilities tend to be large-scale, physically complex, and hence very expensive (hundreds of millions or even billions of dollars)—well beyond the means of most private and industrial organizations to build and operate. High performance neutron sources, based on reactors or accelerators, naturally belong in this category.

The use of these DOE facilities is open to all researchers (federal, industrial, and academic), usually at no charge as long as the scientific information derived from their experiments is kept in the public domain for the benefit of the entire scientific community.

The scientific justification and need for additional and more capable neutron sources in the U.S. has been established by numerous studies dating back to the 1970s. Two National Research Council studies *(Neutron Research on Condensed Matter* 1977 and *Current Status of Neutron Scattering Research and Facilities in the U.S.* 1984) urged DOE to build new neutron sources in order to keep up with research demand and to sustain U.S. scientific leadership in this field. The earlier study led to the construction of IPNS and LANSCE in the early 1980s. In 1984, the broad-based study *Major Facilities for Materials Research and Related Disciplines* recommended construction of four major new materials research facilities including an advanced, high-flux, steady-state neutron source, and a high-intensity pulsed neutron source. As a result, in 1987 DOE tasked ORNL with developing a design for a high-flux, steady-state source based on a nuclear reactor, a project that later became known as the Advanced Neutron Source (ANS). Action on the recommendation for a high intensity pulsed neutron source was to be deferred, due to funding constraints, until after the ANS was completed.

By 1992, a conceptual design for the ANS had been completed, and at the same time, a special panel under the DOE's Basic Energy Sciences Advisory Committee (BESAC) was asked to assess the importance of neutron science for the nation's science, technology, health, and economy, and to make recommendations for both short-term and long-term strategies for neutron sources. The panel was chaired by Professor Walter Kohn (University of California, Santa Barbara, winner of the 1998 Nobel Prize in Chemistry) and included both specialists and generalists from government laboratories (7 panelists), private industry (4 panelists), and universities (3 panelists). Their report, *Neutrons for America's Future* (DOE 1993) (1) reaffirmed the need for constructing ANS as the top priority, (2) recommended that DOE immediately initiate the design of a complementary, 1-MW pulsed spallation source, and (3) urged that existing neutron sources be upgraded. In their judgment, "failure to move ahead quickly with the construction of the ANS and development of a complementary 1-MW pulsed spallation source would have serious, long-lasting consequences for the nation's competitiveness in cutting-edge science, technology, industry, and medicine. The construction of these facilities represents a cost-effective and productive investment in the nation's future."

Although the President's budget requests to Congress for fiscal years 1994 and 1995 included funding to start the ANS construction project, no funds were ever appropriated for construction, and DOE elected to cancel the project in 1996. Concern over the high cost of the project (approximately $3 billion) was the primary factor in the decision. In lieu of ANS, the administration advised that a next-generation pulsed spallation source be pursued (since this was assumed to be much less expensive and was also consistent with the Kohn Panel's second recommendation) and that upgrades to existing DOE neutron sources be considered.

In response to this guidance, a collaboration of DOE laboratories was organized to develop a conceptual design for a new state-of-the-art spallation neutron source. Given ORNL's long history in neutron scattering research (which dates back to Shull's pioneering work on the ORNL Graphite Reactor in the 1940s), their extensive materials research and testing program, and the project management infrastructure remaining from ANS, ORNL assumed the lead role. Together with four other national laboratories [ANL, BNL, LANL, and Lawrence Berkeley (LBNL)] the design work was carried out with each laboratory having lead responsibility for a major technical system in which they have prominent expertise:

- ANL–Instrumentation
- BNL–Proton storage ring and high energy beam transport
- LANL–Linac
- LBNL–Ion source and low energy beam transport
- ORNL–Target, moderators, and conventional construction

This collaborative design approach was chosen because it:

- Assembled the best available expertise to complete a conceptual design in the shortest time with limited funds,
- Accessed the best and most current technologies,
- Incorporated insights from existing feasibility studies done by U.S. and foreign laboratories, and
- Conserved DOE resources by using a "system-of-laboratories."

The collaboration's design work was guided by BESAC, which formed a panel under Dr. Thomas Russell (IBM Research Division) in late 1995 to evaluate technical aspects and basic design requirements. The panel's report (BESAC 1996) made several recommendations that were accepted by DOE and that served to establish the fundamental characteristics for the conceptual design of the SNS:

- Short-pulse operation in the 1-MW power range (1 microsecond proton pulses).
- Design that preserves long-pulse operation as an option.
- Upgradable to a significantly higher power at some point after commissioning.
- Horizontal proton beam injection into the target.
- One target and the capability to produce neutron pulses at frequencies in the range of

30 to 60 Hz, with the potential for installing additional targets and instrumentation in the future.

- Carefully selected initial set of instruments to maximize early scientific impact.
- Set of moderators to provide neutrons with appropriate characteristics to meet user needs.
- Highly predictable and reliable operation for at least 240 days/year.
- Use of low-risk technology initially, with parallel research and development on certain critical systems to advance the state-of-the-art while reducing risks to acceptable levels.

By mid-1997, the five-laboratory collaboration had produced a conceptual design for the SNS (ORNL 1997a, see Figure 1.3-1) that was favorably reviewed by a committee of outside experts (DOE/ER-0705, 1997). This site-independent conceptual design is the basis for the proposed action.

1.3.3 Alternatives Analyzed

The two primary alternatives analyzed in this EIS are (1) the alternative to proceed with building an accelerator-based neutron source and (2) the No-Action Alternative.

Under the to-build alternative, the EIS analyzes the environmental impacts associated with constructing and operating the neutron facility. Four individual siting alternatives are analyzed in the EIS. The effects from the No-Action Alternative serve as a basis for comparison of the effects from the other alternatives. In addition, alternatives considered, but eliminated from consideration, are presented for completeness. Other conceivable technical design options for a spallation source have been evaluated; these technology alternatives and the elimination process are discussed at length in Chapter 3.

1.3.4 Siting Alternatives Considered in this EIS

DOE used a systematic process to select suitable alternative sites for the proposed action (refer to Appendix B). The site-selection process began by identifying four major site exclusion criteria. When these criteria were defined, the process continued in two major phases. Phase 1 focused on using the exclusion criteria to identify the reasonable siting locations for the proposed SNS on a national level. Phase 2 focused on identifying a specific alternative site for the proposed SNS at each of these locations.

Specific SNS project requirements were used to develop the site exclusion criteria. These criteria were as follows:

- A site with a minimum area of 110 acres (45 ha) and a rectilinear shape to accommodate the length of the proposed linear accelerator and possible future expansion of the facility.
- A one-mile (1.6 km) buffer zone around the proposed SNS site to restrict uncontrolled public access and to insulate the public from the consequences of a postulated accident at the facility.
- Proximity and availability of an adequate electric power source. The regional power grid must be able to supply 40 MW of power during periods of operation. The site must be within one quarter to one mile (0.4 to 1.6 km) of existing transmission lines to minimize collateral construction impacts and costs.
- Presence of existing neutron science programs and infrastructure to provide a

pool of neutron science expertise and experience to meet mission goals. The site must have major facilities and programs utilizing neutron scattering techniques.

As a result of this process, DOE identified four reasonable alternative locations for the proposed SNS. These facility locations were ORNL, LANL, ANL, and BNL.

In Phase 2 of the site-selection process, each of the four national laboratories conducted its own systematic site-selection process to identify specific locations for the proposed SNS. These processes focused primarily on laboratory lands, and they involved the identification and evaluation of alternative sites at each laboratory. Site-selection criteria included project requirements and environmental protection considerations. These criteria were applied to the alternative locations to identify one specific location for the proposed SNS at each national laboratory.

This EIS assesses the environmental impacts associated with the four siting alternatives that would result from the construction and operation of the proposed SNS.

ORNL Alternative (Preferred Alternative): To construct and operate the proposed SNS at ORNL in Oak Ridge, Tennessee.

LANL Alternative: To construct and operate the proposed SNS at the LANL in Los Alamos, New Mexico.

ANL Alternative: To construct and operate the proposed SNS at the ANL in Argonne, Illinois.

BNL Alternative: To construct and operate the proposed SNS at the Brookhaven National Laboratory in Upton, New York.

1.4 ENVIRONMENTAL ANALYSIS PROCESS

This EIS is being prepared pursuant to NEPA [42 USC 4321 et seq.], the President's Council on Environmental Quality (CEQ) NEPA regulations in 40 CFR 1500-1508, and DOE NEPA regulations in 10 CFR 1021.

This EIS analyzes the potential environmental impacts of two primary alternatives: the proposed action (to construct and operate an accelerator-based neutron source) and the No-Action Alternative. This proposed facility would meet many of the nation's neutron science needs well into the next century. An artist's conception of the completed neutron facility is shown in Figure 1.4-1.

The preliminary scope of this EIS was defined through examination of the National Environmental Policy Act (NEPA) and safety assessment documents for other DOE accelerator facilities. This review indicated that appropriate topics to address in the EIS analysis would include land use, facility waste streams, and accident scenarios that might impact human health or the environment (ORNL 1997b: 9-1 to 9-2). Other issues of public concern, including socioeconomics and waste management issues (see Section 1.5), were documented through the public scoping processes for each of the four alternative sites.

Preparation of this EIS allows a full dialogue between DOE and all interested parties

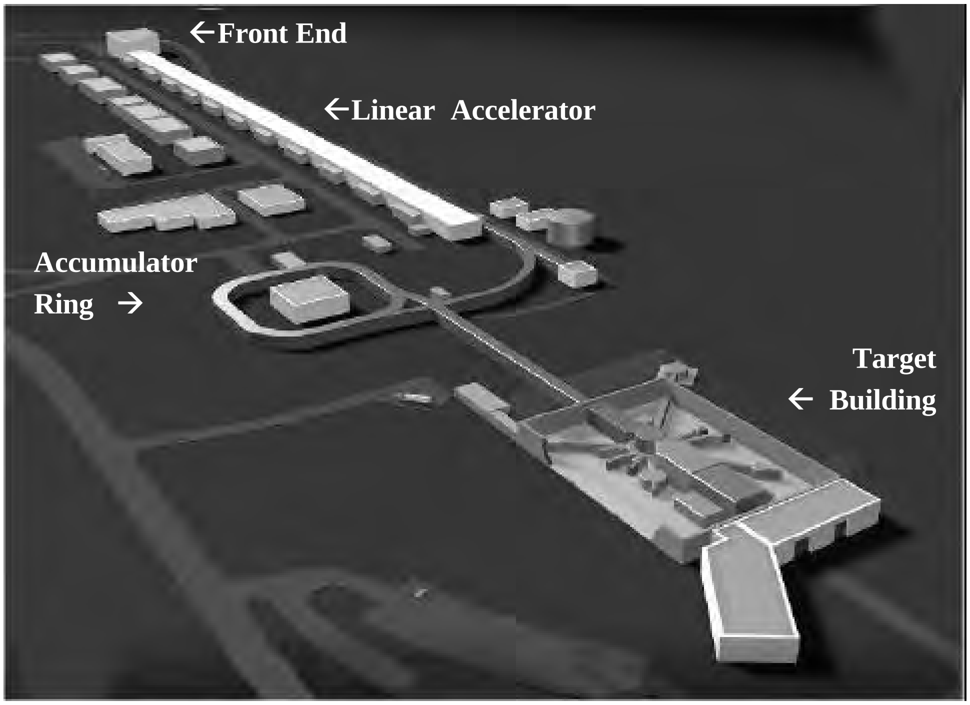


Figure 1.4-1. Artist's conceptual drawing.

regarding the potential environmental consequences of the proposed action and alternatives. Potential interested parties or stakeholders may include the general public; state, county, municipal, and tribal governments; and other federal agencies. The EIS provides the environmental input for decision-making and also the basis for appropriate mitigation measures, if needed, for the course of action selected.

This draft EIS is being distributed to U.S. congressional members and committees; the states of Illinois, New Mexico, New York, and Tennessee; the tribal governments of Cochiti, Jemez, Santa Clara, and San Ildefonso Pueblos; the county governments of Anderson/Roane County (Tennessee), DuPage County (Illinois), Los Alamos/Santa Fe County (New Mexico), and Suffolk County (New York); and the general public for review and comment. DOE invites comments to correct factual errors or to provide insights on matters related to this environmental analysis. In addition to its invitation for written comments, DOE has scheduled public hearings to solicit both oral and written comments on the draft EIS.

After considering the comments received, DOE will revise the draft EIS, as appropriate, and publish a final EIS. The final EIS will be distributed to tribal, state, and local governments; other federal agencies; all parties who commented on the draft EIS; and any interested parties. DOE intends to publish all comments received with a complete response. However, if the number of comments is too voluminous, DOE may publish a comment summary in the final EIS. All comments and responses will be available for public review in DOE reading rooms.

About NEPA

NEPA was enacted to ensure that federal decision-makers consider the effects of proposed actions on the human environment and to open their decision-making process for public scrutiny. NEPA also created the President's Council on Environmental Quality (CEQ) to establish a NEPA review process. DOE's NEPA regulations (10 CFR 1021) augment the CEQ regulations (40 CFR 1500).

An EIS documents a federal agency's analysis of the environmental consequences that might be caused by major federal actions, defined as those proposed actions that might result in a significant impact to the environment. An EIS:

- Explains the purpose and need for the agency to take action.
- Describes the proposed action and the reasonable alternative courses of action that the agency could take to meet the need.
- Describes what would happen if the proposed action were not implemented—the "No-Action" (or Status Quo) Alternative.
- Describes what aspects of the human environment would be affected if the proposed action or any alternative were done.
- Analyzes the changes, or impacts, to the environment that would be expected to take place if the proposed action or an alternative were implemented, compared to the expected condition of the environment if no action were taken.

The DOE EIS process follows these steps:

- Notice of Intent, published in the *Federal Register*, identifies potential EIS issues and alternatives and asks for public comment on the scope of the analysis.
- Public scoping period with at least one public meeting, during which public comments on the scope of the document are collected and considered.
- Draft EIS, issued for public review and comment, with at least one public hearing.
- Final EIS, which incorporates the results of the public comment period on the draft EIS.
- Record of Decision that states:
  - The decision.
  - The alternatives that were considered in the EIS and the environmentally preferable alternative.
  - All decision factors, such as cost and technical considerations, that were considered by the agency along with environmental consequences.
  - Mitigation measures designed to reduce adverse environmental impacts.
  - Mitigation Action Plan, as appropriate, which explains how the mitigation measures will be implemented and monitored.

At least 30 days following the issuance of the final EIS, DOE will issue a Record of Decision (ROD) that will explain all factors, including environmental impacts, that DOE considered in reaching its decision on selecting the alternative to be implemented. The ROD will specify the selected alternative after due consideration of environmental consequences. DOE anticipates that, in addition to environmental impacts, the ROD will be based on cost and infrastructure considerations. Any mitigation measures, monitoring, or other conditions adopted as a part of DOE's decision will be summarized in the ROD, as applicable, and included in a Mitigation Action Plan (MAP) if needed. The MAP will explain how and when mitigation measures would be implemented and how DOE would monitor the mitigation measures over time to ensure their effectiveness. The ROD and MAP, if prepared, will be placed in public reading rooms and will be available to interested parties upon request.

1.5 THE SCOPING PROCESS AND MAJOR ISSUES IDENTIFIED FOR ANALYSIS

DOE published the Notice of Intent to prepare this EIS in the *Federal Register* (62 FR 40062) on July 25, 1997. The public comment period was from July 25 to September 12, 1997. During this period, public meetings were held in Oak Ridge, Tennessee; Argonne, Illinois; Los Alamos, New Mexico; and Upton, New York. A total of 61 individuals representing 15 citizen groups, 14 government organizations, one Native American pueblo, one educational institution, and four elected officials representing themselves and their constituents submitted comments during the public scoping period. Comments received included 152 oral and written comments and 21 endorsements and resolutions. These comments were analyzed and classified according to 21 subject categories.

The subject categories that contained the most substantive comments were socioeconomics, siting alternatives, waste management, and project justification. Nineteen socioeconomics comments were received. The majority of these comments requested analyses of the beneficial effects the proposed action would have in terms of new jobs, personal income, tax revenues, spin-off businesses, need for support from the host state, and other economic factors. Nineteen comments were received on siting alternatives for the proposed action. Most of these comments were in support of or against siting the proposed action at one of the alternative national laboratories, and one recommended consideration of the Hanford site. Others requested more detailed analyses of the criteria used to select alternative sites for the proposed action and analyses of the potential effects that would result from implementing the proposed action on these sites. Fifteen comments on waste management were received. These comments were concerned with waste generation, particularly radioactive waste and hazardous metals, and the proper management of these wastes in compliance with federal and state regulatory requirements. Project justification received 13 comments, most of which were supportive of the proposed action with several opposed to the project. One comment suggested pursuing a cooperative agreement with European countries to use their existing neutron sources.

All of the scoping comments received were summarized in a document entitled *Results of Public Scoping for the Spallation Neutron*

Source/Environmental Impact Statement (DOE-ORO 1997). This document is available to the public in the following reading rooms:

1. U.S. Department of Energy
   Freedom of Information Public
   Reading Room
   Forrestal Building, Room 1E-190
   1000 Independence Avenue, S.W.
   Washington, D.C. 20585
   Telephone: (202) 586-3142

2. U.S. Department of Energy Reading Room
   Oak Ridge Operations Office
   55 Jefferson Circle, Room 113
   Oak Ridge, Tennessee 37831
   Telephone: (423) 241-4780

3. Los Alamos National Laboratory
   Public Outreach and Reading Room
   Los Alamos, New Mexico 87544
   Telephone: (505) 665-2127

4. Argonne National Laboratory
   c/o Documents Department
   University Library, Third Floor Center
   University of Illinois at Chicago
   801 South Morgan Street
   Chicago, Illinois 60607
   Telephone: (312) 996-2738

5. BNL Research Library
   Bldg. 477A Brookhaven Avenue
   Upton, New York 11973
   Telephone: (516) 344-3483

6. Longwood Public Library
   800 Middle Country Road
   Middle Island, New York 11953
   Telephone: (516) 924-6400

7. Mastics-Moriches-Shirley Community
   Library
   301 William Floyd Parkway
   Shirley, New York 11967
   Telephone: (516) 399-1511

DOE considered all comments during preparation of the draft EIS. Individuals and organizations will have an opportunity to review the draft EIS and to provide further comments prior to the preparation of the final EIS.

1.6 ORGANIZATION OF THE EIS

This EIS is organized into two volumes. Volume I contains the Summary and Chapters 1 through 6, which are further outlined below. Volume II contains the appendices that are referenced throughout Volume I.

Chapter 1 – Introduction. Background information on the state of neutron science in the U.S. and its relationship to a next-generation neutron source are discussed. The internal organization of the EIS is presented in this chapter, and the environmental analysis process under NEPA is covered.

Chapter 2 – Purpose and Need for DOE Action. This section includes the reasons DOE proposes to take action at this time.

Chapter 3 – Proposed Action and Alternatives. This chapter describes how DOE proposes to meet the specified needs and alternative ways the specified needs could be met. It includes a summary of expected environmental impacts if the preferred alternative or any of the other analyzed alternatives were to be implemented.

Chapter 4 – Affected Environment. The various aspects of the existing environment (natural, social, and manmade) that might be affected by the preferred alternative or any of the other alternatives are described.

Chapter 5 – Environmental Consequences. The changes or impacts that the alternatives would be expected to have on elements of the affected environment are analyzed. Impacts are compared to the environment that would be expected to exist if no action were taken (the No-Action Alternative).

Chapter 6 – Permits and Consultations. CEQ NEPA regulations require preparation of an EIS in coordination with other applicable environmental requirements that may involve permits and consultations with federal, state, tribal, local, and other agencies. The additional requirements and consultations applicable to the alternatives are described in this chapter.

CHAPTER 2: PURPOSE AND NEED FOR DOE ACTION

The Department of Energy (DOE) is proposing to construct and operate a state-of-the-art neutron source to:

- Satisfy the future needs of U.S. researchers in neutron scattering science for a pulsed-neutron source with much higher intensity, more comprehensive instrumentation, better experimental flexibility, and greater potential for future upgrades than offered by existing U.S. facilities.
- Facilitate new scientific discoveries and develop cutting-edge technologies.
- Augment the capabilities of reactor-based neutron sources.

The U.S. needs a high-flux, short-pulsed neutron source to provide the scientific and industrial research communities with a much more intense source of pulsed neutrons for neutron scattering research than is currently available and to assure the availability of a state-of-the-art facility in the decades ahead. This next- generation neutron source would create new scientific and engineering opportunities as well as help replace the capacity that will be lost by the eventual shutdown of existing sources in the first half of the next century as they reach the end of their useful operating lives.

As explained in the preceding chapter, the neutron science community has long recognized the need for both high intensity pulsed (accelerator-based) and continuous (reactor-based) neutron sources. The two types of sources are complementary. For many scattering techniques, having neutrons available in a series of pulses is preferable to having them in a continuous beam. In addition, spallation sources can generally produce pulsed beams with a much higher peak intensity than those available from comparable sized reactor-based sources. This enables scientists to carry out a number of important flux-limited experiments. In recent years, steady improvements in accelerator technology have made it possible to design and construct sources that can produce even more intense neutron pulses. The proposed SNS, with a proton beam power of 1 MW, would initially produce pulses with a neutron intensity over five times higher than those obtainable from today's best operational spallation source, ISIS in the United Kingdom.

A valuable feature of a pulsed spallation neutron source is the ability to tune the beam of neutrons for particular experiments (the time-of-flight technique). Each pulse of neutrons from the proposed SNS would contain neutrons with a range of energies. The energy level of the neutrons could be determined by noting the length of time it takes for the neutron to travel from the source to the detectors. The high-energy (faster) neutrons would reach the sample ahead of the medium-energy neutrons, and the lowest-energy (slower) neutrons would reach the sample last. Because the neutron energies would be spread out over time, the researcher could tune the neutron beam by selecting the energy level of interest by simply turning the detectors off and on at the appropriate time. Time-of-flight techniques enable the collection of many data points for each pulse of neutrons reaching the sample. Experience has shown that neutron pulses lasting approximately 1 μs (one millionth of a second), each with a pulse occurring from 10 to 60 times per second, are optimal (BESAC 1996).

2.1 NEUTRON RESEARCH AND SOURCES

There are approximately 20 major neutron sources worldwide that produce neutron beams for materials research (refer to Table 1.2-1). Although these facilities are primarily located at large government-owned science laboratories, small research teams based at universities, research institutes, and industrial laboratories typically carry out neutron scattering experiments at these centers. The majority of users require recurrent, short-term access to the facilities, often for no more than a few days at a time. The research carried out at these sources contributes to the scientific and technological infrastructure in their regions and also contributes toward their industrial competitiveness.

Based on the conclusions of the OECD Neutron Science Working Group, which has studied this topic since 1996, there is a growing disparity between the worldwide need for neutron scattering research and the availability of facilities (reactor and spallation sources) to meet these needs. It was estimated that as the oldest sources continue to age, only about one-third of the present sources would remain available by 2010. The next generation neutron sources are then needed not only to create new scientific and engineering opportunities, but also to replace out-dated capacity. In the U.S., the shortfall in neutron scattering resources compared with growing research demand and the lag in experimental capabilities compared with newer and more extensively upgraded foreign facilities have been major concerns for over ten years. As stated most recently in the Kohn and Russell Panel Reports (BESAC 1993, 1996), the present U.S. sources are inadequate to meet the needs of the American scientific community, both in terms of flux and availability. The current generation of neutron sources in the U.S. has lower neutron beam intensities, lower operating powers, and less advanced measuring instruments, when compared to what is currently technologically feasible and desirable.

Given the long lead time from starting conceptual design to the commissioning of a new source (at least 10 years), decisions on new facilities are necessary in the next few years and certainly before 2005. Access to European and Japanese neutron sources by U.S. researchers and manufacturers is difficult, unreliable, and costly. The logistics of scheduling time and configuring instrumentation to conduct specialized experiments are prohibitive because of the commuting distance to these facilities. Because of its proprietary nature, much of the research desired by U.S. industry simply cannot be carried out at foreign facilities.

Scientific discoveries and the new technologies derived from neutron scattering research, as summarized in Chapter 1, have contributed significantly to the development of new products for sale in the international marketplace. Because of the longstanding relationship between basic science and the world of business, scientific and technological advances like these have become major drivers of national economic progress and competitiveness among the industrialized nations of the world. The same type of relationship has developed between basic science and national defense. Since the end of World War II, the U.S. has used scientific discoveries to develop and sustain military capabilities that surpass those of potential international adversaries. These important relationships will continue into the foreseeable future.

Without future investments in major new science facilities, such as the proposed SNS, the nation's economic strength and competitiveness in the world economy, its national defense posture, and the health of its people may be jeopardized as the newest and best related technological developments are made overseas. The construction of a next-generation spallation neutron source in the U.S. would go far in providing a competitive edge for the nation in the physical, chemical, materials, biological, and medical sciences.

2.2 RELATIONSHIP OF THE SNS PROJECT TO OTHER DOE PROJECTS

DOE proposes to build the SNS to satisfy the nation's need for a world-class pulsed neutron scattering research facility. The projects discussed below, while supporting U.S. neutron scattering science in general, are independent actions. These projects are not related to the proposed SNS, and any decisions involving these projects are independent of the determination of whether or not to build the proposed SNS. The projects are summarized in the following sections.

2.2.1 DESIGN AND CONSTRUCTION OF THE ADVANCED NEUTRON SOURCE

Work on an advanced steady-state neutron source was initiated by ORNL in 1987, and by 1992, a conceptual design was completed for a 330-MW reactor-based Advanced Neutron Source (ANS). Congress did not appropriate construction funding in FY 1994 or FY 1995 for ANS, and DOE chose to cancel the project shortly thereafter, principally due to concerns over the high cost of the facility (approximately $3 billion). This occurred after public scoping for an Environmental Impact Statement (EIS); however, the EIS was not completed (DOE 1993a; ORNL 1997a).

2.2.2 THE HIGH-FLUX BEAM REACTOR TRANSITION PROJECT

Upgrade of the High-Flux Beam Reactor (HFBR) at Brookhaven National Laboratory (BNL) was recommended by the 1996 BESAC report on neutron facility upgrades.

Shortly afterward (late 1996), HFBR was shut down for a normal refueling, but before the reactor's planned restart, its spent fuel storage pool was identified as the likely source of elevated tritium concentrations in the groundwater at BNL. The reactor has remained shut down in a defueled condition, and DOE has initiated a Tritium Remediation Project that will continue to prevent the tritium plume from spreading off-site.

DOE has published a Notice of Intent to prepare an EIS concerning the HFBR. The alternatives being considered in the HFBR EIS include the following:

- No Action Alternative (maintain present shutdown, defueled condition)
- Resume Operation Alternative
- Resume Operation and Enhance Facility Alternative
- Permanent Shutdown Alternative

2.2.3 UPGRADE THE HIGH-FLUX ISOTOPE REACTOR

The 1996 BESAC recommended extensive upgrades to the High-Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL). These upgrades include development of an internationally competitive cold neutron scattering facility; establishment of premier thermal neutron capabilities; and improvement of isotope production, materials irradiation facilities, and neutron activation analysis capabilities (DOE 1996b).

DOE determined that the HFIR upgrades are categorically excluded from environmental review under NEPA, and these upgrades are being implemented. These upgrades include modifications of test facilities to perform research, development, and experimental testing using the existing beam lines and added cold neutron source capabilities.

2.2.4 INSTITUTE FOR NEUTRON SCIENCE

ORNL and The University of Tennessee (UT) are collaborating on establishing the Joint Institute for Neutron Science (JINS). This proposed facility is being funded by the state of Tennessee and would provide overnight accommodations, as well as meeting rooms and lecture halls, for scientists visiting the neutron science facilities at ORNL. The JINS is not part of the proposed action in this EIS; it will be built regardless of which alternative action is taken for the proposed SNS. This facility is currently being designed by the Division of Facilities Planning at UT. Construction is expected to begin in the summer of 1999 with occupancy in the summer of 2000. The JINS is to be constructed on the Oak Ridge Reservation (ORR), at a location across from the ORNL 7000 area on Bethel Valley Road. DOE will lease the land for JINS to UT; therefore, DOE will complete the appropriate National Environmental Policy Act (NEPA) documentation prior to commitment of the land to this facility.

CHAPTER 3: PROPOSED ACTION AND ALTERNATIVES

The regulations of the Council on Environmental Quality (CEQ) (40 CFR Parts 1500-1508) direct federal agencies to identify and assess, in the environmental impact statement (EIS), reasonable alternatives to the proposed action that meet the purpose and need for action and could have effects on the quality of the human environment. Additionally, CEQ regulations require a presentation in a comparative format of the potential effects each alternative may have on the quality of the human environment.

This chapter describes the proposed action, the siting alternatives for implementation of the proposed action, and the No-Action Alternative. It also describes the technological and siting alternatives that were previously considered and eliminated from detailed analysis in this EIS, along with the reasoning for their elimination. The description of the proposed action and alternatives, coupled with the description of the affected environment (Chapter 4), enables the analysis of the potential environmental consequences of construction and operation of the proposed Spallation Neutron Source (SNS) (Chapter 5 and summarized in Section 3.5).

3.1 OVERVIEW

The proposed action is to design, construct, and operate a state-of-the-art neutron science facility based on a linear accelerator (linac) coupled with proton accumulator rings and a mercury spallation target. This facility, referred to as the proposed SNS, would satisfy the purpose and need for actions by the Department of Energy (DOE). The SNS would initially have an operating power of 1 MW. Additional structures and components are planned that could allow future increases in operating power to 4 MW and additional research capabilities.

This chapter of the proposed SNS EIS provides a statement of the proposed action and gives a description of the activities that would be undertaken to implement it in Section 3.2. The description of the proposed action is divided into four major sections. Section 3.2.1 identifies the facility components of the proposed SNS at 1 MW and at 4 MW. Section 3.2.2 describes the activities that would be required to construct the proposed SNS. The description entails initial construction and future upgrades that could be proposed for the facility. Section 3.2.3 characterizes operational activities in terms of resource requirements, emissions, discharges, and waste generation that would be involved in operating the proposed SNS over its planned 40-year life span.

Because the facility is being designed to allow future upgrades, discussions evaluating the proposed SNS activities and potential effects include the proposed 1-MW facility and the potential 4-MW-upgraded facility as the upper bounding condition. Furthermore, the discussion emphasizes specific activities with environmental protection implications and includes any known pollution source terms that would be associated with them.

A screening process was used to identify and evaluate potential siting alternatives for the proposed SNS. Initially, a pool of 39 DOE sites were examined as potential host sites for the proposed SNS (refer to Appendix B). Using specific evaluation criteria, all but four sites were eliminated from detailed analysis in the EIS (refer to Appendix B). The remaining four alternative DOE sites, Oak Ridge National Laboratory (ORNL), Los Alamos National Laboratory (LANL), Argonne National Laboratory (ANL), and Brookhaven National Laboratory (BNL), each contain a selected onsite location that is identified in Sections 3.2.5.2 through 3.2.5.5 and described in detail in Chapter 4. The screening process used to select these four DOE sites from the original 39 alternatives is described in Section 3.2.4. Because each of the selected sites has unique characteristics (especially with regard to road access, availability of utilities, and existing waste management systems), implementation of the construction and operational portions of the proposed action would be somewhat different at each site. The unique site characteristics and the various activities required to deal with these differences are accounted for in this EIS. (Refer to Appendix B for the site selection reports.)

Under the No-Action Alternative, DOE would not build the proposed SNS. Impacts associated with this option are discussed in Section 3.3 and used for comparison to the action alternatives throughout this EIS.

A number of technological alternatives to the proposed action were identified and screened prior to initiation of the proposed SNS EIS process. As a result of these evaluations, none were deemed to be viable technological alternatives to the proposed action, and all were eliminated from detailed analysis in the EIS. These alternatives and the reasoning behind their elimination are discussed in Section 3.4.

The discussion of the proposed action and alternatives concludes in Section 3.5 with a comparison of the potential environmental impacts associated with constructing and operating the proposed SNS at each of the four alternative DOE sites.

3.2 THE PROPOSED ACTION

The proposed action is to construct and operate a state-of-the-art neutron science facility to help satisfy the nation’s future needs for neutron scattering research. The key attributes of such a facility are the ability to provide (1) an array of neutron beams with varied, discrete energy levels that can be adapted to the particular experiment to be conducted and (2) the highest possible neutron flux onto the research samples. Therefore, it is proposed to construct a new spallation neutron source based on a non-superconducting, linear accelerator with 1-MW beam power coupled with proton accumulator rings and a mercury target. Sufficient design flexibility would be incorporated into the project to allow significant facility modification at some time in the future to increase the power of the proton beam to 4 MW. The proposed SNS would produce short pulses of neutrons through the spallation process. A description of the proposed action is divided into the following three subsections:

- 3.2.1 Facility Description
- 3.2.2 Construction
- 3.2.3 Operations

Descriptions in these sections reflect the current details of planning and engineering at the conceptual design stage of the project. Because detailed site engineering studies have not been performed, this discussion is generic in nature;

the facility described here could be constructed at any of the four alternative sites. Details that would be site-specific are presented in Section 3.2.4. This descriptive information is condensed from the information included in the *National Spallation Neutron Source Conceptual Design Report/ Volumes 1 and 2* (ORNL 1997a and 1997b). For a more in-depth technical discussion, the reader is directed to that document, which is available in the DOE reading rooms listed in Chapter 1.

The Production of Neutrons for Research: "Spallation"

The production of neutrons by the spallation process would begin with the acceleration of high-energy particles within a linac (linear accelerator). The linac would accelerate charged particles, in this case hydrogen atoms, with an extra electron (H^- ions). Electrons would be stripped from the H^- ions during injection of the particle into an accumulator ring, leaving protons. Protons would be added to the ring until a sufficient number have been accumulated. The protons would then be directed to a target of liquid mercury. High-energy protons would impact mercury molecules in the target, which, in turn, would eject neutrons to dissipate the proton-impact energy. These high-energy neutrons would travel through a substance that decreases or moderates their energy. The neutrons would then be directed through beam tubes to experiment stations.

The number of neutrons produced in the spallation process would depend on the number and energy of the protons bombarding the target. The number of neutrons available per unit of time for experimental use would depend on the target/moderator system efficiency. The total number of neutrons generated for scattering experiments would depend upon the repetition rate of the proton pulse.

3.2.1 FACILITY DESCRIPTION

This summary includes a brief physical description of each of the four main components of the proposed SNS and an explanation of their functions. These basic components for the proposed 1 MW facility include a proton ion source (the front end), the linac, the beam transport and ring system, and the target building that houses the target (Figure 3.2.1-1). This summary description of the proposed SNS facility concludes with a discussion of future upgrade options (Section 3.2.1.5) that would enable the proposed SNS to operate at 4 MW.

3.2.1.1 Front End

The Front End is the part of the proposed SNS accelerator that initially produces the charged hydrogen ions and injects them into the linac. It comprises several components: the ion source, the low-energy beam transport (LEBT), the radio frequency quadrupole (RFQ) accelerator, and the medium-energy beam transport (MEBT). The Front End would be approximately 32.81 ft (10 m) in length. Figure 3.2.1.1-1 presents a schematic diagram of the Front End and linac systems, showing ion source, RFQ accelerator, drift-tube linac (DTL), coupled-cavity drift-tube linac (CCDTL), and coupled-cavity linac (CCL) structures of the proposed SNS.

3.2.1.1.1 Low-Energy Beam Transport

The charged particles produced by the ion source are made to move as a beam, much like a beam of light produced by a laser. The particle beam would leave the ion source and immediately enter the LEBT section of the Front End. During passage through the LEBT, the particles would be grouped into bundles, focused, and accelerated to 65 keV. The LEBT would contain two electromagnetic lenses to focus the beam of particles before it enters the next component of the Front End, the RFQ accelerator.

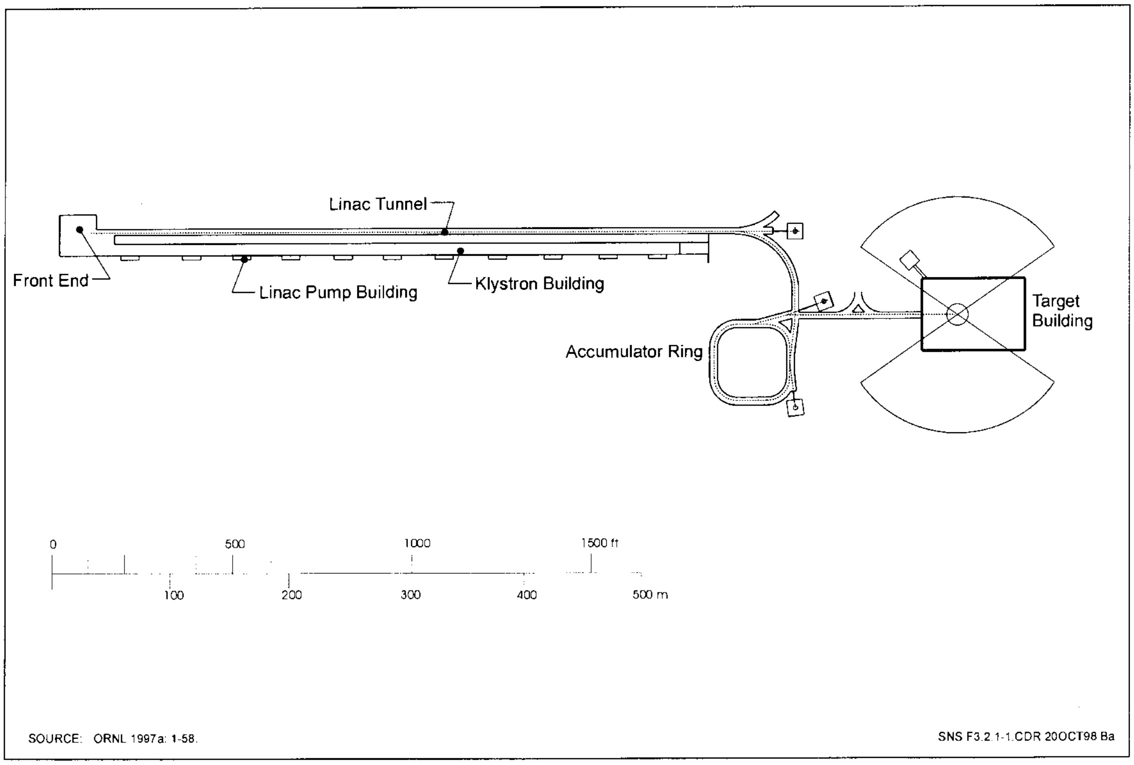


Figure 3.2.1-1. Footprint of the proposed SNS accelerator components.

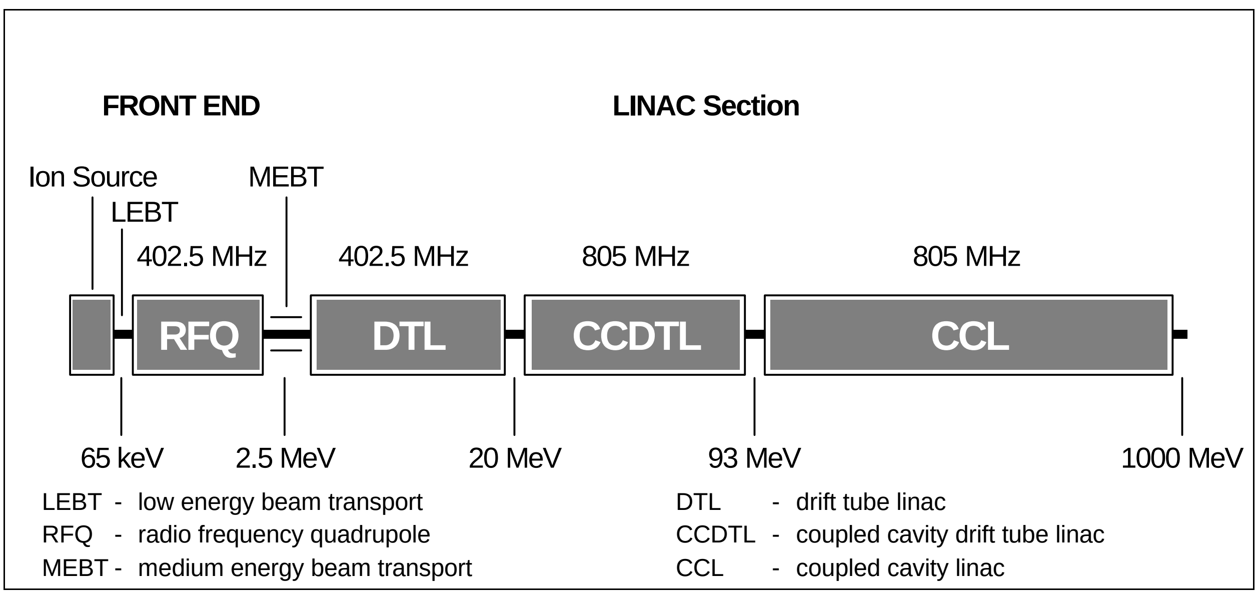


Figure 3.2.1.1-1. Schematic layout of the LEBT Front End and linac section.

3.2.1.1.2 Radio-Frequency Quadrupole Accelerator

The RFQ takes the beam and converts it into a continuous controlled stream consisting of many bunches of particles. The RFQ is named for the symmetrical arrangement of four triangle-shaped vanes that form a small hole through which the beam would pass. These vanes assist in converting the ion stream into packets, or bunches of particles, and controlling the beam within the RFQ. During operation of the RFQ, an oscillating voltage from a 402-MHz klystron would be applied that would accelerate the particles. During this acceleration process, the RFQ would increase the energy of the particle beam from 65 keV to a medium energy of 2.5 MeV. The particles leaving the RFQ would enter the MEBT.

3.2.1.1.3 Medium-Energy Beam Transport

The MEBT would allow the particles from the RFQ to enter the next stage of energy increase or acceleration. The MEBT would finish forming the beam and would also transport the fully organized medium-energy particle beam to the linac to further increase the energy of the particles. The beam would be focused and grouped together with gaps between successive bunches. The particles leaving the MEBT would proceed to the next stage of acceleration in the linear accelerator proper.

> *Klystron*: a specialized electron tube designed to amplify microwave signals or radio waves. There would be a total of 58 klystrons contained in the gallery of the proposed SNS. The klystrons provide the radio frequency (rf) power at the appropriate frequency to accelerate the particles in the linac.

3.2.1.2 Linear Accelerator System

The 1,614-ft (492-m) long linac accepts the beam that has been accelerated by the Front End and accelerates the beam further from 2.5 MeV to 1.0 GeV. The major components of the linac system are the drift-tube linac (DTL), which accelerates the beam from 2.5 MeV to 20 MeV; a coupled-cavity drift-tube linac (CCDTL), which further accelerates the beam to around 95 MeV; and a coupled-cavity linac (CCL), which accelerates the beam to 1.0 GeV. All of the alternative sites would be able to accommodate the linac footprint. The functions of each of the linac components are summarized below.

3.2.1.2.1 Drift-Tube Linac

The DTL is a well-understood structure and has been the workhorse in low-energy accelerators for years. The drift tubes are copper cylinders with a small hole through which the particle beam passes. As the beam passes through the tubes, the particles are subjected to an electric field of rapidly oscillating (402.5-MHz) microwaves. The electric field attracts or repels the particles, depending upon the polarity of the field. The oscillation of the electric field and the length of the drift tubes are such that the particles would be subjected to an accelerating force when they emerge from the end of each tube. The particles enter the next tube before the electric field changes polarity, thus avoiding a deceleration of the particle. The increasing lengths of the drift tubes are calibrated to match the accelerating polarity of the oscillating field, thus providing continued acceleration of the particles throughout the length of the DTL. The drift tubes also contain magnets to ensure the particle beam remains focused (i.e., always accelerating through the center of the drift tubes).

The DTL for the proposed SNS would consist of two sets of drift tubes each housed in a cylindrical tank. The first tank would contain 46 tubes and the second tank would hold 36 drift tubes. The total length of the DTL would be approximately 28.3 ft (8.7 m). The particles would have an energy of 20 MeV as they exit the DTL and enter the CCDTL.

3.2.1.2.2 Coupled-Cavity Drift Tube Linac

The CCDTL would produce the next stage of energy increase or acceleration of the particles. The CCDTL structure would be optimized to accelerate the beam from 20 MeV to 93 MeV. The CCDTL would be a hybrid structure consisting of a coupled-cavity design into which a drift tube has been added in each cavity to allow for the longer transit time through the cavity. Approximately 40 sections, each consisting of several cavities, would be placed end to end to form a single unit, each with an approximate length of 4.9 ft (1.5 m). Focusing magnets and instruments for analyzing the beam would be installed between these units of the CCDTL. The energy required to accelerate the particles would be 805 MHz rf energy from the klystrons. The total length of the CCDTL structure would be 193 ft (60 m). This portion of the linac would accelerate the particles to an energy of 93 MeV. Particles leaving the CCDTL would enter the CCL.

3.2.1.2.3 Coupled-Cavity Linac

The CCL would consist of a series of specially shaped cavities. As the particles travel through the accelerator, gaining speed, the cavities would become longer. The accelerator segments would form the basic building blocks for the accelerator. The modules would be mounted on support structures that would allow them to be aligned. Each module would be connected to a vacuum manifold and a cooling-water system. Magnets for focusing the beam would be located in the drift spaces between segments. Each module would be designed to use the total power output of a single klystron, the cavities being energized by microwaves delivered from the klystrons by waveguides. Upon leaving the CCL, the particle beam would have an energy of 1.0 GeV and would enter the beam transport and ring system.

3.2.1.3 Beam Transport and Ring System

This part of the accelerator system would function to receive the particle beam from the linac, store it in an accumulator ring, and transport the beam to the target. The beam transport and ring system would contain three major components: the high-energy beam transport (HEBT), the accumulator ring, and the ring-to-target beam transport (RTBT). As described below, these systems are designed to collect large numbers of protons (H^+) and deliver them onto the target in a series of short pulses.

The HEBT would carry the fully accelerated beam from the linac to the accumulator ring. The HEBT would contain equipment for beam diagnostics, which would facilitate maintaining the focus of the beam. The configuration of the HEBT would allow the beam to enter the accumulator ring with a minimum of beam loss.

The accumulator ring would receive the beam of H^- ions from the HEBT. This beam would pass through a thin carbon foil that strips the electrons off the particles, converting them to protons (H^+). Magnets in the ring would be used to guide the protons into a beam circulating around the ring. Over 1,200 proton pulses could be accumulated in the ring prior to transfer to the target. The design circumference of the ring would be 722 ft (220 m). The beam would circulate in a clockwise direction. The energy and focus of the beam would be maintained by magnets, rf energy, and instrumentation. Once a full charge from the linac has been accumulated in the ring, the kicker system would be turned on to direct the beam to the target. The kicker would consist of a series of electromagnets that bend the beam, directing it to the RTBT. The RTBT would take the beam from the accumulator ring to the target located inside the target building.

3.2.1.4 Target and Experiment Building

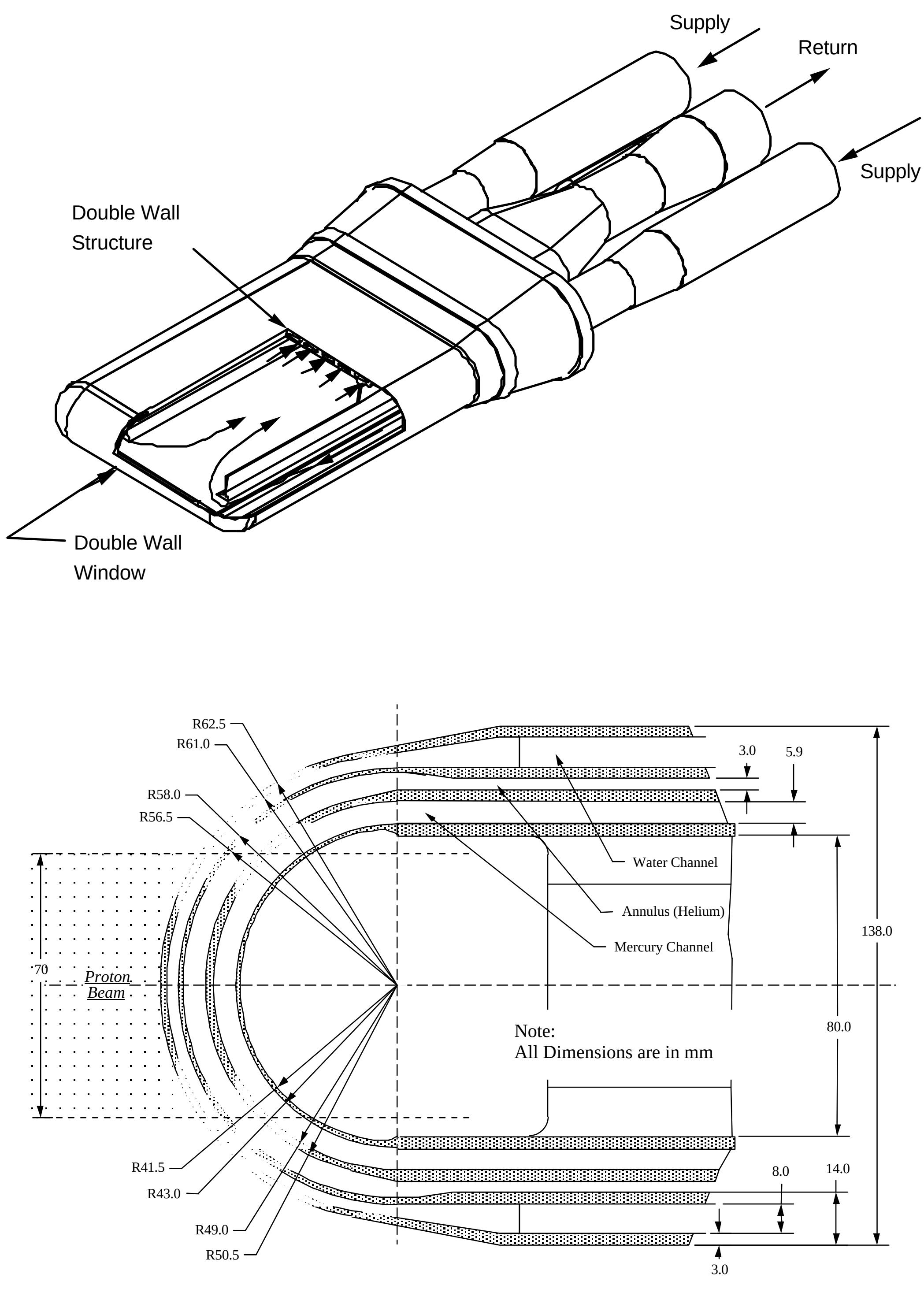
The target and experiment stations would be located inside the target building. This section describes the target, moderator system, shutter system, neutron beam guides, beam stops, and experiment stations.

3.2.1.4.1 Target

The high-energy protons from the accumulator ring would be directed through the RTBT to the target. Upon hitting the target, the protons would cause neutrons within the nuclei of the target material to be ejected as the heavy metal molecules release excess impact energy. Heavy metals provide the most effective source of neutrons for the spallation process because of the high neutron-to-proton ratios. Target materials used at existing spallation neutron sources include uranium, tungsten, and tantalum. However, at proton beam powers above 1 MW, problems from thermal shock would arise while cooling a target made of solid materials. As a result, these solid targets would have a short life span and would require frequent replacement, thereby greatly increasing the amount of radioactive waste generated by the facility. The proposed SNS would use liquid mercury as the target material. The mercury target would have the following advantages over a solid target:

- Mercury, being a liquid, is not as susceptible to thermal shock stresses. Therefore, mercury target material would last for the entire 40-year life span of the proposed SNS.
- The mercury in the target would not be consumed or need to be replaced during the life of the facility. Therefore, much less radioactive waste would be generated than would result from a series of solid targets.
- A liquid target has higher yields of neutron production at higher powers.
- Mercury would be circulated in and through a stainless steel target vessel, thus increasing the thermal mass of the mercury target and facilitating the cooling process. Cooling water would be circulated through the target structure and a heat exchanger to remove heat. This cooling water is isolated from the mercury within the target vessel.

Approximately 35.3 ft³ (1 m³) of mercury would be needed for the proposed SNS target and would be contained in the target vessel and associated heat exchangers. Several layers of containment would be designed into the target assembly. At the point of beam impact, the mercury would circulate inside a rectangular, double-walled chamber (Figure 3.2.1.4.1-1) with cooling water in the outer annulus space and helium in the inner space. The helium chamber would isolate the mercury from the water and provide a leak detection mechanism in the event of partial vessel failure. If the target vessel components begin to fail, the helium layer would help isolate the mercury from the water. If the entire assembly should fail, the mercury and water would be contained in a 71-ft³ (2-m³) shielded vessel below the target assembly. (See



Source: ORNL NSNS/CDR-2/V1: 1997a 5-18 5-19.

Figure 3.2.1.4.1-1. Mercury target vessel.

Appendix A for a description of postulated accidents at the proposed SNS.)

The target assembly would be constructed on a mobile cart system housed in a heavily shielded structure. The target cart would be designed to support all of the mercury- and water-circulating equipment and would provide a means of transporting the target to the hot cell area for maintenance. The target hot cell, located behind the target assembly's normal operating position, would be shielded and equipped to allow for remote handling of the target during maintenance.

Two collection and storage tanks would be located below the floor of the target hot cell. Both tanks would be shielded and self-cooled. One of these tanks, the spill tank, would have open, gravity-feed connections to the target vessel, target hot cell floor, and mercury processing equipment. This tank would contain the mercury and water in the event of equipment failure or spill. The other tank, the mercury storage tank, would be used to temporarily store the mercury during maintenance operations.

Maintenance operations would include replacement of the target window. The proton beam travels through this window to impinge on the mercury. Although the window is made of stainless steel, the proton beam would deteriorate this window over time, requiring replacement. Other maintenance activities would include servicing the pumps that circulate the mercury, replacing vacuum seals, and performing routine inspections. During maintenance activities, the mercury would be drained into the shielded mercury storage tank. The mercury would not be removed from the target hot cell.

3.2.1.4.2 Moderator Systems

Neutrons emitted directly from the target assembly would be traveling too fast to be useful in neutron scattering experiments. Moderators would be designed to slow the neutrons in order to optimize their interactions with the materials being studied. Neutrons are slowed in a moderator by transferring part of their energy to the moderator through their successive collisions with moderator molecules. The energy gained by the moderator material is in the form of heat that is transferred to a cooling system.

The proposed SNS would have two types of moderators. Ambient-temperature water moderators would use deionized water maintained at a temperature below 86° F (30°C). Cryogenic moderators would use liquid hydrogen to maintain a temperature between 16 and 25 °K (-430.6 and -414.4 °F; -257 and -248°C). The hydrogen would be contained in a continuous, inert blanket of helium. This safety measure would provide insulation of the hydrogen from atmospheric air and prevent air from entering the moderator systems.

3.2.1.4.3 Shutter System

Shielding shutters would be installed on each of the neutron beam lines. The shutters would be used to interrupt the neutron beam to allow samples to be removed or inserted into individual experimental chambers while the overall spallation source is operational. The shutters would be massive structures made of tungsten. The shutters would provide 6.6 ft (2 m) of shielding and would be approximately 13.1 ft (4 m) in height. Each would weigh approximately 16 tons and would be moved by an electric-motor-powered screw drive. When open, the shutters would permit the flow of neutrons through the beam guides to the experiment stations.

3.2.1.4.4 Neutron Beam Guides

The neutrons would be guided to the experiment stations through beam guides. These guides would be shielded tubes that conduct the moderated neutrons beyond the bulk shielding of the target assembly to the experiment stations containing neutron detection instrumentation. A target system building would have a maximum of 18 beam guides, 9 from each moderator set (thermal and cold).

3.2.1.4.5 Beam Stops

Beam stops are engineered structures designed to receive the beam whenever circumstances require the beam to be diverted from the target station or the accumulator ring. These large masses of steel and concrete would absorb the beam energy and would shield the staff and the environment from any residual radiation. Beam stops would be constructed at strategic locations along the beam path where they would be available for use in emergency situations (such as downstream equipment failure) or as a beam tuning tool for upstream system testing.

3.2.1.4.6 Target and Experiment Building

The proposed SNS initially would have one target providing 60 pulses of neutrons every second. A second target that would provide 10 to 20 pulses of neutrons every second is a potential future upgrade (Section 3.2.1.5). Each of these targets would be contained in a separate target building, providing the planned total of 36 neutron beams. Each target building would contain an experiment hall and experiment support buildings. All the instrumentation for conducting neutron scattering experiments would be constructed in the experiment support buildings. Most of the neutron detection instruments would fit entirely within the associated experiment halls. However, a few long-flight-path instruments would be on neutron beam lines that extend through the walls of the experiment halls (refer to Figure 1.3-1).

3.2.1.5 Future Upgrade Options

A recommendation in the Basic Energy Sciences Advisory Committee (BESAC) reports has been to build into the original design a clear upgrade capability to higher-power operation. This has played a key role in selection of technology, as well as in the layout and configuration of the baseline 1-MW design. The decision of whether or not to upgrade the facility would be made after the 1-MW facility is operational. In anticipation of the decision to upgrade the SNS, the facility would be constructed in stages. Only one of the target stations (60 Hz) would be included in the first construction stage. The baseline project includes only the first 10 neutron beam lines, instrumentation, and support equipment. They would be installed and ready for commissioning at the time the source becomes operable. A scientific program could begin within a few months after startup.

It is expected that additional instruments would be installed at the rate of one or two per year to fill the first target building. Thus, all the available neutron scattering beams on the first target station would be expected to be occupied by operational instruments within approximately five years after the source begins operating. At that time in the future when the second target station is proposed, several of the existing neutron scattering instruments would be moved from the first target station to the second, where they could operate even more effectively. The fully upgraded SNS facility would have 4 MW of beam power available for two target stations, one optimized for operation at approximately 60 Hz and the other at approximately 10 Hz. Achieving 4 MW would require building a second front end system and a second accumulator ring. Each set would then be capable of delivering beams suitable for 2-MW operation. Figure 3.2.1.5-1 shows a site plan for the proposed SNS as it would look when fully upgraded at a future time.

3.2.1.5.1 Second Target Station

A high priority for the user community would be the addition of a second target station to increase experimental flexibility and to accommodate additional instruments. Target station optimization is influenced by the pulse repetition rate required for a specific research experiment.

The first target station would be optimized for a repetition rate of approximately 60 Hz. The second target station would allow an instrument group to be optimized at a lower beam repetition rate in the range of 10 to 20 Hz. No technical challenges have been identified that must be resolved before adding the second target building. Plans for upgrading the facility would be designed such that no interruption in user programs would last for more than six months.

The second target building would be built adjacent to the first target building (refer to Figure 3.2.1.5-1). For cost savings, structural design in the first hall could be duplicated. A crossover beam line would be built, and a switching magnet would be added to the first RTBT to send pulses to the second station.

3.2.1.5.2 Upgrade from 1 MW to 2 MW

An inherent feature of the baseline 1-MW design would be the relative ease in reaching the 2-MW level of performance. In general, this upgrade would consist of increasing the output of the ion source and upgrading the power systems of the linac. The overall footprint of the facility [the 110 acres (45 ha) encompassing the buildings and associated support facilities] would not change. Table 3.2.1.5.2-1 summarizes what would be involved in this upgrade.

The specifications for beam loss for the proposed SNS would be very strict to avoid excessive activation of components. Maintenance of the strict beam-loss specifications at the higher current level would be a challenge, but incrementally increasing the beam current and resolving beam loss problems as they occur would result in an overall increase in performance.

3.2.1.5.3 Upgrade from 2 MW to 4 MW

The second stage of power upgrade would require more significant expansion of accelerator capabilities. The requirements are summarized in Table 3.2.1.5.3-1.

The upgrade would consist of constructing a second front end and a second accumulator ring. The second front end would be housed in the same building as the first front end. The second accumulator ring would be constructed on the other side of the linac, mirroring the first ring (refer to Figure 3.2.1.5-1). The rings would be connected to the two target buildings with RTBTs that would allow the operators to direct the beam from either ring to either target. To reach maximum beam power, the particles in both rings would be directed to one target.

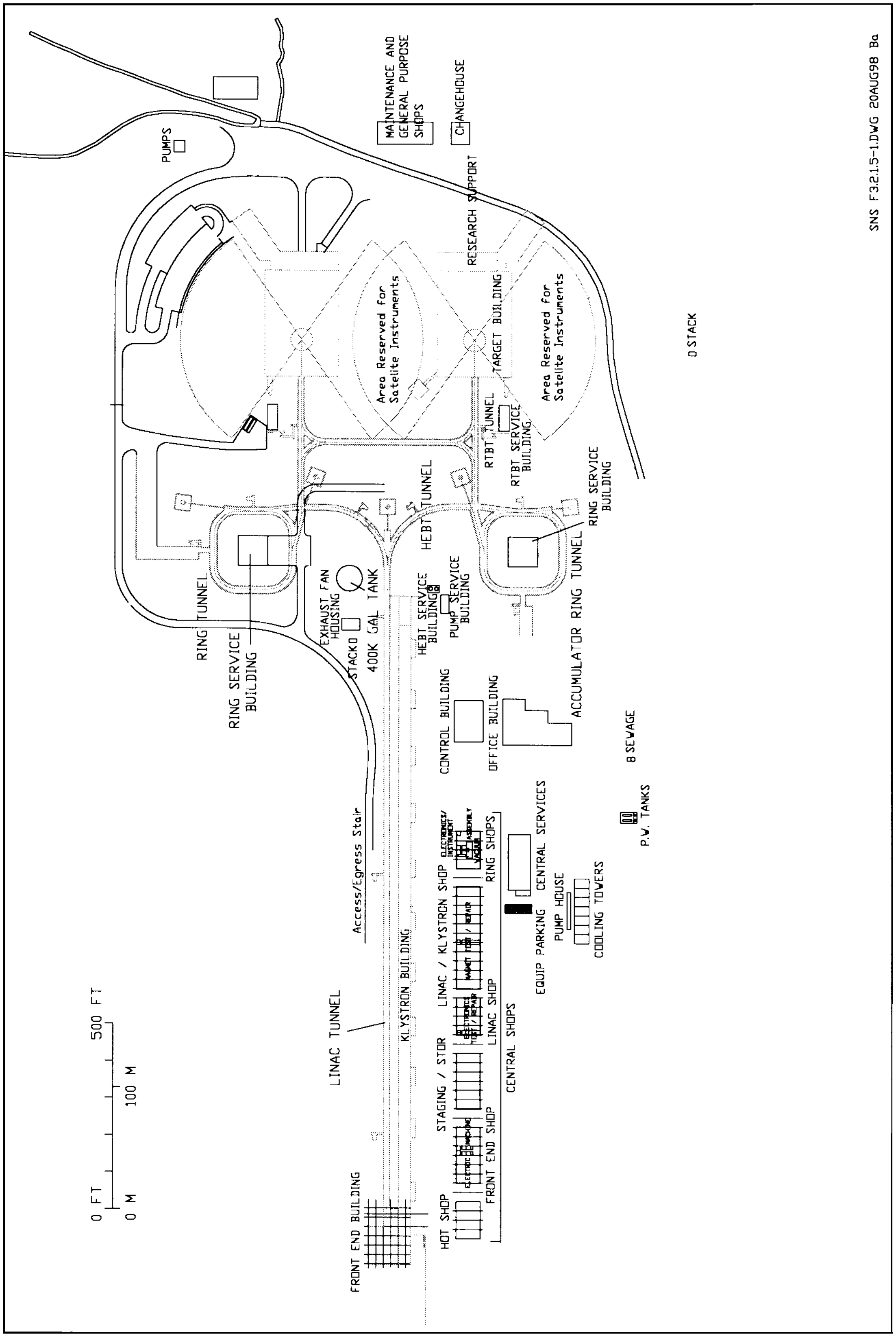


Figure 3.2.1.5-1. Site plan for fully upgraded facility.

Table 3.2.1.5.2-1. Requirements for upgrade to 2-MW beam power on target.

Proposed SNS Component	Requirements
Ion source	The current of the ion source (front end) would be doubled to 70 mA. The ion source would have to be engineered to dissipate the increase in thermal loading at 70 mA, as compared to 35 mA.
LEBT and RFQ	No changes. Designed to handle the increased beam power.
Linac	All of the components installed for 1-MW operations would be designed to deliver a beam power of 2-MW on target. Some of the linac power and support systems would be upgraded.
MEBT, HEBT, accumulator ring, and RTBT	No changes. Components installed for 1-MW operations would be designed to produce a beam power of 2 MW on target.
Beam chopper	May require enhancement in performance, particularly to ensure that specifications of the chopper gap are met.
Klystrons	Additional 12 klystrons required. The rf waveguides, feeds, and coupling between the CCDTL and CCL modules would be redistributed.
Target	An increase in beam power on target would require an improved target design and an upgrade of the target cooling system. Technical improvements indicated by lower-power operations would be incorporated.
Balance of proposed SNS facilities	Power distribution and cooling system capacities would be upgraded. The initial design would include sufficient space for these upgrades.

Table 3.2.1.5.3-1. Requirements for upgrade to 4-MW beam power on target.

Proposed SNS Component	Requirements
Ion Source, LEBT, RFQ, and MEBT	Duplicate all components by constructing a second front end capable of 70 mA. A funnel would be needed to combine the two front end beams into one beam for the linac injection.
Linac	Add 14 additional klystrons. The rf waveguides, feeds, and coupling between the CCDTL and CCL modules would be redistributed.
HEBT	Construct a second HEBT from the linac to the second accumulator ring.
Accumulator ring	Construct a second accumulator ring capable of handling a 2-MW beam. Crossover beam transports would also be constructed.
RTBT	Construct an additional RTBT to connect the new accumulator ring to the targets.
Beam Chopper	May require enhancement in performance, particularly to ensure that specifications of the chopper gap would be met.
Target	No changes. The mercury target would be designed to handle 4 MW of beam power. The capacity of the target cooling system would be increased.
Balance of proposed SNS Facilities	Power distribution and cooling system capacities would be upgraded. The initial design would include sufficient space for these upgrades.

3.2.2 CONSTRUCTION

This section of the EIS provides a description of the activities that may be required to construct the proposed SNS, with specific activities depending on individual site requirements. In addition to outlining site preparation and construction of various facilities and systems, it includes the projected size of the construction workforce, worker safety during construction, construction traffic levels, and generation of waste through construction activities. Figure 3.2.2-1 outlines the proposed project schedule by phases of construction and operation.

3.2.2.1 Workforce

During the first year of construction (FY 2000), only 35 out of the 166 full-time design and construction employees on the proposed SNS project nationwide would be dedicated to construction (refer to Figure 3.2.2-1). In the third year (currently scheduled for FY 2002), full-time project employees would peak at 578, of which 480 would be dedicated to construction. Prior to construction completion in the fifth year (currently scheduled for FY 2004), the full-time project employees would decrease to 313, including 110 construction workers (Brown 1998a).

3.2.2.2 Traffic

Most of the vehicular traffic related to construction of the proposed SNS would be created by construction managers and workers, suppliers of construction materials, and service providers. Table 3.2.2.2-1 summarizes the type and number of vehicles for each category. A significantly smaller amount of traffic would consist of intermittent site inspection visits by personnel from DOE, the host laboratory contractor, design laboratories/contractors, and others with an interest in the conduct of operations at the construction site. This traffic would consist of vehicular movement confined to construction areas and vehicular movement between the proposed SNS construction areas and points outside of these areas.

Traffic between points inside construction areas would be a direct function of specific construction demands. This traffic would consist almost entirely of frequent, short distance trips by earthmoving equipment such as bulldozers, backhoes, heavy trucks, and light trucks.

The heaviest daily traffic would consist of round-trip vehicular movement between the proposed SNS construction areas and outside points. This traffic would consist of commuting by construction managers and workers, movement of heavy trucks between construction areas and offsite facilities (such as borrow areas), visits by supply trucks and service providers, and intermittent business-related visits. Table 3.2.2.2-2 presents a conservative estimate of the number of truck trips to the site during construction. These materials correlate with the construction activities described in Section 3.2.2. Traffic would begin at relatively low levels with the onset of physical construction activities in the second year (FY 2000) and would increase to its maximum in the third (FY 2001) and fourth (FY 2002) years, the peak construction years for the proposed SNS. During this time, worker commutes would constitute a maximum of about 466 daily round trips to the proposed SNS construction areas; material transport would add 7 daily round trips and service providers would add an additional 3 daily round trips.

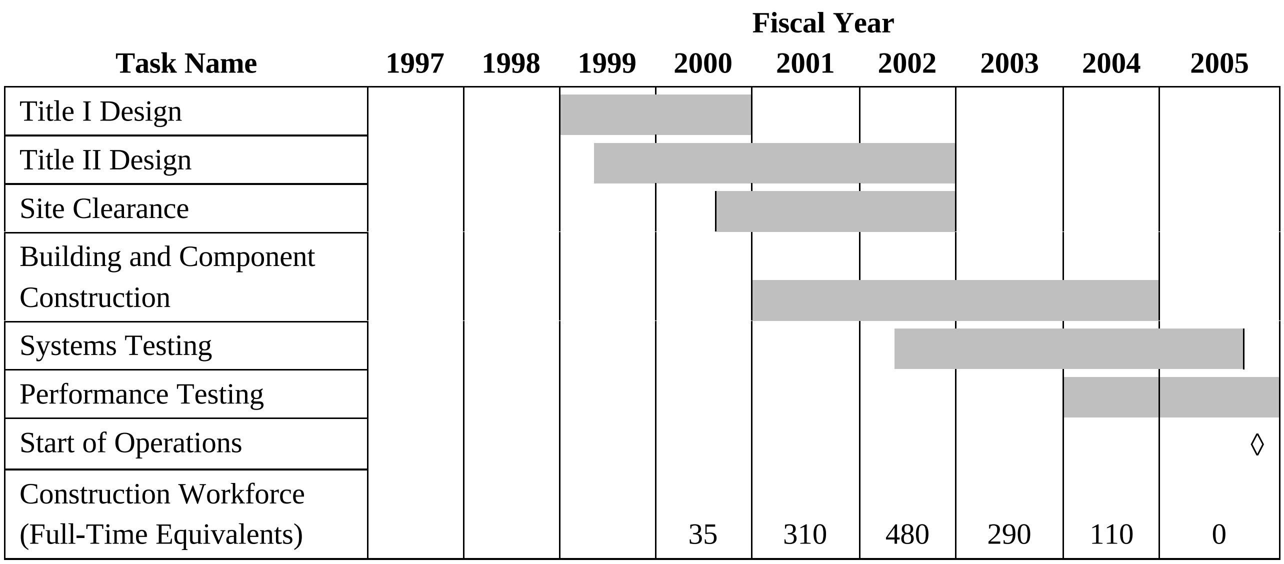


Figure 3.2.2-1. Proposed SNS summary schedule for design and construction.

Table 3.2.2.2-1. Construction traffic.

Activity	Vehicle		Daily Round Trips
Managers/workers	Passenger		466/dy[1]
Material transport	Truck		7/dy[2]
Service providers	Truck		3/dy[3]
		Total	476

[1]Based on Tables 5.2.10.1-2, 5.3.10.1-1, 5.4.10.1-2, and 5.5.10.1-1.
[2]Value calculated per Table 3.2.2.2-2.
[3]Best professional judgement.

Table 3.2.2.2-2. Construction truck material shipments.

Material	Number of Trucks
Concrete (Sect. 3.2.2.4)	2,250
Steel (Sect. 3.2.2.4)	200
Crushed stone for UNAC (Sect. 3.2.2.9)	1,278
Temporary employee parking (Sect. 3.2.2.6)	361
Permanent employee parking (Sect. 3.2.2.6)	48
4 miles of paved roads (Sect. 3.2.2.6)	3,911
Sanitary waste during construction (Sect. 3.2.2.11)	468
Total trucks during construction	8,516

8,516 ÷ 5 yr construction = 1,703 trucks per yr
1,703 trucks per yr ÷ 250 workdays per yr = 7 truck round trips per workday.

This level of traffic would diminish with the decrease in construction activities between FY 2002 and FY 2004.

3.2.2.3 Site Preparation

The central buildings and systems of the proposed SNS would be constructed within a hammer-shaped footprint of approximately 110 acres (45 ha) (ORNL 1997b: 8-1). This area would accommodate the fully upgraded facility. During construction of the 1-MW facility, the land not needed for the construction of facilities would be used as a lay-down area and as temporary parking lots for construction workers.

Construction of the proposed SNS would start with site preparation and grading activities. These activities would begin with the removal of existing vegetation in specific areas designated for construction and construction-support operations. Where possible, natural vegetation on or adjacent to the site would be preserved and protected (ORNL 1997b: 8-30).

Construction locations within the site would be graded and backfilled using heavy equipment. Earth-moving would be performed in accordance with DOE Standard Specification CV-1.3 (ORNL 1997b: 8-30). Laydown areas for construction materials and areas for temporary construction facilities would be created (ORNL 1997b: 8-30).

All topsoil would be scraped and stockpiled in a designated location for onsite landscaping and revegetation efforts. Any excess topsoil would be stockpiled and preserved for future use. To the extent possible, maintainable slopes would be used at all changes in elevation. Newly graded slopes over 3:1 (three units horizontal to one unit vertical) would be considered for retaining walls, soil stabilization, and maintenance-free landscaping. Appropriate provisions would be made for the disposal of rock and other excavated debris. Onsite burying of debris would be prohibited (ORNL 1997b: 8-30).

The removal of vegetation and the loosening of soils during site preparation could enhance the potential for soil erosion and transport to surface water bodies during periods of precipitation. Permanent and temporary erosion-control measures would be used at the earliest feasible times to minimize such effects. Temporary stormwater management and silt retention facilities, such as silt fences, would be provided where early placement of permanent improvements would be impractical. As soon as possible, denuded and disturbed areas would be revegetated with appropriate native plant species to minimize erosion and downstream siltation. Cut-and-fill slopes would be sufficiently stabilized by mechanical methods or planting vegetation to prevent failure and erosion (ORNL 1997b: 8-30).

A permanent retention basin would be constructed as part of the overall runoff control to mitigate the amount of sediment loading to receiving streams. The basin would also serve to equalize the flow of water to the receiving stream.

3.2.2.4 Construction Materials

Based on the conceptual design, approximately 50,000 yd^3 (38,228 m^3) of concrete and 4,000 tons of steel would be used for construction of the proposed SNS and for shielding. At this time, estimates of other building materials are not available.

Concrete and steel shielding blocks may be available from existing DOE facilities. For example, concrete and steel shielding blocks may be available from the decommissioning of the Bevatron facility at the Lawrence Berkeley National Laboratory. In addition, recycled steel from other DOE facilities may be available. Concrete and steel from these sources may be slightly radioactive. Reuse of slightly contaminated material was established as waste minimization policy by DOE. If DOE decides it is feasible to use the concrete and steel blocks in the proposed SNS, an assessment of the potential radiation doses to workers and the general public would be made prior to transporting the material to the proposed SNS site.

3.2.2.5 Utilities

Utility construction would extend electricity, telephone/data communications, natural gas, potable water, and sanitary sewer service to the proposed SNS facilities (ORNL 1997b: 8-34). Where possible, these services would be extended from the points where existing sources of sufficient quantity and capacity make their nearest approaches to the proposed SNS site. Doing this would limit the total area of land that would be disturbed by new utility construction.

The extension of utility services into the proposed SNS site would entail vegetation clearing throughout the utility corridors. With respect to overhead electricity and telephone/data communications lines, vegetation removal would focus primarily on trees where forested areas intersect the transmission line corridors. Ground cover and understory vegetation would be cleared for the laying of pipelines and sanitary sewage lines, since these components require the excavation of pits and trenches. Some shallow soil excavation and augering would be necessary to extend electrical service to the proposed SNS site. Activities would involve the setting of utility poles, transmission line towers, and other such components of overhead utility systems.

3.2.2.6 Roads and Parking Lots

A system of roads and parking lots would be constructed on the proposed SNS site. These would be both temporary and permanent. Temporary roads and parking lots (dirt and gravel) would be established at the beginning of construction activities to provide construction vehicles with ease of access to and among the various onsite construction locations. Where feasible, the locations of temporary roads and parking lots would coincide with planned roadways and parking lots or planned construction areas, to minimize zones of disturbance on the site (ORNL 1997b: 8-28). Temporary parking lots would be provided for construction vehicles (ORNL 1997b: 8-34). If necessary, temporary parking could be established a short distance from the construction site, with buses transporting the workers. By the end of construction, 4 mi (6.4 km) of permanent, paved roads and parking areas for 250 persons would be constructed. On a site-specific basis, additional construction and improvement of permanent, paved roads would be necessary to effectively connect the onsite roads and parking lots with the system of existing roads in the vicinity of the proposed SNS site. Permanent roads and parking lots would be subject to finish grading; excavation of trenches for drainage features, such as concrete curbs and guttering; paving; and the painting of paved surfaces with traffic control symbols and parking lines (ORNL 1997b: 8-29).

3.2.2.7 Stormwater Drainage System

A stormwater drainage system would be constructed for the proposed SNS site. The stormwater drainage system would collect, detain, carry, and discharge stormwater runoff from the site so that water neither interferes with the safe operation and maintenance of the proposed SNS facilities nor causes erosion or other damage to natural or man-made features of the site (ORNL 1997b:8-30). The system would include the drainage of newly constructed and improved roads connecting the proposed SNS site to existing roads. It would consist of contoured landforms and a system of subsurface pipes, junction boxes, and culverts to route stormwater to a retention basin. The retention basin would have sufficient capacity for a 100-year, 24-hour design storm. The system would mitigate the effects of excess runoff on downstream systems and would be monitored as required (ORNL 1997b: 8-30).

3.2.2.8 Proposed SNS Facilities

Temporary and permanent facilities would be constructed by the proposed SNS project. The temporary facilities would be established to support construction of the permanent proposed SNS facilities. The following types of temporary support facilities may be needed during construction of the proposed SNS (ORNL 1997b: 8-33 and 8-34):

- Storage, staging, and laydown areas for pipe, reinforced concrete, steel, cabling, conduit, rebar, fuel, and other construction materials.
- Shops, sheds, and test laboratories.
- Concrete batch plant and its aggregate stockpiles.
- Containment for aggregate stockpile runoff.
- Spoil disposal areas.
- Stockpile areas for excavated soil and rock.
- Borrow areas.
- Construction offices.
- Waste concrete disposal facility.
- Truck wash.
- Toilet facilities.
- Class IV landfill for disposal of construction debris.
- Facility to receive sanitary waste.

Most of these facilities would be established within the 110-acre (45-ha) proposed SNS footprint. However, borrow areas, stockpile areas for excavated soil and rock, spoil disposal areas, and a landfill for construction debris could be at offsite locations in the vicinity of the proposed SNS site.

To minimize the footprint area, all temporary facilities on the proposed SNS site would be located within areas subject to disturbance by site preparation activities. Facilities not slated for reuse as permanent facilities would be removed from the proposed SNS site when they are no longer needed. Construction of the temporary facilities would result in the generation of spoil, construction debris, and possibly other types of waste, which would be managed in accordance with the requirements identified in Section 3.2.2.11. Whenever practical, some facilities initially required for temporary use would be located and constructed with the potential to be reused as permanent shop or warehouse space. Construction would be in accordance with appropriate requirements in the Uniform Building Code (ORNL 1997b: 8-33 and 8-34).

Earth fill for the proposed SNS site would be obtained from offsite borrow areas. This fill would consist of excavated soil or excavated soil mixed with rock and would meet engineering requirements for foundation support and settling parameters. Borrow areas would be selected to minimize travel distances to the proposed SNS site.

Temporary security fencing would be erected around the construction site. This fencing would protect construction equipment and building materials. In addition, it would control access during construction and restrict vehicular traffic to authorized roads (ORNL 1997b: 8-34). This barrier would also limit the total area of land disturbed by construction activities.

The construction and use of several temporary facilities would involve minor discharges. Operation of the concrete batch plant would entail some water discharges. Operation of the truck wash facility would result in short-term discharges of wash and rinse waters, possibly containing small amounts of oil and other hydrocarbons. Construction wastewater would be collected in tank trucks and transported to appropriate waste management facilities for treatment. Thus, pollutant discharges to soil, surface water, and groundwater would be minimized.

The fuel storage facility would be equipped with sufficient secondary containment to prevent spills to the environment. Any releases from wash or fuel storage facilities would be pumped to tanks for transport to the local process water treatment facility. No release to local drainages would be permitted.

Permanent facilities on the proposed SNS site would consist of major buildings and several ancillary structures. Buildings would house the accelerator equipment and instrumentation, described in Section 3.2.1, that comprise the proposed SNS, as well as the support systems, laboratories, and offices necessary for its safe and effective operation. Ancillary structures would support the proposed SNS operations in the buildings, prevent soil erosion, provide structural support for equipment, and bolster site security. These structures would include cooling towers, an electrical substation, foundation pads for transformers, a fire water tank, retaining walls, fencing, and security inspector posts.

Fifteen permanent buildings would be constructed on the proposed SNS site for the 1-MW facility. These buildings would cover more than 6 acres (2.43 ha) of land within the 110-acre (45-ha) proposed SNS footprint. The constructed floor space in these buildings would be nearly 364,942 ft^2 (33,903 m^2) (ORNL 1997b: 8-1). The buildings that would be constructed, the major equipment that would be assembled within them, and their designed interior areas are listed in Table 3.2.2.8-1. Duplicates of existing buildings, such as the Target Building, would be constructed in association with later upgrades to an operating power of 4 MW (see Section 3.2.1.5). Refer to Figures 3.2.1-1 and 3.2.1.5-1 for the building layout.

Construction of the permanent buildings and ancillary structures would begin with excavations for building foundations, ancillary structure foundations/support pads, and retaining walls. These excavations would be performed with heavy equipment. Completion of the proposed SNS buildings would proceed as a standard construction project, except for the possible inclusion of slightly radioactive steel and concrete materials in the beam line tunnel buildings (refer to Section 3.2.2.4). These buildings would be constructed to resist natural

Table 3.2.2.8-1. Buildings to be constructed for the proposed SNS.

Building	Equipment Summary and Function	Size (ft²)
Front End	Ion source; LEBT, RFQ, and MEBT; vacuum system, power supplies, cooling and service system storage, local control room.	18,345
Linac Tunnel	Linac structure; power, electrical, cooling, and service distribution systems; access towers.	23,778
Klystron Gallery	Klystrons, modulators, and rf power systems; magnet power systems; HVAC systems; waveguides to linac; 4 capacitor rooms.	54,810
HEBT Tunnel	HEBT structures; power, electrical, and service distribution systems.	9,255
Ring Tunnel	Ring structures; power, electrical, and service distribution systems.	14,482
RTBT	RTBT structures; power, electrical, and service distribution systems.	8,672
Target	Target, target moderator systems, shielding, target maintenance cell, experiment systems; electrical, cooling, and service systems for target, moderators, and experiment systems; waste collection systems; shops, equipment rooms, laboratories, and offices to support research instruments and activities. Compressor area.	120,565
Ring Service	Power supplies (including rf), electrical systems, cooling systems, vacuum systems, and HVAC systems.	7,500
RTBT Service	Power supplies, electrical systems, cooling systems, vacuum systems, and HVAC systems.	1,960
Beam Stop Service	Target, shielding, electrical, and service systems.	6,240
Central Utilities	Deionized cooling water system, chilled water system, compressed air, and heat exchangers.	9,000
Central Shop	Machine shop, storage, electrical shop, office space, shielded decay area, test and repair shops for klystrons and magnets, electronic equipment, vacuum systems and equipment, and tools and parts storage. Hot shop.	64,500
Integrated Control	Integrated control room, electrical and mechanical support equipment, service systems for control room, office and storage space to support control room activities.	8,660
Administration	Office and support space for operating personnel.	17,175
Site (miscellaneous foundations, pads, etc.)	Tank, transformer, pumps, switchyard, diesel generators, etc. Foundations, pads and structural features.	NA

NA - Not available.

phenomena such as earthquakes, wind, and flooding (ORNL 1997b: 8-40). Construction of the proposed SNS buildings would include the erection of structural support members and construction of the soil shielding berms (refer to Section 3.2.2.9). In addition, it would include the installation of utility, communications, environmental control, mechanical, data management, safety, fire protection, and waste system components. Construction would be completed with the finish and trim work and final installation of the accelerator equipment, controls, and instrumentation.

Erection of the ancillary structures would begin with the laying of foundations, support pads, and retaining walls. Completion of the ancillary structures would entail the erection of the cooling towers, electrical substation, security inspector posts, and permanent fencing. In addition, it would include the installation of transformers on their foundation pads.

3.2.2.9 Exterior Shielding Design

The conceptual design of the proposed SNS has exterior shielding to protect the environment from ionizing radiation. The beam line tunnels (linac, HEBT, rings, RTBT, and beam stops) would be backfilled with a soil cover contoured to match the natural slope (Figure 3.2.2.9-1). The thickness of the berm would be approximately 26 ft (7.9 m). The shielding calculations done by ORNL were for a representative soil type and were not site-specific. No significant differences are expected in the shielding properties of soils at different sites.

This berm would be constructed from fill set aside during excavation (with additional soil from a local borrow area, if needed). A diversion trench would carry any surface runoff away from the facility and the berm. A water-diverting barrier would be placed just below the surface of the soil berm to repel water from infiltration. A groundwater interceptor system would be constructed under the tunnel building. It would capture any groundwater that might breach the barrier and hold it for sampling within a leak-proof collection system. Foundation drains would be incorporated into the system. The system would be connected to the site's stormwater drainage system to allow the release of uncontaminated water. Other connections would allow transport of contaminated water to appropriate waste systems for treatment (ORNL 1997b: 8-31).

Beam loss is a term used to describe particles that escape the beam. These accelerated particles travel through the surrounding material. Many of them end up in the soil berm surrounding the linac tunnel. These particles would interact with the molecules in the soil, causing "activation" or the creation of slightly radioactive molecules within the soil. The soils nearest the tunnel would contain approximately 99.95 percent of radionuclides within the first 13 ft (4 m)] of soil in the berm. At decommissioning, soils adjacent to the tunnel would constitute a radioactive source term that may require mitigation or monitoring.

Construction of the proposed SNS would incorporate features into the design of the berm shield (Figure 3.2.2.9-2) to protect against infiltration of groundwater and migration of radionuclides. The linac tunnel would be covered with an impermeable clay material (obtained by compaction of native soils possessing a high clay content) that would be

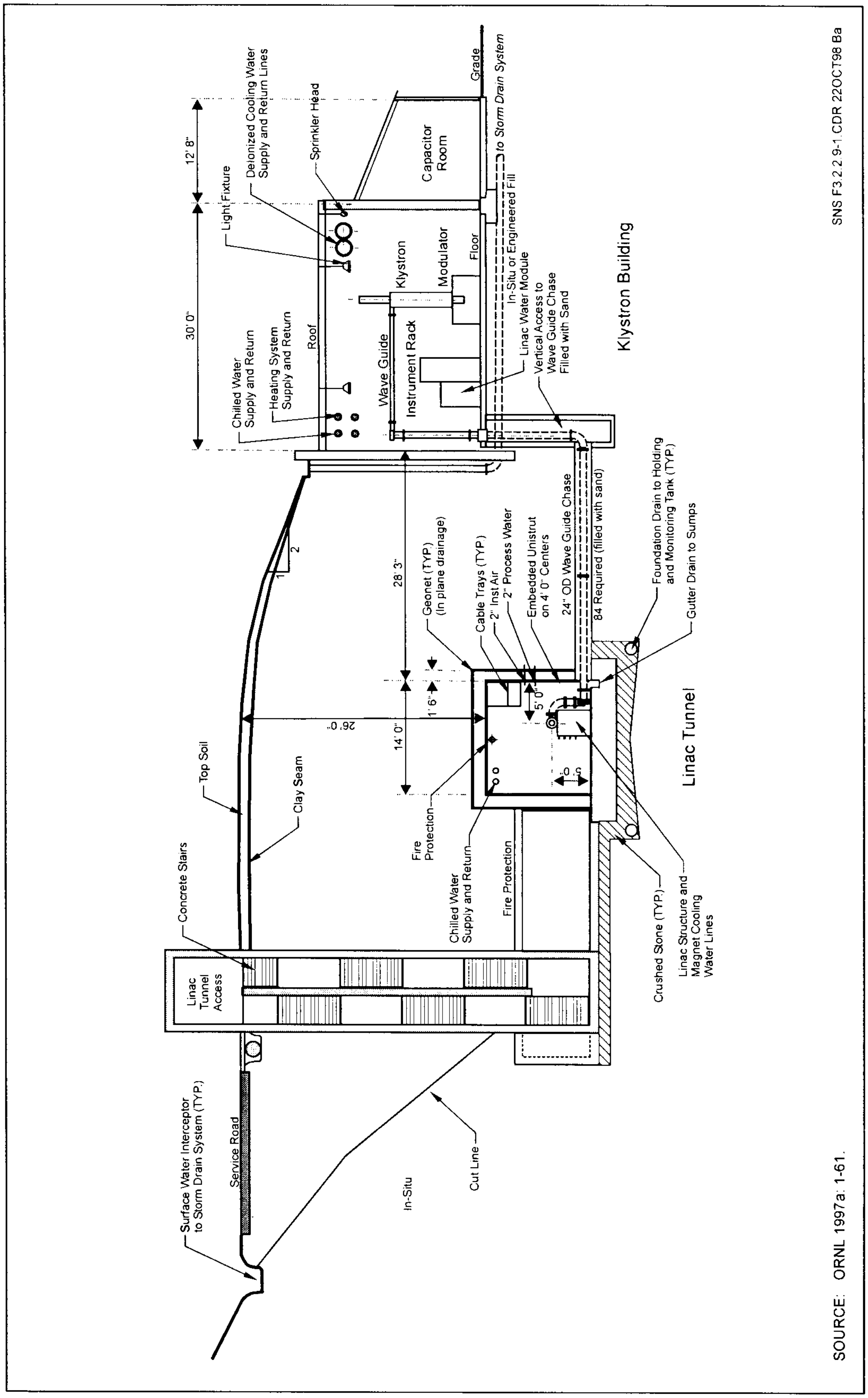


Figure 3.2.2.9-1. Detail of linac tunnel and shielding berm.

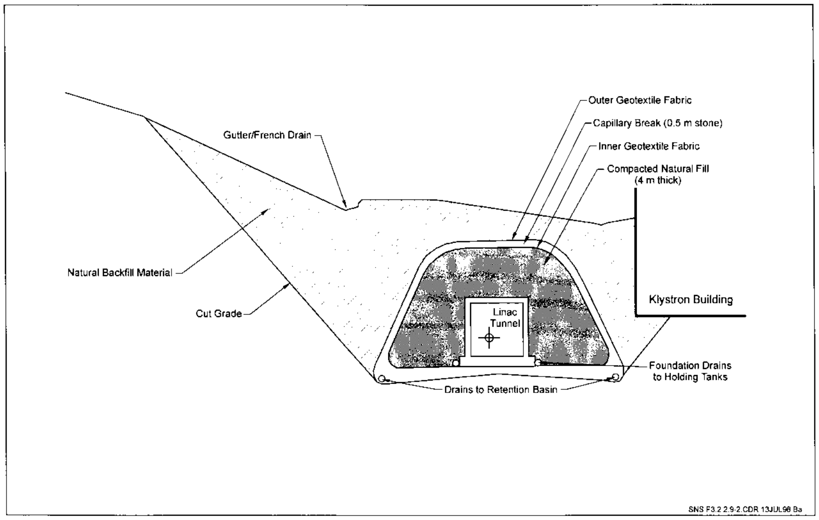


Figure 3.2.2.9-2. Linac berm shield.

surrounded by a 1.6-ft (0.5-m) interval of coarse crushed stone. These layers would then be backfilled with native soils, and the surface would be contoured to a natural slope. The crushed stone would act as a capillary break between the native soils and the compacted clay layer. The stronger capillary attraction of the finer-grained native soils would divert infiltrating groundwater away from the compacted clay materials. Drains at the base of the capillary break would carry diverted water to a retention basin for later discharge. To maintain its effectiveness, a porous but fine-mesh geotextile fabric membrane would be placed above and below the crushed stone to prevent the migration of soil particles into the stone interval. The capillary break would provide redundant protection to the impermeable clay layer permitting the shield materials and the tunnel structures to remain dry, thereby eliminating a mechanism for nuclide transport. As an added measure, foundation drains would be placed at the base of the linac tunnel to capture any infiltrating water that might by-pass the impermeable clay layer. These drains would channel this water into holding tanks for monitoring and proper disposal.

3.2.2.10 Landscaping

The proposed SNS site would be landscaped during the construction phase of the project. The landscaping would primarily involve the finishing of onsite landforms and the revegetation of cleared areas. This activity would simultaneously establish the final erosion control measures for the site and promote a variety of desirable aesthetic and environmental conditions (ORNL 1997b: 8-27).

The landscaping techniques, final landforms, and revegetation activities would be chosen to promote the recovery of natural resources disturbed during construction. For example, natural flora in unlandscaped areas would be reestablished and proper selection of final land contours and cover vegetation would prevent the erosion of topsoil. Landscape elements would be selected to enhance the diversity of native wildlife on the proposed SNS site. They would give prominence to attractive site features and de-emphasize or obscure less desirable features (parking areas, loading docks, and storage areas) and would provide visual buffers between security zones. Where feasible, trees would be used as elements of energy conservation for the proposed SNS buildings and for onsite control of noise. Where appropriate, open areas would be developed as environmental research zones (ORNL 1997b: 8-32).

Geotechnical systems, rip-rap, or other appropriate landscaping materials would be used in the construction of retaining walls to avoid the negative visual effect of massive retaining structures. Retaining walls that are part of buildings would be integrated structurally with the requirements of the groundwater interceptor system (ORNL 1997b: 8-31).

3.2.2.11 Waste Generation

The site preparation and excavation activities at the proposed SNS site could result in excess quantities of excavated material consisting of soil and rock. (ORNL 1997b: 8-33). None of this spoil material would be hazardous or radioactive waste. That portion of spoils material that could not be used onsite would be disposed of at a nearby borrow area. The disposed materials would be spread and compacted at the disposal area to maintain current drainage patterns. Construction materials waste would not be disposed of at this facility (ORNL 1997b: 8-33), but at a permitted construction debris landfill in accordance with current procedures at the selected site.

Nonradioactive and nonhazardous construction debris would be shipped to a permitted disposal site. This waste would consist of nonrecyclable excess materials (i.e., wood, drywall, and masonry) from facility construction and the demolition of temporary facilities. Any similar waste materials from the operation of temporary shops and test laboratories would also be disposed of in this facility.

Waste concrete would be disposed of in a disposal facility with appropriate waste acceptance criteria. No concrete contaminated with hazardous or radioactive materials would be disposed of in this facility.

Some hazardous wastes would be generated by construction activities at the proposed SNS. In addition, radioactive scrap steel and concrete waste could be generated as a consequence of reusing slightly radioactive steel and/or concrete from other DOE sites in the construction of several permanent proposed SNS buildings. Any hazardous wastes generated during construction at the proposed SNS would be managed in accordance with applicable requirements under the Resource Conservation and Recovery Act (RCRA).

Portable toilets would be used as sanitary waste facilities during construction of the proposed SNS. The waste in these toilets would be removed on a regular schedule by a qualified sanitary waste contractor. In the latter phases of construction, some of the new buildings would be connected to the permanent sanitary waste system for the proposed SNS site. In such cases, these facilities would be used instead of the portable toilets.

3.2.2.12 Noise

Construction activities at the proposed SNS site would generate noise produced by heavy construction equipment, trucks, power tools, and percussions from pile drivers, hammers, and dropped objects. In all cases, the levels of noise would be representative of levels at large-scale building sites. Table 3.2.2.12-1 describes peak and attenuated noise levels expected from operation and construction equipment.

Relatively high and continuous levels of noise would be produced by heavy equipment operations during the site preparation phase of construction. However, after this time, heavy equipment noise would become more sporadic and brief in duration.

The noise from trucks, power tools, and percussion would be sustained through most of the building erection and equipment installation activities on the proposed SNS site. As construction activities reach their conclusion, sound levels on the proposed SNS site would decrease to levels typical of daily SNS operations.

3.2.2.13 Air Emissions

Construction of the proposed SNS would result in some pollutant emissions to the atmosphere. However, these emissions would be temporary. The primary emission during construction would be fugitive dust during the clearing and grading of the site. Dust suppression techniques, primarily water sprays with a dust suppressant, would be used to control dust.

3.2.3 OPERATIONS

Operation of the proposed SNS in the 1-MW configuration would begin in FY 2005, when most of the construction activities at the proposed SNS site would have been completed. These operations would continue for the 40-year design life of the facility. However, this design

Table 3.2.2.12-1. Peak and attenuated noise levels (in dBA) expected from operation of construction equipment.

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

Source: Golden et al. 1980.

life would not preclude operational extensions beyond 40 years (DOE 1997c). This section identifies the workforce required for operations and characterizes the proposed SNS operations in terms of resource requirements and operational activities that have the potential to cause impacts, such as air emissions and waste discharges.

3.2.3.1 Workforce

The proposed SNS would be operated by a permanently assigned staff and visiting scientists. Permanent staffing would begin with facility commissioning, currently scheduled for FY 2004-2005. By the first full year of operation, FY 2006, approximately 250 individuals would be working at the proposed SNS—approximately 180 resident employees (scientists and support personnel) and 70 visiting scientists. Approximately 125 additional people would be added to the workforce when the second target is completed.

It is anticipated that 1,000 to 2,000 visitors and sightseers would tour the proposed SNS each year. This level of visitation would begin during the first full year of operations and continue throughout the life of the facilities. The proposed SNS would have a visitor center as an integral part of the facility. In addition, portions of the facility would be designed to allow viewing by the visiting public.

3.2.3.2 Traffic

The commuting by proposed SNS staff and visiting scientists would constitute the heaviest operations-related traffic in the vicinity of the proposed SNS. This traffic would begin at relatively low levels with commissioning of the proposed SNS site in FY 2004-2005. By the first full year of operations in 2006, a substantial increase in daily round trips to the proposed SNS site would occur. This level of commuter traffic would continue until the proposed SNS is supplied with an additional ring and target and operated at 4 MW. After this upgrade and an attendant increase to approximately 375 employees, the daily round trips would increase to approximately 302. The addition of a small number of visiting scientists after the upgrades would minimally increase daily round trips to the proposed SNS.

The traffic generated by delivery vehicles, service vehicles, and visitors (3/day) to the proposed SNS site would always be a much smaller component of the operations-related traffic than the commuter traffic. However, later upgrades to the proposed SNS may be associated with small increases in such traffic. For the remaining life of the proposed SNS, daily round trips would stabilize at approximately 305 per weekday (refer to Table 3.2.3.2-1).

Table 3.2.3.2-1. Operations traffic.

Activity	Daily Round Trips
Maximum employee commutes/day	302/day[1]
Service vehicles and supply trucks	3/day
Total number of vehicles	**305/day**

[1]Value taken from Table 5.2.10.1-2.
Source: Tables 5.1.10.1-2, 5.2.10.1-1, 5.3.10.1-2, and 5.4.10.1-1

3.2.3.3 Material Consumption

Operational activities at the proposed SNS would consume a wide array of raw materials. Table 3.2.3.3-1 lists the major raw materials that would be used by proposed SNS operations. However, at this time the quantities of materials that would be consumed are not known.

3.2.3.4 Utilities

Daily operations at the proposed SNS would be heavily dependent upon the utility systems that serve the site. This would be especially true for the accelerator systems and target systems that require large supplies of electrical power for operation and water for cooling.

Table 3.2.3.4-1 shows the utility systems that would serve the proposed SNS, their operational functions, and the projected quantities of utility-based energy and raw materials that would be used per unit time during operation of the proposed SNS. The listed quantities reflect projected peak use of energy and raw materials per unit time for the facility at 1 MW and fully upgraded at 4 MW.

3.2.3.5 Air Emissions

Air emissions from the proposed SNS during operations would be primarily ventilation air from the linac tunnel, accumulator rings, and target building. The linac and ring tunnels would be ventilated to allow hands-on maintenance when the facility is not operating. The ventilation system would be designed to include a short retention time before the air is released to the environment. The type and amount of radionuclides that would be released during operations at both 1-MW and 4-MW beam powers are shown in Table 3.2.3.5-1. Only radionuclides that make up one percent

Table 3.2.3.3-1. Proposed SNS raw material usage.

Materials	Use
Charcoal absorbent	Absorber system in gaseous waste system. Removes mercury from off-gases
Refrigerant fluid	Air conditioning equipment in the linac tunnel
Helium gas	Gas distribution and cryogenic systems
Nitrogen gas	Gas distribution and cryogenic systems
Hydrogen gas	Gas distribution and cryogenic systems, moderators, and targets
Deuterium gas	Gas distribution and cryogenic systems
Argon gas	Gas distribution system and beam loss monitoring
Oxygen gas	Gas distribution system
Acetylene gas	Gas distribution system
Diesel fuel	Electrical system (emergency generators)
Gasoline	Yard and ground maintenance operations
Oil	Yard and ground maintenance operations and electrical system
Scintillation cocktail	Research laboratories
Laboratory chemicals (acids, bases, solvents, etc.)	Research laboratories

Source: ORNL 1997b

Table 3.2.3.4-1. Proposed SNS utility systems.

Utility System	Operational Functions in Proposed SNS	Projected Use / Unit Time
Natural gas	Feeds fuel to the boilers and localized unit heaters in the building heating system.	1,000 lb/hr - maximum
Water	Supplies water to the tower water cooling system, deionized cooling water system, chilled water system, building heating system, process water system, potable water system, demineralized water system, fire suppression system, and two target moderators.	800 gpm - 1 MW 1,600 gpm - 4 MW
Electrical	Supplies electrical power to the accelerator and target systems, instrumentation and control systems, communications and alarm systems, lighting systems, cathodic protection systems, and all other systems/equipment that use electricity.	62 MW power supply to deliver a 1-MW beam 90 MW power supply to deliver a 4-MW beam

Source: ORNL 1997b.

Table 3.2.3.5-1. Projected annual emissions of radionuclides from proposed SNS facilities.

	Target Building Exhaust (Ci)						Tunnel Confinement Exhaust (Ci)			
	Cooling Systems[a]		Target Off-Gas[a]		Beam Stops[b]		Linac, Ring, and Beam Transfer Tunnels[b]		Total	
Nuclide[c]	1 MW	4 MW	1 MW	4 MW	1 MW	4 MW	1 MW	4 MW	1 MW	4 MW
H-3	2.8	11.1	22.4	89.6	0	0	0	0	25.2	100.7
C-10	0	0	0	0	0	0	25.5	40.4	25.5	40.4
C-11	0	0	0	0	0	0	40.6	60.4	40.6	60.4
N-13	0	0	0	0	0	0	318	483	318	483
O-14	0	0	0	0	0	0	89.9	133	89.9	133
O-15	0	0	0	0	0	0	341	519	341	519
Al-28	0	0	0	0	0	0	8.6	0	8.6	0
Ar-37	126	502	0	0	250	467	0	0	376	969
Xe-125	0	0	1.2	5	0	0	0	0	1.2	5
Xe-127	0	0	80.5	322	0	0	0	0	80.5	322
Hg-197	0	0	3.6	14.4	0	0	0	0	3.6	14.4
Hg-203	0	0	3.3	13.2	0	0	0	0	3.3	13.2
Total	128.8	513.1	111	444.2	250	467	823.6	1235.8	1313.4	2660.1

[a] DeVore 1998h.

[b] DeVore 1998c.

[c] Nuclides listed contribute one percent or more of the total activity released from a given system.

or more of the total number of curies released are included in the table.

There would be air emissions from the proposed SNS target system, primarily during periods of maintenance. Ventilation air from the target system would be compressed into tanks for a minimum of seven days to allow many of the short-lived radionuclides to decay. The air would then be released through charcoal and

HEPA filters to the atmosphere. The type and amount of radionuclides that would be released from the target systems are included in Table 3.2.3.5-1.

Air pollutants would be emitted from the beam stops. The release of radionuclides from the beam stops would only occur during maintenance. No releases would occur during normal operations of the proposed SNS. Gases released from the beam stops would be compressed into tanks to allow radionuclides to decay for a minimum of seven days. The air would then be released through HEPA filters to the atmosphere. The type and amount of radionuclides that would be released from the cooling systems, target systems, beam stops, and tunnel confinement are included in Table 3.2.3.5-1. All air releases would be through monitored stacks on the proposed SNS buildings.

3.2.3.6 Effluent Discharges

Operation of the cooling towers, groundwater interceptor system, and stormwater drainage system would result in effluent discharges to soil and/or surface water bodies at the proposed SNS. These discharges would consist of cooling tower blowdown, any groundwater that might collect in the groundwater interceptor system under the concentric shielding design, and stormwater runoff from the proposed SNS site.

During operation of the proposed SNS, excess heat must be removed from many of the components. Many components of the linac are water-cooled. The beam stops would be designed to dissipate the energy of the beam and thus would be water-cooled. Components of the target assembly would also be water-cooled. Some of this heat would be recovered and used for general space heating; however, most of this heat would be dissipated to the environment through a bank of eight mechanical cooling towers. Approximately 500 gpm (1,892 lpm) of water would be required for operation of the cooling towers; approximately half of this water would be released to the atmosphere, mostly in the form of water vapor. The other half of the water would be released as blowdown to surface water. In order to upgrade the proposed SNS to 4-MW beam power, five additional cooling towers would need to be installed and approximately 700 gpm (2,650 lpm) of water would be required for operation of the cooling towers.

The cooling tower blowdown water would not contain any radioactivity. The water would contain biocides and anti-scaling agents required for proper operation of the tower. Cooling towers dissipate heat primarily by evaporation. Therefore, the constituents in the water would be concentrated by a factor of four. The temperature of the blowdown would be between 90 and 95 °F (32 and 35 °C).

The blowdown water would be dechlorinated, if necessary, and released to the retention basin. The retention basin would be designed with an appropriate residence time to allow the water to cool further, before being released to the environment. If necessary, the retention basin would include fountain or water sprays to assure that the temperature of the water released to the environment would be within 5°F of the temperature of the receiving stream.

The groundwater interceptor system beneath the beam shielding berms would collect any water that might penetrate the water-diverting barrier in the berms and infiltrate through the berm soil. Only a minimal amount of water would be expected in this system. This water would be collected in a sump that would be inspected monthly, and any water found in the sump would be removed and sampled. If contamination were found, the water would be transported to the appropriate waste-treatment systems. Water with no contamination would be released to the stormwater drainage system.

The stormwater drainage system on the proposed SNS site would intercept precipitation runoff from the proposed SNS buildings, walks, plazas, roads, parking lots, and landscape surfaces. The majority of this water would be directed to the retention basin. The retention basin would allow excess silt to settle out before the water would be released through the surface water discharge. This discharge would require a National Pollutant Discharge Elimination System (NPDES) permit.

3.2.3.7 Waste Generation

All wastes generated by the proposed SNS would be handled according to procedures already in place at the selected site for the proposed SNS (refer to Sections 5.1.11, 5.2.11, 5.3.11, and 5.4.11). Operation of the proposed SNS would result in the generation of four types of waste (Table 3.2.3.7-1).

Sanitary and hazardous wastes are considered solid waste under RCRA and state-administered waste management rules. Solid waste can occur in the form of solids, liquids, or gases. The types of solid waste generated by operations at the proposed SNS would include hazardous waste, primarily liquids such as solvents, and nonhazardous and nonradioactive waste generated by human sanitation activities at the proposed SNS. This waste would be generated in both solid and liquid form. It would include trash, human waste, and waste liquids such as personal shower wash and rinse water. In addition, the generated solid waste would include mixed waste, which is waste that contains both hazardous and radioactive constituents.

Low-level radioactive waste would be generated by operations at the proposed SNS. This waste would be generated in liquid form [liquid low-level waste (LLLW)] and solid form (solid low-level waste) (ORNL 1997b: 8-139 to 8-140). Further details of waste generation and disposal can be found in Chapter 5.

Table 3.2.3.7-1. Annual waste generation by the proposed SNS.

Waste Type	Generation Rate 1-MW Beam	Generation Rate 4-MW Beam
Hazardous Waste		
Liquid	41 m^3/yr	41 m^3/yr
Low-Level Radioactive Waste		
Liquid	166 m^3/yr	665 m^3/yr
Process waste (potentially LLW)	3,940 m^3/yr	15,800 m^3/yr
Solid	513 m^3/yr	1,026 m^3/yr
Mixed Waste		
Liquid	10.8 m^3/yr	10.8 m^3/yr
Solid	3.5 m^3/yr	7 m^3/yr
Sanitary Waste		
Liquid	47 m^3/yr	69 m^3/yr
Solid	900 m^3/yr	1,349 m^3/yr

3.2.3.8 Safety

Daily operations at the proposed SNS would entail a number of potential hazards to human safety and health. The proposed SNS would be designed, constructed, and operated to protect workers and the public from these potential hazards.

The potential hazards associated with operations at the proposed SNS would fall into two major categories: standard industrial hazards and nonstandard industrial hazards. Most of the hazards posed by the proposed SNS operations would be standard industrial hazards. These hazards would be posed by the presence of combustible materials (general materials, hydrogen gas, and natural gas); electrical energy (high voltage); potential energy (cranes); mechanical energy (forklifts and other vehicles); asphyxiants (refrigerant fluid and helium); and toxic, corrosive, or oxidizing materials. Additional potential hazards common to the proposed SNS and many other industrial facilities would include laser operations, electrical power outages, and general fires. The potential nonstandard industrial hazards would consist of ionizing radiation; nonionizing radiation; magnetic fields; and toxic, corrosive, or oxidizing materials (mercury target) not normally classified as standard industrial hazards (ORNL 1997b: 9-6 to 9-8). Engineering and administrative controls would be implemented to protect the proposed SNS workers and the public from these operational hazards.

Engineering controls would be incorporated during design and construction of the proposed SNS. The buildings, systems, and equipment that comprise the proposed SNS would be designed and constructed in accordance with the Uniform Building Code; National Electric Code; fire, life safety, and piping codes; and other applicable and appropriate consensus standards (ORNL 1997b: 9-5). The use of combustible materials in construction and equipment would be limited (ORNL 1997b: 9-19). Smoke and fire detection systems would conform to National Fire Protection Association standards relevant to their construction and installation, as would the fire suppression systems installed throughout the proposed SNS (ORNL 1997b: 9-20).

Workers would be protected from ionizing radiation during operations by established distances from sources and installed shielding. The shielding design policy for the proposed SNS (ORNL, 1997b: 9-12) limits the radiation dose rate to that specified in 10 CFR 835 (less than 100 mrem annually for a maximally exposed nonradiological worker). The shielding, consisting of steel, lead, concrete, and earth, would be supplemented by a variety of engineered systems and controls, including beam containment and monitoring systems, radiation detectors and monitors, audible/visible radiation warning devices, scram buttons in areas subject to irradiation, locked doors, and interlock systems to disable the beam if anyone attempts to enter the tunnels or target area during beam operations (ORNL 1997b: 9-12 to 9-16). The proposed SNS would be equipped with additional engineering features to prevent the uncontrolled release of radioactive mercury and other radioactive materials in the event of an operational accident (ORNL 1997b: 9-16 to 9-19).

The proposed SNS would be operated in strict compliance with a variety of administrative, safety, and health controls. These controls would include all applicable portions of the Occupational Safety and Health Administration (OSHA) regulations; federal, state, and local environmental statutes and regulations; "Work Smart Standards" derived from DOE orders and guidance; and current safety and health procedures of the Management and Operations contractor organization. The continuation of safe operations would be bolstered by a regular program of safety evaluations and compliance audits.

The proposed SNS would be a low-hazard facility with no significant potential to affect offsite residents or nearby travelers. Emergency preparedness planning would emphasize operational contingencies that support impacted workers or equipment at the facility. An emergency plan would be developed to ensure that emergency response resources could be applied quickly and efficiently at the proposed SNS (ORNL 1997b: 9-22).

3.2.3.9 Noise

Operations at the proposed SNS would not produce continuous noise at high or extreme (>90 dB) levels. The same would be true for intermittent noises, although an unforeseeable incident might occur that would briefly spike a high noise level. The highest level of noise among proposed SNS operations would be produced by the cooling towers. Overall noise levels on the proposed SNS site, including operation of the cooling towers, would be comparable to existing noise levels at the host national laboratory. During the landscaping process, trees would be strategically planted to create noise barriers (ORNL 1997b: 8-27).

3.2.4 ALTERNATIVE SITES

Four alternative sites are considered in detail in this EIS (refer to Appendix B). Through the screening process discussed below, four alternative sites for construction and operation of the proposed SNS were identified: ORNL, LANL, ANL, and BNL. DOE used a phased approach to identify potential siting alternatives for the proposed SNS. The first phase narrowed the potential sites for placement of the proposed SNS to four of the DOE national laboratories. The second phase involved identifying a specific location within each of the four national laboratories. The approach to site selection is summarized below. Further details are provided in Appendix B.

3.2.4.1 Identification of Alternative Sites

This section describes the requirements and processes that were used to determine sites for the construction and operation of the proposed SNS.

3.2.4.1.1 Technical/Logistical Requirements

The initial task in the site-selection process involved the definition of specific project requirements. These requirements were used to develop technical and logistical site exclusion criteria. For siting the proposed SNS, the following criteria were deemed necessary to meet the mission goal of supporting neutron science research and providing neutrons for materials research:

- A site with a minimum area of 110 acres (45 ha) and a rectilinear shape to accommodate the length of the proposed linear accelerator and possible future expansion of the facility.
- A 1-mi (1.6-km) buffer zone around the proposed SNS site to restrict uncontrolled public access and to insulate the public from the consequences of a postulated accident at the facility.

- Proximity and availability of an adequate electric power source. The regional power grid must be able to supply 40 MW of power during periods of operation. The site must be within 0.25 to 1 mi (0.4 to 1.6 km) of existing transmission lines to minimize collateral construction impacts and costs.
- Presence of existing neutron science programs and infrastructure to provide a pool of neutron science expertise and experience to meet mission goals. The site must have major facilities and programs utilizing neutron scattering techniques.

3.2.4.1.2 Phase 1 Site Selection

DOE conducted a site-selection process (Appendix B) to systematically identify suitable alternative sites for the proposed SNS. This process followed a two-tiered approach. The first level consisted of a decision to limit potential proposed SNS sites to existing DOE facilities. The second was identification of the basic technical and logistical requirements for meeting the mission goals of the proposed SNS Project (refer to Appendix B).

3.2.4.1.3 Use of Existing DOE Facilities

The logical universe of candidate sites for the proposed SNS in the U.S. was classified into three major categories: (1) existing DOE sites; (2) DOE acquisition and development of other federal property or a new, privately owned site; or (3) joint use of a nonfederal site (i.e., an academic facility).

DOE has an estimated 2.37 million acres (0.96 million ha) of land and many facilities nationwide from which to select candidate sites (DOE 1997b). Not suitable for the development of the proposed SNS are DOE operations offices, site offices, power administrations, and special purpose offices. The search was limited to facilities, such as national laboratories, that would likely have sufficient land holdings to accommodate the proposed SNS.

Other existing federal sites included Department of Defense facilities (e.g., closed U.S. Air Force bases) or lands managed by other federal agencies, such as the Department of the Interior. DOE also had the option of acquiring a new, privately owned site through purchase, trade, or possible condemnation. However, acquisition of these properties would have required lengthy, costly, and detailed site selection, environmental compliance, and jurisdictional transfer processes. In addition, while some of these sites might have offered the physical, power, and infrastructure requirements needed to meet the proposed SNS Project mission goals, none of them could offer the necessary neutron science and infrastructure support requirements.

A final candidate site category included co-location of the proposed SNS facility at a nonfederal location, such as an academic center or private research facility. This category was dropped from further consideration because few, if any, non-DOE facilities could offer neutron science and infrastructure support needed for efficient operation of the SNS. Also, establishing a facility with the overall magnitude of the proposed SNS would be similar to establishing another national laboratory. This site category would not maximize the use of existing federal and/or DOE resources, would not be cost efficient, and could duplicate existing DOE missions, thereby being in direct conflict with current DOE initiatives, as defined in several recently released studies and reports (DOE 1997b).

Therefore, it was deemed appropriate to limit the search for alternative proposed SNS sites to federal properties. Furthermore, this search was limited to specific types of DOE facilities, such as the national laboratories, because of their scientific and technical infrastructures.

Most of the DOE-owned or -operated facilities were immediately eliminated from consideration because of the nature of the sites or the uniqueness of the programs carried out at the sites. For example, DOE operations offices were excluded from the list of considered sites because they are typically in office buildings located in or near downtown population areas, and they lack sufficient land to meet proposed SNS Project objectives. DOE power administration offices and most special project offices are specialized, and they do not have the necessary program experience or infrastructure to support the proposed SNS. Examples would include the oil reserves in California and Louisiana and the oil shale reserves in Colorado and Wyoming. Based on the 4 DOE facility-screening criteria, 39 DOE facilities or sites were carried forward as the universe of potential sites for the proposed SNS.

Each of the 39 facilities was reviewed against the 4 major exclusion criteria. Failure of a site to meet any of the four criteria resulted in its elimination from further consideration. Through this process, 35 facilities were eliminated. The four remaining sites represent the array of reasonable site alternatives for the proposed SNS. These sites are ORNL, LANL, ANL, and BNL. They are the siting alternatives considered for detailed analysis in this EIS (refer to Sections 3.2.4.2. through 3.2.4.5).

3.2.4.1.4 Phase 2 Site Selection

Phase 2 of the site-selection process involved selecting a specific location for the proposed SNS at each of the four national laboratories. DOE sent the proposed SNS site requirements to each of the four national laboratories, each of which was responsible for selection of their preferred site for the proposed SNS. The four site alternatives identified by the site-selection process are described briefly below. Detailed characterization of each site is presented in Chapter 4.

3.2.4.2 Oak Ridge National Laboratory (Preferred Alternative)

As required by CEQ regulations for implementing NEPA [40 CFR 1502.14(e)], DOE has identified the preferred alternative: to construct and operate the proposed SNS at ORNL in Oak Ridge, Tennessee. The Oak Ridge Reservation (ORR) is located in and around the city of Oak Ridge, Tennessee. It was acquired by the federal government in 1942 for the wartime Manhattan Project. The ORR contains three major facilities: ORNL, the Y-12 Plant, and the East Tennessee Technology Park (ETTP, formerly the K-25 Site), and occupies approximately 35,516 acres (14,379 ha) in Roane and Anderson counties. The ORR and the proposed site for the SNS are shown in Figure 3.2.4.2-1. This site was selected through a formal evaluation process. The site-selection report describing this process is provided in Appendix B.

The proposed site comprises a long, wide, and gently sloping ridge top with a broad saddle area at its eastern end. This area is planned for the target station and would require a minimum of excavation. The linac, transport line, and ring

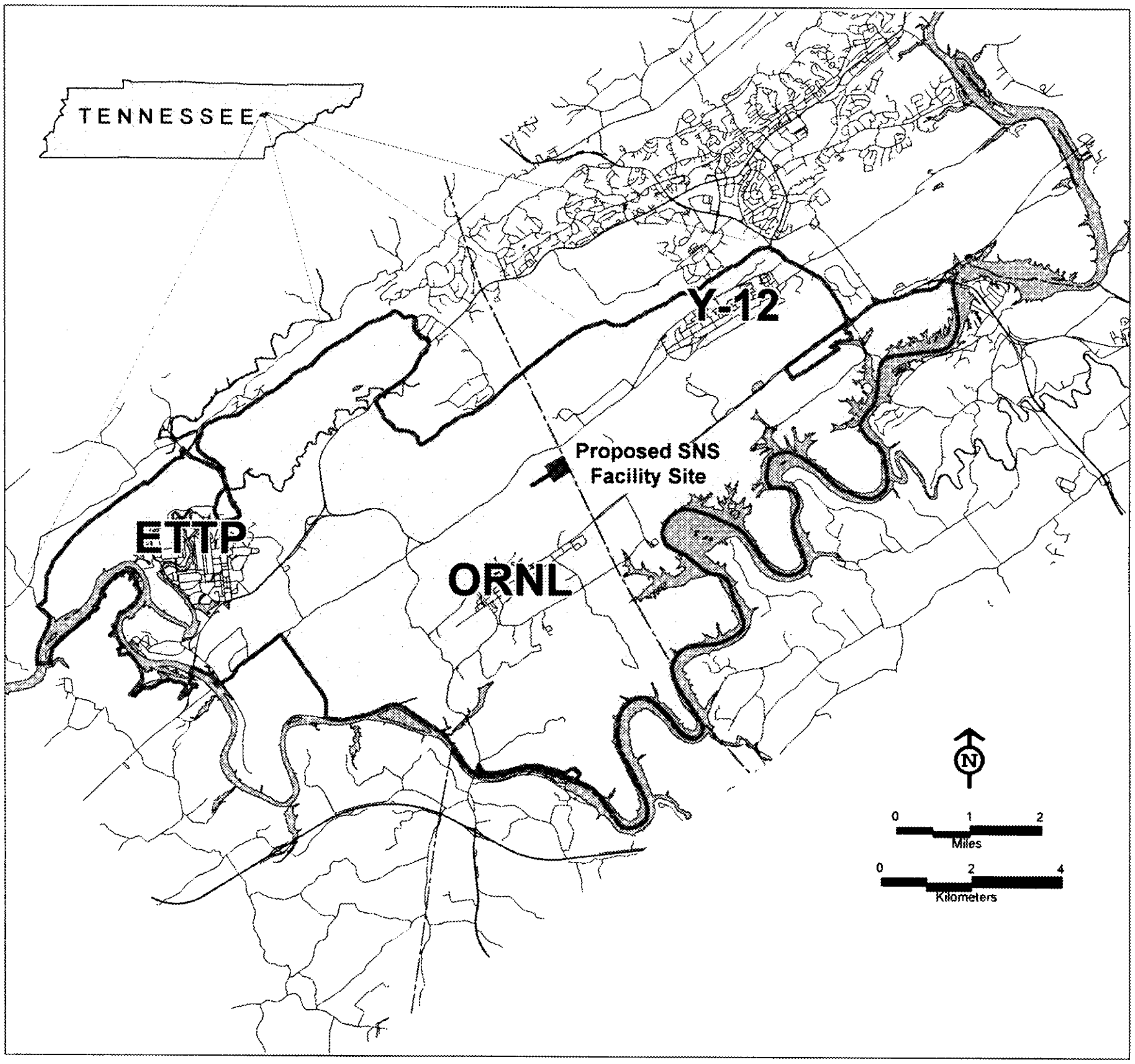


Figure 3.2.4.2-1. ORNL proposed SNS site.

tunnels would be notched into the south side of the ridge using cut-and-fill techniques, providing economical construction and effective shielding strategies. Initial characterization of the site indicates bedrock located approximately 150 feet below the planned level of the accelerator components with very stable soil being the primary matrix for emplacement of the physical plant. Appropriate foundations would provide the required stability for the accelerator and support structures. The entire site is currently undeveloped.

Table 3.2.4.2-1 describes site-specific information concerning utilities and infrastructure requirements at the ORNL site. Detailed characterization of the ORNL site is provided in Section 4.1.

Table 3.2.4.2-1. Utility and infrastructure requirements for the proposed SNS site at ORNL.

Facility Requirements	Site-Specific Attributes
Site access	Primary access is by Chestnut Ridge Road from Bethel Valley Road. The condition of Chestnut Ridge Road is passable and of gravel construction. The road is currently accessible through a gate with virtually no traffic on this road. Approximately 2 mi (3.2 km) of Chestnut Ridge Road would be upgraded in accordance with the Tennessee Department of Transportation (DOT) standards and specifications to support heaviest anticipated traffic, including emergency vehicles weighing up to 20 tons.
Borrow material and spoils disposal	The proposed SNS will have soil berms shielding the linac, storage rings, and beam transfer lines. The source of the material for the berms is stockpiled material from the site excavation. New service road would be constructed from the proposed SNS site to the West Borrow Area, located approximately 1,500 ft southwest of the proposed site. The West Borrow Area is an operating source of dirt and fill material for projects on the ORR.
Electrical power	Power required for the proposed SNS (62 MW for 1-MW beam; 90 MW for 4-MW beam) would be provided by the DOE-owned 161-kV transmission line located less than 3,000 ft (914 m) west of the site. A feed line would be constructed from the existing line to a new primary substation at the proposed SNS site.
Potable water	Potable water [800 gpm (3,028 lpm) for 1-MW beam; 1,600 gpm (6,057 lpm) for 4-MW beam] would come from 24-in (61-cm) ORNL water main, which runs through the eastern end of the proposed site. Existing capacity within the plant and supply lines is available to meet anticipated demand.
Natural gas	Natural gas (1,000 lb/hr in winter months) would be piped from the ORNL 100-psig distribution header from the East Tennessee Natural Gas Company (ETNG) B-Station. Approximately 5,000 ft (1,524 m) of pipeline would be constructed along Chestnut Ridge Road to the site. The ETNG line is sized sufficiently to supply the demand at the proposed SNS.
Steam	The proposed SNS facility would include steam generation. Steam is available from the ORNL steam plant but would require a minimum of 1.5 mi (2.4 km) of insulated steam pipe, a condensate collection system, and/or a return system.
Compressed air	The proposed SNS facility would include air compressors.
Chilled water	The proposed SNS facility would include water chillers (32,000 tons).

3.2.4.3 Los Alamos National Laboratory

This alternative would involve the construction and operation of the proposed SNS on a site at LANL. The geographic location of LANL is illustrated in Figure 3.2.4.3-1. The site was selected through a formal evaluation process. Appendix B contains the site-selection report describing this process.

LANL is located in Los Alamos County in north-central New Mexico, approximately 60 mi (97 km) north-northwest of Albuquerque and 25 mi (40 km) northwest of Santa Fe. The 43-mi² (111-km²) laboratory is situated on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-to-west oriented canyons cut by intermittent streams. Since its inception in 1943 as the Manhattan Project's site for development of the first nuclear weapons, LANL's primary mission has been nuclear weapons research and development and related projects.

Most laboratory and community development is confined to the mesa tops. The surrounding land is largely undeveloped, and large tracts of land north, west, and south of the laboratory are held

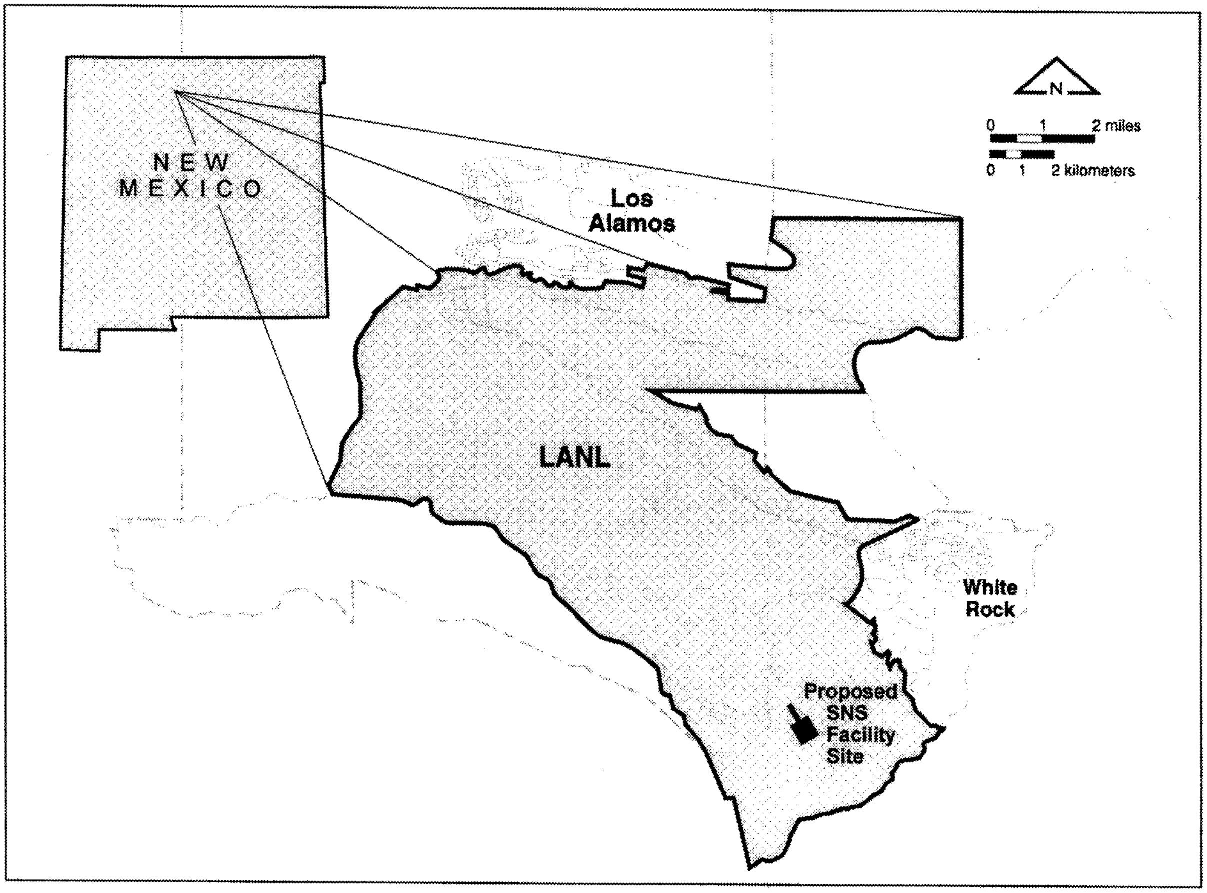


Figure 3.2.4.3-1. LANL proposed SNS site.

by the Santa Fe National Forest, Bureau of Land Management, Bandelier National Monument, General Services Administration, and Los Alamos County. The Pueblo of San Ildefonso borders the laboratory to the east. Table 3.2.4.3-1 describes site-specific information concerning utilities and infrastructure requirements at the LANL site. Detailed characterization of the proposed project site is provided in Section 4.2.

3.2.4.4 Argonne National Laboratory

The implementation of this alternative would involve constructing and operating the proposed SNS on a site at ANL. Like ORNL, ANL was established in 1942 as a part of the Manhattan Project. ANL's mission is research and development in basic energy and related sciences and is an important engineering center for the study of nuclear and nonnuclear energy sources. Figure 3.2.4.4-1 shows the geographic location of ANL. This site was selected through a formal evaluation process. The site-selection report outlining this process is provided in Appendix B.

ANL occupies 1,500 acres (610 ha) of gently rolling land in the Des Plaines River Valley of DuPage County, Illinois. It is about 27 mi (43 km) southwest of downtown Chicago and 24 mi (39 km) west of Lake Michigan. Surrounding the ANL site is the Waterfall Glen Nature Preserve, a 2,040-acre (826-ha) greenbelt forest preserve of the DuPage County Forest Preserve District. This land was deeded to the

Table 3.2.4.3-1. Utility and infrastructure requirements for the proposed SNS site at LANL.

Facility Requirements	Site-Specific Attributes
Site access	Primary access would be via a new access road off State Road 4 to the proposed SNS site. State Road 4 is a rural state highway, and any highway upgrades would have to be negotiated with the New Mexico State Highway Department. Other traffic concerns may be associated with access to Bandelier National Monument.
Borrow material and spoils disposal	Borrow material sources within LANL are limited and are not located near the proposed SNS site. One option would be to negotiate with Los Alamos County for borrow material currently located at the Los Alamos County Landfill.
Electrical power	LANL's existing electrical power system infrastructure is not adequate to support an additional 62-MW (1-MW beam) or 90-MW (4-MW beam) demand. It would be necessary to bring in a new 115 kV line from east of the site or to construct an SNS site-specific power generator. The specific siting of a new line is still under evaluation.
Potable water	Accommodating this need [800 gpm (3,028 lpm) for 1-MW beam; 1,600 gpm (6,057 lpm) for 4-MW beam] would require extensive potable water delivery system upgrades, including many lines, lift stations, and storage tanks. The nearest potable water system at TA-39 would not be able to provide the required demand.
Natural gas	Natural gas is not available. Alternate energy source (e.g., electricity) would be necessary for space heating and hot water.
Steam	The proposed SNS facility would include steam generation.
Compressed air	The proposed SNS facility would include air compressors.
Chilled water	The proposed SNS facility would include water chillers.

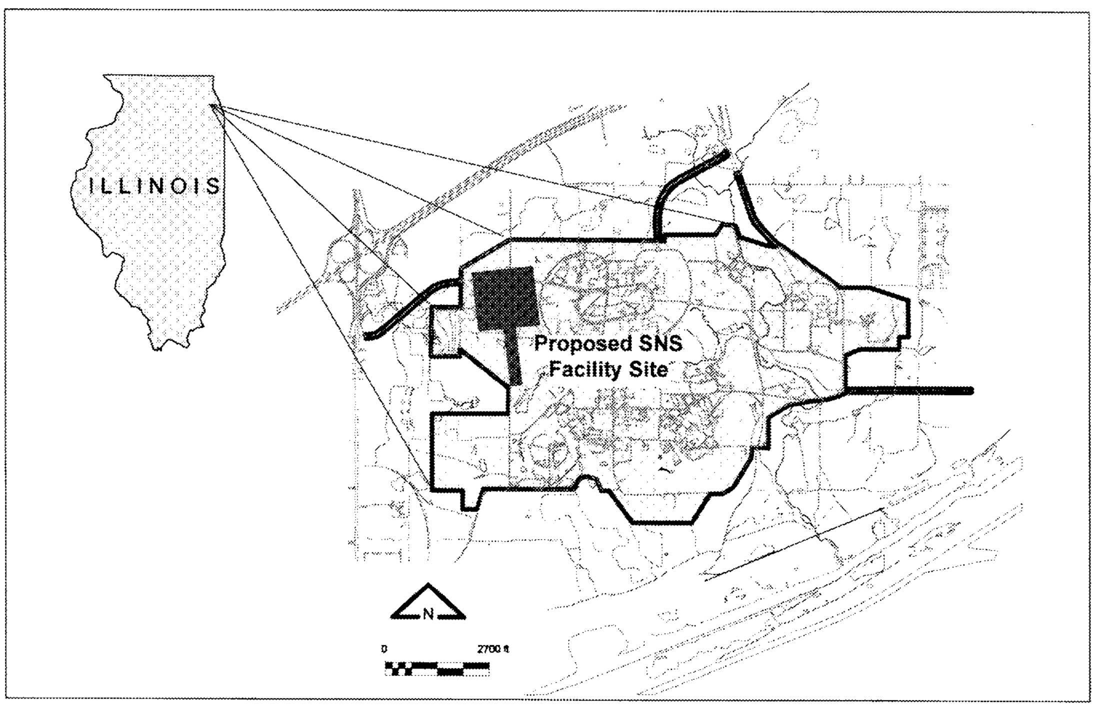


Figure 3.2.4.4-1. ANL proposed SNS site.

DuPage County Forest Preserve District in 1973 for use as a public recreation area, nature preserve, and demonstration forest. Nearby highways are Interstate 55 to the north and Illinois Highway 83 to the east. About 1 mi (1.6 km) south of ANL are the Des Plaines River, the Chicago Sanitary and Ship Canal, and the Illinois Waterway (Illinois and Michigan Canal). Table 3.2.4.4-1 describes site-specific information concerning utilities and infrastructure requirements at the ANL site. Detailed characterization of the proposed ANL site is provided in Section 4.3.

3.2.4.5 Brookhaven National Laboratory

This alternative would involve the construction and operation of the proposed SNS on a site at BNL. The geographic location of BNL on Long Island is illustrated in Figure 3.2.4.5-1. A formal evaluation process was used to select this site. The site-selection report describing this process is provided in Appendix B.

Table 3.2.4.4-1. Utility and infrastructure requirements for the proposed SNS site at ANL.

Facility Requirements	Site-Specific Attributes
Site access	Primary access is from West Gate Road and Kearney Road. The existing road is a two-lane blacktop road that currently handles mostly automobile traffic and handles intermittent heavy truck traffic. It is capable of handling construction traffic. Approximately 1 mi (1.6 km) of West Gate Road would have to be constructed, circumventing the proposed SNS site, to replace the access to ANL from the West Gate.
Borrow material and spoils disposal	Borrow material could be obtained by providing retention ponds and replacement wetland areas. Any additional material would be obtained from clean fill sources outside of ANL.
Electrical power; Connected	Electrical power of 62 MW for a 1-MW beam and 90 MW for a 4-MW beam are required for the proposed SNS. Remaining capacity of 50 MW exists from substation 549A. This substation would have to be upgraded to provide the necessary power. A 6,600-ft (2,012-m) long 138-kV overhead line is needed to connect the proposed SNS site to substation 549A. The route for the 138-kV line is from substation 549A, up Southwood Drive and along Outer Circle Road to Watertower Road to the 800 Area.
Potable water	Potable water is supplied to ANL from Lake Michigan. The current system can meet the proposed SNS demand [800 gpm (3,028 lpm) for 1-MW beam; 1,600 gpm (6,057 lpm) for 4-MW beam].
Non-potable water	Non-potable water, suitable for cooling tower operation, is available from the ANL Canal Water Distribution System [remaining capacity is about 2 mgpd (7.6 million lpd)]. Approximately 2,000 ft (610 m) of pipeline would be constructed along West Gate Road.
Natural gas	The ANL gas distribution system delivers 10 psig. Approximately 2,000 ft (610 m) of gas line would be constructed from the existing distribution system along West Gate Road to the proposed site. The natural gas lines around the ANL site are scheduled to be upgraded next year. Any capacity increases and/or line extensions could be incorporated in this upgrade.
Steam	Steam heat would require about 1,500 ft (457 m) of steam lines. ANL can accommodate about 300,000 lb/hr of additional steam demand.
Compressed air	The proposed SNS facility would include air compressors.
Chilled water	The proposed SNS facility would include water chillers.

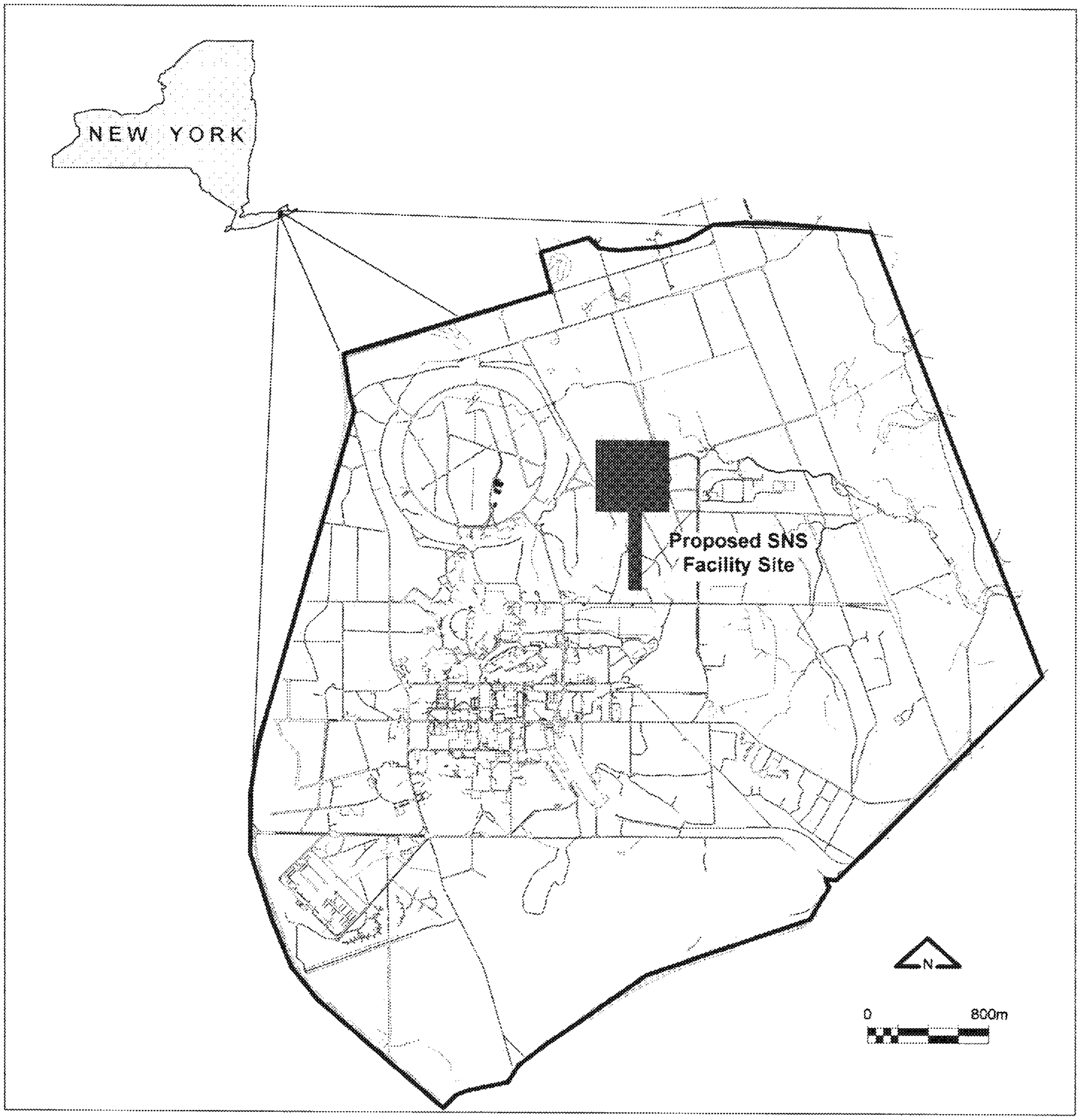


Figure 3.2.4.5-1. BNL proposed SNS site.

The BNL is located in Suffolk County on Long Island, approximately 60 mi (97 km) east of New York City. The BNL is situated on 5,263 acres (2,130 ha) of land, most of which is wooded and undeveloped. The BNL was established in 1947 as a part of the Manhattan Project. It was established on the former site of Camp Upton, a U.S. Army facility during World Wars I and II. The BNL's current mission is to conceive, design, construct, and operate large, complex research facilities for fundamental scientific studies and to conduct basic and applied research in the physical, biomedical, and environmental sciences and in selected energy technologies. Table 3.2.4.5-1 provides site-specific information concerning utilities and infrastructure requirements at the BNL site. Detailed characterization of BNL is provided in Section 4.4.

3.3 NO-ACTION ALTERNATIVE

This alternative serves as a basis for comparison against other alternatives evaluated in the EIS. It describes continuation of the current (status quo) situation into the future, if the proposed action is not implemented.

The No-Action Alternative for this EIS would be to continue using the existing neutron science facilities in the U.S. without construction and operation of the proposed SNS at the preferred site or one of the three alternative sites. Because of currently high and ever-increasing demand for access to neutron science facilities, the existing U.S. facilities would increasingly fail to meet domestic experimentation demand under the No-Action Alternative.

Table 3.2.4.5-1. Utility and infrastructure requirements for the proposed SNS site at BNL.

Facility Requirements	Site-Specific Attributes
Site access	Primary access is from East Fifth Avenue and Relativistic Heavy Ion Collider Road. Existing roads are adequate for anticipated traffic.
Borrow material and spoils disposal	Material for the soil berm would come from various firebreaks on BNL. Spoils would be stored in the BNL transfer station.
Electrical power	For the demands of 62-MW (1-MW beam) or 90-MW (4-MW beam) a new 69-kV transmission line would have to be constructed to the LILCO 138-kV grid. The length of the line would be approximately 1 mi (1.6 km), and it would run parallel to BNL's existing stand-by 69-kV transmission line. The LILCO grid would require a new 138-to-69-kV substation.
Potable water	Potable water demands [800 gpm (3,028 lpm) for a 1-MW beam; 1,600 gpm (6,057 lpm) for 4-MW beam] could be supplied by three domestic water wells in the area, each capable of producing approximately 1,200 gpm (4,542 lpm).
Natural gas	The present usage peaks at approximately 200,000 ft^3/hr, and 40,000 ft^3/hr is available. The gas line is approximately 4,000 ft (1,219 m) from the proposed site.
Steam	The present steam load at BNL peaks at 170,000 lb/hr. The present steam plant has a firm capacity of 295,000 lb/hr. There is sufficient capacity for an estimated load of 1,500 lb/hr, which is required for the Long Island climate.
Compressed air	The proposed SNS facility would include air compressors.
Chilled water	The proposed SNS facility would include water chillers.

3.4 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS

There are several different methods for producing high-power, short-pulse beams of protons in the 1-GeV power range that were evaluated during the conceptual design of the proposed SNS. The following alternatives were considered; however, DOE concluded that they are technically inferior. Additional details of the technical rationale can be found in the *Conceptual Design Report* (ORNL 1997a and 1997b).

3.4.1 PARTIAL-ENERGY LINAC AND A RAPID-CYCLING SYNCHROTRON

The partial-energy linac and a rapid-cycling synchrotron is a well-understood, proven accelerator technology. However, significant drawbacks to this approach make it unsuitable for the proposed SNS. The most important concern is associated with future upgrades to a higher operating power and thus increased research capability. Unlike the full-energy linac of the proposed SNS, which allows upgrading the facility to 2-MW beam power without a major construction project, any and all updates to a synchrotron facility would require major construction activity. Even modest upgrading (2-MW) of the facility would be a major construction project, entailing the building of a second booster synchrotron to reach the proton energy necessary for the higher beam power. A fully upgraded facility (4 MW) would require a beam energy on target of 10 GeV. This upgrade would require changing the design of the target, moderators, and shielding, thereby undertaking another large-scale construction project.

The second most important concern with the partial-energy linac and rapid-cycling synchrotron option is the limited flexibility for accommodating different pulse frequencies. The proposed SNS would be designed to produce neutron pulses at varying rates of 10 to 60 Hz. The normal operating mode of the synchrotron would be 30 Hz. Higher repetition rates are not possible and lower rates can only be achieved by discarding some of the 30-Hz pulses, which would result in a loss of overall power delivered to the target.

This alternative would not allow DOE to meet the purpose and need for action. Therefore, it is not analyzed further in this EIS.

3.4.2 FULL-ENERGY SUPERCONDUCTING LINAC WITH AN ACCUMULATOR RING

This alternative incorporates superconductivity technology into the design of the proposed SNS. Superconductivity technology is quite mature for fabricating magnets and constructing several radio-frequency linacs. The Continuous Electron Beam Accelerator Facility, located in Newport News, Virginia, and the Large Electron-Positron located in Switzerland are examples of superconducting cavities that have met stringent accelerator requirements for technical performance and reliability. Both of these structures are designed for electron beams, and they operate in continuous wave mode.

However, the requirements for the proposed SNS include pulsed operations. Anticipated problems with pulsed operation using superconducting linacs have been identified and characterized, but they have not been resolved (Alonso, 1998). Although there is an ongoing research and development program in Europe, it is unknown whether good technological solutions can be found within the necessary time frame. This could result in an indefinite delay in providing the required neutron source that fulfills the purpose and need (refer to Chapter 2). The research and development of superconducting pulsed linacs will be closely watched to possibly incorporate breakthroughs that may come. However, the proposed SNS Project has insufficient resources to conduct the extensive research and development program that would be required to resolve the technical uncertainties associated with this technology. Therefore, this alternative is not analyzed further in this EIS.

3.4.3 INDUCTION LINAC, EITHER FULL-ENERGY OR INJECTING A FIXED-FREQUENCY ALTERNATING GRADIENT ACCELERATOR

The induction linac offers the attractive possibility of producing very short pulses of very high current without the need for an accumulator or synchrotron ring. However, no existing induction linac has accelerated protons to the energies required by the next-generation neutron source. Designing such an accelerator is viewed as straightforward and, in fact, an initial feasibility study has been performed. However, costs would be greater than for options utilizing rings, and the reliability of the high-power switches for the required service life is viewed as problematic. Although a concerted development effort for this technology is currently underway at Lawrence Berkeley National Laboratory, too much technical uncertainty remains to accept this technology as viable for the proposed SNS.

The fixed-frequency alternating gradient accelerator component of the induction linac presents some attractive features, most notably the ability to efficiently accelerate high-current beams injected by either an rf linac or, most intriguingly, by an induction linac. Studies on the viability of a fixed-frequency alternating gradient accelerator design have been conducted for spallation source application in both Europe and the U.S. However, as is the case with the induction linac, no fixed-frequency alternating gradient accelerator has been built in the range of performance required for the proposed SNS, and the technology is not viewed as mature enough to be technically viable at this time. Therefore, this alternative is not analyzed further in this EIS.

3.5 ENVIRONMENTAL CONSEQUENCES

This section provides a comparative summary of the potential environmental impacts that would result from implementing the proposed action at each of the four SNS siting alternatives and from implementing the No-Action Alternative. All impacts are described in terms of the various aspects of the existing environment that might be expected to change over time as a result of their implementation. This summary is based on the detailed environmental impacts identified and described in Chapter 5 of this EIS.

Table 3.5-1 covers the environmental impacts, which are presented according to internal headings that correspond to the major impacts analysis subheadings in Chapter 5 of this EIS. Under the other internal headings this table covers impacts on long-term productivity of the environment and cumulative impacts. Cumulative impacts are the effects on the existing environment that would result from the incremental effects of the proposed action when added to the effects from other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or nonfederal), private industry, or individuals undertake these other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

INDEX

Table 3.5-1 Comparison of impacts among alternatives.

Category **Page**

Table 3.5-1. Comparison of impacts among alternatives.

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
1a. Impacts on Geology and Soils (Construction)				
No effects from seismicity.				No effects from seismicity.
Erosion and siltation during construction. Minimal effects on soils or site stability.				No effects on soils or site stability.
1b. Impacts on Geology and Soils (Operations)				
The soil in the berm used to shield the linac tunnel would be subject to neutron activation caused by a small portion of particles (hydrogen ions) escaping from the particle beam as it travels down the linac. An estimated total of 3.09 E05 Ci of radioactive isotopes would be generated in the soil berm by neutron activation over the life of the facility. The maximum design beam loss rate is 1.0 E-09 amps per meter of linac. This design limit is the same for all linac beam power levels, hence soil activation would be the same at both 1 and 4 MW. For the analysis of potential effects, the beam loss is assumed to be 10.0 E-09. The total curies (3.09 E05) is based on this conservative limit.				No effects on soils.
No effects from seismicity or on site stability because of design to meet known seismic hazards at ORNL.	No effects from seismicity or site stability because of design to meet known seismic hazards at LANL.	No effects from seismicity or site stability because of design to meet known seismic hazards at ANL.	No effects from seismicity or site stability because of design to meet known seismic hazards at BNL.	No effects from seismicity.
2a. Impacts on Water Resources (Construction)				
No effects on floodplains. Minimal increase in run-off and siltation from improvements to Chestnut Ridge Road.	No effects on floodplains.	Construction in very small areas on the 100-year floodplains (<5 acres) of an unnamed tributary of Sawmill Creek and Freund Brook.	No effects on floodplains.	No effects on floodplains.
Minimal effects on surface water (see Impact 1a).				No effects on surface water.
2b. Impacts on Water Resources (Operations)				
No effects on floodplains.				No effects on floodplains.
Overall effects expected to be minimal. Discharges to surface water would increase average base flow by 50%, (continued on next page)	Overall effects expected to be minimal. Discharges to surface water would result in channel erosion in (continued on next page)	Overall effects expected to be minimal. Discharges to surface water would increase base flow, resulting in (continued on next page)	Overall effects expected to be minimal. Discharges to surface water would increase base flow, resulting in (continued on next page)	No effects on surface water resources.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
2b. Impacts on Water Resources (Operations) — continued				
resulting in increased stream velocity and channel erosion in White Oak Creek. Minimal effects from biocides and antiscaling agents relative to flow. Slight increase (4%) in radionuclide flux over White Oak Dam.	intermittent TA-70 drainages. Most flow would infiltrate soil before reaching Rio Grande River. Minimal effects from biocides and antiscaling agents relative to flow.	increased stream velocity and channel erosion in an unnamed tributary of Sawmill Creek. Minimal effects from biocides and antiscaling agents relative to flow.	increased stream velocity and channel erosion in the headwaters of the Peconic River. Most flow would infiltrate the subsurface in the river channel before reaching the BNL boundary. Minimal effects from biocides and antiscaling agents relative to flow.	
Potential localized increase in groundwater radionuclide concentrations (at a depth of 100 ft or more) due to leaching of neutron-activated soil in the shielding berm for the linac tunnel. Three radionuclides would equal or exceed the 10 CFR Part 20 limit (shown in parentheses) at 10 m away from the site: ^{14}C 4.4 E-04 μCi/cc (3E-04 μCi/cc), ^{22}Na 5.5 E-05 μCi/cc (6 E-06 μCi/cc), and ^{54}Mn 3.0 E-05 μCi/cc (3 E-05 μCi/cc).	Pumping may lower water levels in nearby wells and affect productivity of main aquifer. Potential localized increase in groundwater radionuclide concentrations due to leaching of neutron-activated soil in the shielding berm for the linac tunnel. Groundwater effects would be least likely at LANL because of low infiltration rate and greater depth [820 ft (250 m)] to main aquifer.	Potential localized increase in groundwater radionuclide concentrations due to leaching of neutron-activated soil in the shielding berm for the linac tunnel. A potable groundwater aquifer lies at a depth of 165 ft (50 m). The downward rate of water movement through the saturated zone of the Wadsworth Till is only 3.0 ft/yr (0.9 m/yr). High clay content of the till would retard radionuclide migration, but accurate prediction of migration rates and potential for aquifer contamination would be difficult because of the complex deposits.	Highest potential for increase in groundwater radionuclide concentrations due to leaching of neutron-activated soil in the shielding berm for the linac tunnel. The sole source aquifer for Long Island would lie only 20 ft (6.1 m) below the SNS. High permeability of the soils [17 ft/yr (5.2 m/yr)] would allow higher levels of radionuclides in the aquifer in the immediate vicinity of the SNS. Exceedance of drinking water limits for a human receptor at an off-site location would be unlikely.	No effects on groundwater resources.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
3a. Impacts on Climate and Nonradiological Air Quality (Construction)				
Temporary increases in suspended particulates (PM_{10}) during work hours (10-hr day). Primarily fugitive dust from vegetation clearing, excavation, and land contouring.				No effects on nonradiological air quality.
3b. Impacts on Climate and Nonradiological Air Quality (Operations)				
No effects on local or regional climate.				No effects on local or regional climate.
Combustion of natural gas would emit air pollutants, CO_2, CO, NO_2, and PM_{10}, limited by NAAQS. Off-site levels of pollutants would all be less than 20% of the NAAQS limit. Diesel back-up generators would only run in an emergency. Effects on nonradiological air quality would be expected to be minimal.	Combustion of natural gas would emit air pollutants, CO_2, CO, NO_2, and PM_{10}, limited by NAAQS. Off-site levels of pollutants would all be less than 5% of the NAAQS limit. Diesel back-up generators would only run in an emergency. Effects on nonradiological air quality would be expected to be minimal.	Combustion of natural gas would emit air pollutants, CO_2, CO, NO_2, and PM_{10}, limited by NAAQS. Off-site levels of pollutants would all be less than 5% of the NAAQS limit. Diesel back-up generators would only run in an emergency. Effects on nonradiological air quality would be expected to be minimal.	Combustion of natural gas would emit air pollutants, CO_2, CO, NO_2, and PM_{10}, limited by NAAQS. Off-site levels of pollutants would all be less than 5% of the NAAQS limit. Diesel back-up generators would only run in an emergency. Effects on nonradiological air quality would be expected to be minimal.	No effects on nonradiological air quality.
4a. Impacts on Noise Levels (Construction)				
Short-term increase in noise to continuous moderate levels (approximate average level of 86 dBA). Effects on humans and wildlife would be minimal because of distances (more than 400 ft) from sources, natural barriers, and worker hearing protection.				No effects on noise levels.
4b. Impacts on Noise Levels (Operations)				
Elevated continuous noise levels from cooling towers, compressors, and ventilation fans/blowers (approximate average level of 86 dBA). Minimized with landscape barriers. Periodically increased traffic noise. Minimal overall noise effects to human and wildlife populations.				No effects on noise levels.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
5a. Impacts on Ecological Resources (Construction)				
Removal of vegetation from 110 acres (45 ha) of land (less than 0.5% of the total forested area of the ORR) would result in increased forest fragmentation. This would have a minimal effect on terrestrial wildlife movement because a forested path along Chestnut Ridge would be retained. Only a portion of the ridge and ORR would be affected.	Removal of vegetation from 110 acres (45 ha) of land. Minimal effects on wildlife movement or the roosting, feeding, and reproduction of birds because 90% of TA-70 would remain undeveloped.	Removal of vegetation from 110 acres (45 ha) of land partially developed in the past. This would result in a long-term reduction of wildlife habitat and populations on the SNS site and in adjacent areas. These effects would be minimal because the species that would be involved are neither rare nor game species and other habitat exists in the region.	Removal of vegetation from 110 acres (45 ha) of land would displace wildlife to surrounding areas. This displacement may exceed carrying capacity in these areas, resulting in a small but permanent population reduction for one or more species. The proposed site lies within the Compatible Growth Area of the Pine Barrens. The 110 acres represent less than 20% of the Pine Barrens Protection Area.	No effects on terrestrial resources.
Construction would temporarily disturb wildlife occupying areas adjacent to the proposed site. This could result in emigration of some sensitive species from the surrounding area.				No effects on terrestrial resources.
Construction of the SNS would encroach on two small wetlands, with a combined area of 0.12 acres. A third, forested wetland, with an area of 1.6 acres, may receive increased runoff and siltation during construction activities. This wetland contains two plant species that are uncommon in Tennessee. There would be minimal effects on four additional (continued on next page)	No effects on wetlands within the SNS site or in TA-70 because there are no wetlands on or in the vicinity of the proposed site.	Approximately 3.5 acres (1.4 ha) of wetlands would be destroyed by construction. DOE would consult on plans to mitigate their loss. Temporary, minor effects to other wetlands surrounding the proposed site during construction.	There are no wetlands within the proposed SNS site. Minimal effects on Peconic River wetlands from runoff and sedimentation because of implementing runoff and erosion control measures.	No effects on wetlands.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
5a. Impacts on Ecological Resources (Construction) — continued				
small wetlands located outside of the construction area. Appropriate mitigation measures, including wetland replacement or enhancement and control of surface runoff, would be employed to minimize effects to these wetlands.				
Minimal effects on aquatic resources from increased runoff and sediment loading in White Oak Creek due to runoff and erosion control measures. Minimal effects on cool water fish (banded sculpin and blacknose dace) habitat from vegetation clearing and associated solar radiation increase of water temperature in White Oak Creek, because of leaving a 100- to 200-ft (30- to 60-m) uncleared vegetation buffer zone along the creek for shade.	No effects on aquatic resources. There are no aquatic resources on or in the vicinity of the proposed site.	Minimal effects on aquatic resources, particularly bottom-dwelling fauna, from increased runoff and sediment loading in Freund Brook, because of establishing a 100- to 200-ft (30- to 60-m) uncleared vegetation buffer zone along the brook and implementing erosion control measures.	Minimal effects on aquatic resources from increased runoff and sediment loading in the Peconic River, because of establishing a minimum 300-ft (91-m) uncleared vegetation buffer zone between the SNS site and the river and implementing erosion control measures.	No effects on aquatic resources.
Minimal effects on threatened and endangered (T&E) plant species due to implementation of protective measures. No T&E or other (continued on next page)	Minimal effects on American peregrine falcon and bald eagle population from small reductions in non-nesting habitat. No T&E plant (continued on next page)	No protected species were identified on the proposed SNS site. Therefore, no effects on T&E or other protected species.	Minimal effects on state-protected plant species identified on the SNS site due to implementation of protective measures. No (continued on next page)	No effects on T&E or other protected species.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
5a. Impacts on Ecological Resources (Construction) — continued				
protected animal species were identified within the proposed footprint of the SNS.	species were identified on the SNS site.		T&E or other protected animal species were identified on the SNS site.	
5b. Impacts on Ecological Resources (Operations)				
During operations, runoff from the site would be directed to the sediment retention basin; thus increased runoff to wetlands in the vicinity of the site would be expected to be minimal.	Minimal effects on wetlands in arroyos of Ancho Canyon and unnamed canyon to the northeast because cooling water flow could not reach these areas, except possibly during a heavy rain event.	During operations, runoff from the site would be directed to the sediment retention basin; thus increased runoff to wetlands in the vicinity of the site would be expected to be minimal.	During operations, runoff from the site would be directed to the sediment retention basin; thus increased runoff to wetlands in the vicinity of the site would be expected to be minimal.	No effects on wetlands.
Minimal effects on aquatic resources in the headwaters area of White Oak Creek. Cooling water and runoff from the proposed site would be collected in the sediment retention basin. Discharge to White Oak Creek would be south of Bethel Valley Road. If necessary, the cooling tower blowdown would be dechlorinated. The retention basin would allow for reduction in the temperature of the water prior to discharge in White Oak Creek. Only minimal effects to aquatic resources (continued on next page)	No effects on aquatic resources.	Biotic communities in Sawmill Creek may change as a result of increased flow from cooling water and runoff discharged into it from the sediment retention basin. These effects on aquatic resources would be minimal because the temperature of the discharge would be reduced to ambient temperature in the sediment retention basin.	No effects on aquatic resources in the upper reaches of the Peconic River because cooling water and runoff in the sediment retention basin would be released to the river near the current Sewage Treatment Plant outfall. Downstream flow increase would be less than a routine rain event, resulting in minimal effects to aquatic resources. If necessary, the cooling tower blowdown would be dechlorinated. The retention basin could allow for reduc-tion in the temperature of the (continued on next page)	No effects on aquatic resources.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
5b. Impacts on Ecological Resources (Operations) — continued				
downstream from the discharge point would be expected.			water prior to discharge to the Peconic River. Only minimal effects to aquatic resources would be expected.	
Minimal effects on T&E plant species due to implementation of protective measures. No T&E or other protected animal species were identified on the proposed SNS site. Two plants protected by the State of Tennessee, pink lady's slipper and American ginseng, were found in areas adjacent to the proposed site.	No T&E plant species were identified on the proposed SNS site. Minimal effects on American peregrine falcon and bald eagle populations because their use of the SNS site area would be less likely after development.	No known T&E or other protected species at ANL would be affected.	Minimal effects on state-protected plant species identified on the proposed SNS site due to implementation of protective measures. No T&E or other protected animal species were identified on the proposed SNS site.	No effects on T&E or other protected species.
6a. Impacts on Socioeconomics (Construction)				
Peak construction workforce of 578 workers would occur during construction of the 1-MW facility. Approximately 25% of workers may come from outside the Region of Influence (ROI). Based on experience with past major construction projects, most in-migrating workers would not relocate their families. However, if all in-migrating workers brought (continued on next page)	Peak construction workforce of 578 workers would occur during construction of the 1-MW facility. Approximately 25% of workers may come from outside the ROI. Based on experience with past major construction projects, most in-migrating workers would not relocate their families. However, if all in-migrating workers brought families into (continued on next page)	Peak construction workforce of 578 workers would occur during construction of the 1-MW facility. Approximately 25% of workers may come from outside the ROI. Based on experience with past major construction projects, most in-migrating workers would not relocate their families. However, if all in-migrating workers brought families (continued on next page)	Peak construction workforce of 578 workers would occur during construction of the 1-MW facility. Approximately 25% of workers may come from outside the ROI. Based on experience with past major construction projects, most in-migrating workers would not relocate their families. However, if all in-migrating workers brought families into (continued on next page)	No effects on regional population growth.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
6a. Impacts on Socioeconomics (Construction) — continued				
families into the area, the regional population would increase by approximately 0.01%. This would have minor effects on housing and regional community services.	the area, the regional population would increase by approximately 0.02%. This would have minor effects on housing and regional community services.	into the area, the regional population would increase by approximately 0.01%. This would have minor effects on housing and regional community services.	the area, the regional population would increase by approximately 0.01%. This would have minor effects on housing and regional community services.	
Design and construction employment would peak in FY 2002 during construction of the 1-MW facility. Based on modeling of regional economics, there would be an estimated 1,499 new jobs created, including direct, indirect, and induced jobs. Unemployment rate may potentially decrease from 3.2 to 3.0%.	Design and construction employment would peak in FY 2002 during construction of the 1-MW facility. Based on modeling of regional economics, there would be an estimated 1,447 new jobs created, including direct, indirect, and induced jobs. Unemployment rate may potentially decrease from 6.6 to 5.8%.	Design and construction employment would peak in FY 2002 during construction of the 1-MW facility. Based on modeling of regional economics, there would be an estimated 1,795 new jobs created, including direct, indirect, and induced jobs Because of the very large regional population, no decrease in the regional unemployment rate would be expected.	Design and construction employment would peak in FY 2002 during construction of the 1-MW facility. Based on modeling of regional economics, there would be an estimated 1,481 new jobs created, including direct, indirect, and induced jobs. Unemployment rate may potentially decrease from 3.4 to 3.3%.	No economic benefit.
6b. Impacts on Socioeconomics (Operations)				
Workforce for operation of the proposed SNS would be 250 persons for the 1-MW facility and 375 for the 4-MW facility. Regional population growth of approximately 0.01% due to worker in-migration would (continued on next page)	Workforce for operation of the proposed SNS would be 250 persons for the 1-MW facility and 375 for the 4-MW facility. Regional population growth of approximately 0.03% due to worker in-migration would (continued on next page)	Workforce for operation of the proposed SNS would be 250 persons for the 1-MW facility and 375 for the 4-MW facility. Regional population growth of approximately 0.01% due to worker in-migration would (continued on next page)	Workforce for operation of the proposed SNS would be 250 persons for the 1-MW facility and 375 for the 4-MW facility. Regional population growth of approximately 0.01% due to worker in-migration would (continued on next page)	No effects on regional socioeconomics.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
6b. Impacts on Socioeconomics (Operations) — continued				
have minor effects on housing and regional community services.	have minor effects on housing and regional community services.	have minor effects on housing and regional community services.	have minor effects on housing and regional community services.	
Operation of the proposed SNS at 4 MW would result in substantial regional spending for operator salaries, supplies, utilities, and administrative support. Operation of the proposed SNS would result in a maximum of 1,704 direct, indirect, and induced jobs. Operations would result in approximately \$68.7 million in local wages, \$7.5 million in business taxes, and \$75.9 million in personal income. Unemployment rate may potentially decrease from 3.2 to 3.0%. The effects of operation of the proposed SNS at the 1-MW power level would be similar but slightly less than the 4-MW case.	Operation of the proposed SNS at 4 MW would result in substantial regional spending for operator salaries, supplies, utilities, and administrative support. Operation of the proposed SNS would result in a maximum of 1,486 direct, indirect, and induced jobs. Operations would result in approximately \$66.8 million in local wages, \$7.6 million in business taxes, and \$71.4 million in personal income. Unemployment rate may potentially decrease from 6.6 to 5.8%. The effects of operation of the proposed SNS at the 1-MW power level would be similar but slightly less than the 4-MW case.	Operation of the proposed SNS at 4 MW would result in substantial regional spending for operator salaries, supplies, utilities, and administrative support. Operation of the proposed SNS would result in a maximum of 1,776 direct, indirect, and induced jobs. Operations would result in approximately \$82.9 million in local wages, \$8.7 million in business taxes, and \$91.2 million in personal income. Unemployment rate may potentially decrease from 5.2 to 5.1%. The effects of operation of the proposed SNS at the 1-MW power level would be similar but slightly less than the 4-MW case.	Operation of the proposed SNS at 4 MW would result in substantial regional spending for operator salaries, supplies, utilities, and administrative support. Operation of the proposed SNS would result in a maximum of 1,551 direct, indirect, and induced jobs. Operations would result in approximately \$71.6 million in local wages, \$10.3 million in business taxes, and \$80.5 million in personal income. Unemployment rate may potentially decrease from 3.4 to 3.2%. The effects of operation of the proposed SNS at the 1-MW power level would be similar but slightly less than the 4-MW case.	No economic benefits.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
6b. Impacts on Socioeconomics (Operations) — continued				
Operation of the proposed SNS would not cause high and/or adverse impacts to any of the surrounding populations. Therefore, there would not be a disproportionate risk of significantly high and adverse impact to minority and low-income populations.				The No-Action alternative would not cause high and/or adverse impacts to any of the surrounding populations. Therefore, there would not be a disproportionate risk of significantly high and adverse impact to minority and low-income populations.
7a. Impacts on Cultural Resources (Construction)				
No effects on prehistoric resources. No prehistoric cultural resources have been identified on or in the vicinity of the proposed SNS site.	Five prehistoric archaeological sites within the 65% survey area at the SNS site and eligible for listing on the NRHP would be destroyed by site preparation activities. In the unsurveyed area of the proposed SNS site, any prehistoric sites listed on or eligible for listing on the NRHP could also be destroyed by site preparation. If this site were chosen for construction of the SNS, the remaining 35% would be surveyed and assessed for specific effects prior to the initiation of construction activities. Effects on (continued on next page)	Prehistoric site 11DU207, adjacent to the proposed SNS site, may be disturbed or destroyed by construction activities. ANL has not assessed the NRHP eligibility of site 11DU207. If this site were chosen for construction of the SNS, an assessment of eligibility would be performed prior to the initiation of construction activities. If it is determined that a cultural resource would be affected, the effects would be mitigated by avoidance, if possible, or data recovery.	No effects on prehistoric resources. No prehistoric No effects on prehistoric resources. No prehistoric cultural resources have been identified on or in the vicinity of the proposed SNS site.	No effects on prehistoric resources.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
7a. Impacts on Cultural Resources (Construction) — continued				
	prehistoric archaeological sites would be mitigated by data recovery.			
No effects on historic resources. No historic cultural resources have been identified on or in the vicinity of the proposed SNS site.	No effects on historic resources within the surveyed 65% of the SNS site and buffer zone because no such resources have been identified in these areas. Site preparation activities in the unsurveyed area of the proposed SNS site would destroy any historic sites, structures, or features listed on or eligible for listing on the NRHP. If this site were chosen for construction of the SNS, the 35% area would be surveyed and assessed for specific effects prior to the initiation of construction activities. Effects would be mitigated by data recovery.	No effects on historic resources. Historic Period (A.D. 1600–present in the ANL area) buildings and features in the 800 Area on the proposed SNS site would be destroyed by site preparation activities. However, they are less than 50 yrs old and are not considered to be historic cultural resources.	A number of earthen features (potentially NRHP-eligible) at Stations 2, 4, 8, and 10 on the SNS site may have been associated with World War I trench warfare training at Camp Upton. They would be destroyed by construction activities. Effects would be mitigated by data recovery.	No effects on historic resources.
No effects on traditional cultural properties (TCPs). No TCPs identified on or in the vicinity of the proposed SNS site.	Five TCPs (prehistoric archaeological sites) within 65% survey area at SNS site would be destroyed by site preparation activities. If any prehistoric archaeological sites are located within the unsurveyed 35% of the SNS	No effects on TCPs. No TCPs identified on or in the vicinity of the proposed SNS site.	No effects on TCPs. No TCPs identified on or in the vicinity of the proposed SNS site.	No effects on TCPs.

(continued on next page)

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
7a. Impacts on Cultural Resources (Construction) — continued				
	site, these TCPs would also be destroyed. Because specific identities and locations of other on-site TCPs are not known, potential effects on such specific resources are uncertain.			
7b. Impacts on Cultural Resources (Operations)				
No effects on prehistoric or historic resources. Operational activities would be largely confined to the SNS site. No prehistoric or historic cultural resources have been identified on or in the vicinity of the proposed SNS site.	No effects on prehistoric or historic resources. Operational activities would be largely confined to the SNS site. No prehistoric archaeological sites would be present on the site after construction. No historic cultural resources have been identified on the proposed SNS site.	No effects on prehistoric or historic resources. Operational activities would be largely confined to the SNS site. No prehistoric or historic cultural resources have been identified on the proposed SNS site.	No effects on prehistoric or historic resources. Operational activities would be largely confined to the SNS site. No prehistoric cultural resources have been identified on or in the vicinity of the proposed SNS site. No historic cultural resources would be present on the site after construction.	No effects on prehistoric or historic resources.
No effects on TCPs. No TCPs identified on or in the vicinity of the proposed SNS site.	American Indian tribal groups have identified water resources (surface water and groundwater) as TCPs. See Impacts 2b and 10b for operational effects on these TCPs. Because specific identities and locations of on-site TCPs are not known, potential operational effects on such specific resources are uncertain.	No effects on TCPs. No TCPs identified on or in the vicinity of the proposed SNS site.	No effects on TCPs. No TCPs identified on or in the vicinity of the proposed SNS site.	No effects on TCPs.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
8a. Impacts on Land Use (Construction)				
Introduce large-scale development to the proposed SNS site, utility corridors, and new rights-of-way. Considering that about 64% of the 34,516 acres (13,794 ha) of ORR land is undeveloped, this would be a minimal overall effect. A greenfield site is proposed because no brownfield sites that meet SNS requirements are available.	Introduce large-scale development to the proposed SNS site, utility corridors, and new rights-of-way. Considering the 16,000 acres (6,478 ha) of undeveloped land at LANL, the effect on undeveloped laboratory lands as a whole would be minimal.	Displace the remaining support services operations in the 800 Area. Demolition of the three remaining 800 Area buildings. These would be minimal effects. Introduce large-scale development to Open Space areas due to limited ANL land. Increase the pace of remediation on numerous Solid Waste Management Units (SWMUs) within the proposed SNS site. A beneficial effect would be use of a partial brownfield site for constructing the SNS.	Introduce large-scale development to the proposed SNS site, utility corridors, and new rights-of-way. Considering the large amounts of Open Space land at BNL, the effects would be minimal.	No effects on current land use.
The National Oceanic and Atmospheric Administration/ Atmospheric Turbulence and Diffusion Division (NOAA/ATDD) is conducting the Temperate Deciduous Forest Continuous Monitoring Program (TDFCMP) in the Walker Branch Watershed [0.75 mi. (1.2 km)] east of the proposed SNS site. This long-term program is monitoring the continuous exchange of CO_2, (continued on next page)	No effects on the use of land by environmental research projects. Land on and in the vicinity of the SNS site is not being used for environmental research projects, and none are planned.	No effects on the use of land by environmental research projects. Land on and in the vicinity of the SNS site is not being used for environmental research projects, and none are planned. The ecology plots at ANL are areas of land potentially suitable for ecological research, but little, if any, actual ecological research has ever been conducted in these areas. Currently, there are no on- (continued on next page)	No effects on the use of land by environmental research projects. Land on and in the vicinity of the SNS site is not being used for environmental research projects, and none are planned.	No effects on the use of land by environmental research projects.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
8a. Impacts on Land Use (Construction) — continued				
H_2O vapor, and energy between the deciduous forest and atmosphere. CO_2 from construction vehicles could affect the TDFCMP and one long-term ORNL ecological research project in the Walker Branch Watershed. Potential effects would be loss of CO_2 data quality and data comparability over time.		Going or planned ecological projects in Ecology Plots 6, 7, and 8 on the proposed SNS site.		
Potential limitations on future use of the proposed SNS site and land areas adjacent to it.				No effects on future land use.
Reduce the area of ORR land open to recreational deer hunting by 110 acres (45 ha). Effect would be minimal because about 26,406 acres (10,735 ha) would still be open to hunting.	Potential restriction or end of public hiking trail use near the SNS site in TA-70.	No reasonably discernible effects on parks, preserves, and recreational resources. The effects from the proposed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics that support park, nature preserve, and recreational land uses outside ANL and within the laboratory boundaries.	No reasonably discernible effects on parks, preserves, and recreational resources. The effects from the proposed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics that support park, nature preserve, and recreational land uses in the vicinity of BNL.	No effects on parks, preserves, or recreational resources.
The proposed SNS would come into view only along the upper reaches of the Chestnut Ridge Road and southwest road accesses to the proposed SNS site. This (continued on next page)	Change views in SNS site area from piñon-juniper woodlands to industrial development. SNS facilities visible to public from points on State Route 4, access road (continued on next page)	Potential interference of SNS facilities with natural views from interior points in the Waterfall Glen Nature Preserve, especially on the west side during late autumn, (continued on next page)	Most visual panoramas in the area around BNL and within the laboratory contain features indicative of development. The proposed action would add the SNS (continued on next page)	No effects on visual resources.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
8a. Impacts on Land Use (Construction) — continued				
effect would be minimal because these roads would be traveled primarily by DOE and ORNL personnel, construction workers, and service providers. It would not be visible to the public from land-based vantage points outside the ORR, most points on the ORR, or frequently traveled roads such as Bear Creek Road and Bethel Valley Road. No established visual resources on the ORR would include the proposed SNS.	to proposed SNS site, the site, and hiking trails in TA-70. Highly visible at night—absence of other lighted facilities. Not visible from White Rock and popular public use areas in Bandelier National Monument.	winter, and early spring. This would result from the close proximity of the proposed SNS site to the west ANL perimeter, which is adjacent to the nature preserve.	facilities to this visual environment, and they would be compatible with it. This effect on visual resources would be minimal.	
8b. Impacts on Land Use (Operations)				
Land use change from Mixed Research/Future Initiatives to Institutional/Research.	Change in current land use from Environmental Research/Buffer to Experimental Science.	Change in current land use from Ecology Plots (Nos. 6, 7, and 8), Support Services, and Open Space to a programmatic land use category specific to SNS operations or Programmatic Mission-Other Areas.	Change in current land use from Open Space to Commercial/Industrial.	No effects on current land use.
CO_2 from SNS stacks would adversely affect TDFCMP (NO_x minimal) and one ORNL research project in the Walker Branch Watershed. (continued on next page)	No effects on the use of land by environmental research projects. Land on and in the vicinity of the proposed SNS site is not being used for (continued on next page)	No effects on the use of land by environmental research projects. Land on and in the vicinity of the proposed SNS site is not being used for (continued on next page)	No effects on the use of land by environmental research projects. Land on and in the vicinity of the proposed SNS site is not being used for (continued on next page)	No effects on the use of land by environmental research projects.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
8b. Impacts on Land Use (Operations) — continued				
H_2O vapor from cooling towers may affect the TDFCMP and two ORNL research projects. Effects would be loss of data quality and data comparability over time.	environmental research projects, and none are planned.	environmental research projects, and none are planned.	environmental research projects, and none are planned.	
No effects on DOE zoning (SNS operations compatible). Through a DOE process called Common Ground and a citizen stakeholder group referred to as the End Use Working Group, citizens in the Oak Ridge area have developed future ORR land use recommendations for DOE. Use of the proposed SNS site for the proposed action would be at variance with recommended Common Ground zoning of the site for Conservation Area Uses. It would also be at variance with a draft End Use Working Group advisory to use brownfield sites for new DOE facilities. A greenfield site is proposed for the SNS because no brownfield sites that meet project requirements are available.	No effects on DOE zoning (SNS operations compatible).	The SNS operations would be at variance with Support Services, Ecology Plot No. 8, and Open Space zoning on the SNS site. However, a guiding principle behind ANL zoning is the expansion of other land uses into the Ecology Plots and Open Space. The amount of Support Services land used would be negligible.	The SNS operations would be at variance with Open Space zoning on the SNS site. However, a guiding principle behind BNL zoning is expansion of other land uses into Open Space. Operation of the SNS would probably result in an eventual change in end use zoning of the SNS site and adjacent land from predominantly Open Space to Commercial/ Industrial.	No effects on zoning for future land use.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
8b. Impacts on Land Use (Operations) — continued				
Future adverse CO_2 effects on the TDFCMP and two ORNL research projects. Minimal No_x effects from SNS stacks. Potential future H_2O vapor effects on the TDFCMP and eight ORNL research projects. Potential future effects on strategic ORNL ecological research initiatives. Effects would be loss of data quality and data comparability over time.	No future uses of SNS site and vicinity land for environmental research are planned. As a result, effects on specific future research projects cannot be assessed.	No future uses of SNS site and vicinity land for environmental research are planned. The ecology plots at ANL are areas of land potentially suitable for ecological research, but little, if any, actual ecological research has ever been conducted in these areas. There are no planned environmental research projects in the portions of Ecology Plots 6, 7, and 8 adjacent to the proposed SNS site. As a result, effects on specific future research projects cannot be assessed.	No future uses of SNS site and vicinity land for environmental research are planned. As a result, effects on specific future research projects cannot be assessed.	No effects on the future use of land by environmental research projects.
Potential limitations on future use of the proposed SNS site and land areas adjacent to it.				No effects involving future land use limitations.
Continued restriction of recreational deer hunting on 110-acre (45-ha) SNS site. Effect would be minimal because about 26,406 acres (10,735 ha) would still be open to hunting.	Continued restriction or end of public hiking trail use near the SNS site in TA-70.	No reasonably discernible effects on parks, preserves, and recreational resources. The effects from the proposed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics that support park, nature preserve, and recreational land uses outside ANL and within the laboratory boundaries.	No reasonably discernible effects on parks, preserves, and recreational resources. The effects from the proposed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics that support park, nature preserve, and recreational land uses in the vicinity of BNL.	No effects on parks, preserves, or recreational resources.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
8b. Impacts on Land Use (Operations) — continued				
The proposed SNS would come into view only along the upper reaches of the Chestnut Ridge Road and southwest road accesses to the proposed SNS site. This effect would be minimal because these roads would be traveled primarily by DOE personnel, SNS employees, service providers, and visitors to the SNS facilities, including visiting scientists. It would not be visible to the public from land-based vantage points outside the ORR, most points on the ORR, and frequently traveled roads such as Bear Creek Road and Bethel Valley Road. No established visual resources on the ORR would include the proposed SNS.	Change views in proposed SNS site area from piñon-juniper woodlands to industrial development. SNS facilities visible to public from points on State Route 4, access road to proposed SNS site, the site, and hiking trails in TA-70. Highly visible at night—absence of other lighted facilities. Not visible from White Rock and popular public use areas in Bandelier National Monument.	Potential interference of SNS facilities with natural views from interior points in the Waterfall Glen Nature Preserve, especially on the west side during late autumn, winter, and early spring. This would result from the close proximity of the proposed SNS site to the west ANL perimeter, which is adjacent to the nature preserve.	Most visual panoramas in the area around BNL and within the laboratory contain features indicative of development. The proposed action would add the SNS facilities to this visual environment, and they would be compatible with it. This effect on visual resources would be minimal.	No effects on visual resources.
9a. Impacts on Human Health (Construction)				
Based on rates for general industrial construction accidents, 110 potential occupational injuries but less than 1 fatality are predicted.	Based on rates for general industrial construction accidents, 110 potential occupational injuries but less than 1 fatality are predicted.	Based on rates for general industrial construction accidents, 110 potential occupational injuries but less than 1 fatality are predicted.	Based on rates for general industrial construction accidents, 110 potential occupational injuries but less than 1 fatality are predicted.	No effects on human health.

(continued on next page)

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
9a. Impacts on Human Health (Construction) — continued				
		Due to the preferred location of the SNS within the 800 Area SWMU, construction activities may expose workers to organic compounds and possibly radioactive materials.		
9b. Impacts on Human Health (Operations)				
Minimal effects on the health of workers or the public. For operation at 1-MW power, the maximally exposed individual (MEI) would receive an annual radiation dose of 0.40 mrem, or 4% of the 10-mrem limit (40 CFR Part 61). For operation at 4-MW power, the MEI would receive an annual dose of 1.5 mrem, or 15% of the limit. Operation of the SNS at 1-MW power for 10 years and at 4-MW power for 30 years would result in 0.2 latent cancer fatalities (LCFs) in the off-site population attributable to the SNS.	Minimal effects on the health of workers or the public. For operation at 1-MW power, the MEI would receive an annual radiation dose of 0.47 mrem, or 4.7% of the 10-mrem limit (40 CFR Part 61). For operation at 4-MW power, the MEI would receive an annual dose of 1.8 mrem, or 18% of the limit. Operation of the SNS at 1-MW power for 10 years and at 4-MW power for 30 years would result in 0.09 LCFs in the off-site population attributable to the SNS.	Minimal effects on the health of workers or the public. For operation at 1-MW power, the MEI would receive an annual radiation dose of 3.2 mrem, or 32% of the 10-mrem limit (40 CFR Part 61). For operation at 4-MWpower, the MEI would receive an annual dose of 12 mrem, or 120% of the limit. Operation of the SNS at 1-MW power for 10 years and at 4-MW power for 30 years would result in 1.3 LCFs in the off-site population attributable to the SNS.	Minimal effects on the health of workers or the public. For operation at 1-MW power, the MEI would receive an annual radiation dose of 0.91 mrem, or 9.1% of the 10-mrem limit (40 CFR Part 61). For operation at 4-MWpower, the MEI would receive an annual dose of 3.4 mrem, or 3.4% of the limit. Operation of the SNS at 1-MW power for 10 years and at 4-MW power for 30 years would result in 1.2 LCFs in the off-site population attributable to the SNS.	No effects on human health.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
9b. Impacts on Human Health (Operations) — continued				
Potential effects on off-site population for combined operations at 1- and 4-MW power. Potential effects on off-site population predicted to maximally exposed individual for initial 1-MW and upgraded 4-MW operations — 0.2 excess LCFs over 40 years.	Potential effects on off-site population for combined operations at 1- and 4-MW power. Potential effects on off-site population predicted to maximally exposed individual for initial 1-MW and upgraded 4-MW operations — 0.09 excess LCFs over 40 years.	Anticipated effects on off-site population for combined operations at 1- and 4-MW power. Potential effects on off-site population predicted to maximally exposed individual for initial 1-MW and upgraded 4-MW operations — 1.3 excess LCFs over 40 years.	Anticipated effects on off-site population for combined operations at 1- and 4-MW power. Potential effects on off-site population predicted to maximally exposed individual for initial 1-MW and upgraded 4-MW operations — 1.2 excess LCFs over 40 years.	No effects on human health.
No observable effects on workers or public from mercury emissions. Mercury levels would be approximately 100,000 times less than OSHA and NIOSH recommendations and the EPA reference concentration for members of the public.				No effects on human health.
9c. Impacts on Human Health (Accidents)				
Extremely unlikely that workers would be exposed to levels of direct radiation that could induce radiation effects. The SNS shield design would be such that with a high-consequence, low-probability design-basis accident, the dose to a maximally exposed individual would be 1 rem in an uncontrolled area and 25 rem for a worker in a controlled area.				No impacts on health.
No effects expected at 1 MW. At 4 MW, only "beyond-design-basis" accident estimated to occur less than once per 1,000,000 years would induce 31 excess LCFs in off-site population.	No effects expected.	No effects expected at 1 MW. At 4 MW, LCFs expected in off-site population for three accident scenarios: one "beyond-design-basis" accident (120 LCFs) occurring less than once per 1,000,000 years; one extremely unlikely accident (2.7 LCFs) occurring between once per 10,000 and once per 1,000,000 years; and one anticipated accident (2.1 LCFs).	No effects expected at 1 MW. At 4 MW, LCFs expected in off-site population for three accident scenarios: one "beyond-design-basis" accident (85 LCFs) occurring less than once per 1,000,000 years; one extremely unlikely accident (1.9 LCFs) occurring between once per 10,000 and once per 1,000,000 years; and one anticipated accident (1.6 LCFs).	No effects on human health.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
10a. Impacts on Support Facilities and Infrastructure (Construction)				
Traffic on ORNL access roads would increase approximately 7%. The estimated peak construction workforce of 578 employees would be expected to add approximately 466 daily round trips and 10 material/service trucks to the total ORNL traffic of 7,810 vehicle trips. Effects on traffic could include increased general congestion on existing access roads to the ORR.	Traffic on LANL access roads would increase approximately 7%. The estimated peak construction workforce of 578 employees would be expected to add approximately 466 daily round trips and 10 material/ service trucks to the total LANL traffic of 6,980 vehicle trips. The access route, State Highway 4, to the proposed site is a relatively lightly traveled road. Construction traffic would increase traffic on this road by approximately 45%. State Highway 4 also provides access to Bandelier National Monument. This increase in traffic would increase the general congestion on this road.	Approximately 1 mile (1.6 km) of the existing Westgate Road would have to be relocated to the north in order to circumvent the SNS site and replace the existing Westgate Road access to ANL. Traffic on ANL access roads would increase approximately 7%. The estimated peak construction workforce of 578 employees would be expected to add approximately 466 daily round trips and 10 material/ service trucks to the total ANL traffic of 6,290 vehicle trips. Construction traffic would affect the composition and speed of the traffic, resulting in an increase in the general congestion on existing access roads.	Traffic on BNL access roads would increase approximately 16%. The estimated peak construction workforce of 578 employees would be expected to add approximately 466 daily round trips and 10 material/service trucks to the projected total BNL traffic of 2,500 vehicle trips. Because of the condition of the access roads to BNL, this increase is not considered significant.	No effects on support facilities and infrastructure.
10b. Impacts on Support Facilities and Infrastructure (Operations)				
Operation of the proposed SNS at 4 MW would add 305 daily round trips and 3 service trucks per day, or a 5% increase over current traffic levels. Effects on (continued on next page)	Operation of the proposed SNS at 4 MW would add 305 daily round trips and 3 service trucks per day, or a 4% increase over current traffic levels. Effects on. (continued on next page)	Operation of the proposed SNS at 4 MW would add 305 daily round trips and 3 service trucks per day, or a 5% increase over current traffic levels. Effects on (continued on next page)	Operation of the proposed SNS at 4 MW would add 305 daily round trips and 3 service trucks per day, or a 12% increase over current traffic levels. Effects on (continued on next page)	No effects on support facilities and infrastructure.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
10b. Impacts on Support Facilities and Infrastructure (Operations) — continued				
traffic could increase general congestion on existing access roads to the ORR.	traffic could increase general congestion on existing access roads to LANL.	traffic could increase general congestion on existing access roads to ANL.	traffic could increase general congestion on existing access roads to BNL. Because of the condition of the access roads to BNL, this increase is not considered significant.	
Existing electrical service is adequate for the proposed 1-MW SNS and the 4-MW upgrade. Existing transmission lines would be extended approximately 3000 ft. Environmental effects of construction the electrical feeder would be negligible.	The existing electrical power system at LANL does not have adequate capacity to meet the demands of the proposed SNS. Meeting these demands would require a 115-kV transmission line from the east side of the site. Additional required efforts could include new power grid configurations and an SNS site-specific power generation station.	The existing electrical power system at ANL has sufficient capacity for the proposed SNS operating at 1-MW power. However, there is not sufficient capacity at ANL for the 4-MW SNS. Sufficient power is available from Commonwealth Edison. Approximately 6,600 ft of new 138-kV transmission line would be constructed to connect the proposed SNS to an adequate substation. The transmission line would be constructed in developed areas, so environmental effects would be minimal.	Existing electrical service at BNL is adequate for the proposed 1-MW SNS. However, in order to accommodate the 4-MW facility, a new 69-kV transmission line would be required extending to the Long Island Lighting Company's (LILCO's) 138-kV grid. The length of this line would be approximately 1 mile and would parallel the existing 69-kV line. All upgrades would occur within existing utility corridors; therefore, environmental effects would be minor.	No effects on electrical service.
The existing steam supply at ORNL is adequate to meet the needs of the proposed SNS. If the decision is made to use ORNL steam, approximately 2 miles of (continued on next page)	Steam is not available at or in the vicinity of the proposed SNS site. The facility would include steam generation.	The existing steam supply at ANL is adequate to meet the needs of the proposed SNS. If the decision is made to use ANL steam, approximately 1,500 ft of steam line would (continued on next page)	The existing steam supply at BNL is adequate to meet the needs of the proposed SNS. If the decision is made to use BNL steam, approximately 4,000 ft of steam line would (continued on next page)	No effects on the steam supply.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
10b. Impacts on Support Facilities and Infrastructure (Operations) — continued				
steam line would be constructed. Much of the construction would be on previously disturbed land. Environmental effects would be expected to be minimal.		be constructed, crossing developed land. Environmental effects would be expected to be minimal.	be constructed, crossing developed land. Environmental effects would be expected to be minimal.	
The existing East Tennessee Natural Gas 22-in. gas main has adequate capacity to supply the proposed SNS. Approximately 5,000 ft of new gas line would be constructed along Chestnut Ridge Road, the main access road to the proposed site. This would encroach on 0.12 acres of palustrine emergent wetlands.	There is adequate capacity from the existing natural gas system at LANL to meet the needs of the proposed SNS. However, there are no existing gas lines in the vicinity of the proposed site. An expansion of the natural gas infrastructure would be necessary.	There is adequate capacity from the existing natural gas system at ANL to meet the needs of the proposed SNS. The natural gas system at ANL is scheduled to be upgraded in FY 1999. A high-pressure gas main is located near the proposed site. Modifications necessary to accommodate the proposed SNS could be accomplished during the scheduled upgrade.	There is sufficient capacity in the existing natural gas system at BNL to meet the needs of the proposed SNS. Approximately 4,000 ft of new gas line would be constructed, primarily across developed land. Environmental effects would be expected to be minimal.	No effects on natural gas system.
The existing 24-in. water main located adjacent to the proposed site has adequate capacity to supply water to the SNS.	The domestic water system at LANL can not meet the projected demands for LANL, including the proposed SNS and the surrounding communities. Accommodating the proposed SNS would require extensive upgrades to the delivery system, including new water mains, lift stations and storage tanks.	The domestic water system at ANL has sufficient capacity to meet the needs of the proposed SNS. In addition, ANL has a non-potable laboratory water supply the could be used for cooling tower makeup.	The domestic water system at BNL has sufficient capacity to meet the needs of the proposed SNS.	No effects on the domestic water system.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
10b. Impacts on Support Facilities and Infrastructure (Operations) — continued				
The existing sewage treatment plant at ORNL has adequate capacity to treat wastes from the proposed SNS.	The existing sewage treatment plant at LANL has sufficient capacity to treat wastes from the proposed SNS. The plant is several miles from the proposed site. Sanitary sewage would have to be trucked to the treatment plant or a small package plant included in the SNS facilities.	The existing sewage treatment plant at ANL has adequate capacity to treat wastes from the proposed SNS.	The existing sewage treatment plant at BNL has adequate capacity to treat wastes from the proposed SNS.	No effects on sewage treatment.
11a. Impacts on Waste Management (Construction and Operations)				
Hazardous Wastes Treatment No hazardous waste treatment facilities at ORNL. Storage Projected generation, excluding SNS, 1998–2040: 160 m^3/yr. Total capacity available for SNS wastes: 139 m^3/yr. Amount generated by SNS: 40 m^3/yr. (continued on next page)	**Hazardous Wastes** Treatment No hazardous waste treatment facilities at LANL. Storage Projected generation, excluding SNS, 1998–2040: 942 m^3/yr. Total capacity available for SNS wastes: Not applicable. Amount generated by SNS: 40 m^3/yr. (continued on next page)	**Hazardous Wastes** Treatment No hazardous waste treatment facilities at ANL. Storage Projected generation, excluding SNS, 1998–2040: 115 m^3/yr. Total capacity available for SNS wastes: Not applicable. Amount generated by SNS: 40 m^3/yr. (continued on next page)	**Hazardous Wastes** Treatment No hazardous waste treatment facilities at BNL. Storage Projected generation, excluding SNS, 1998–2040: 100 drums/yr. Total capacity available for SNS wastes: Not applicable. Amount generated by SNS: 200 drums (40 m^3)/yr. (continued on next page)	**Hazardous Wastes**

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
11a. Impacts on Waste Management (Construction and Operations) — continued				
Hazardous Wastes (cont'd) <u>Conclusion</u> No effect on hazardous waste storage facilities would be anticipated because DOE has contracts in place for disposal of wastes as generated.	**Hazardous Wastes (cont'd)** <u>Conclusion</u> No effect on hazardous waste storage facilities would be anticipated because DOE has contracts in place for disposal of wastes as generated.	**Hazardous Wastes (cont'd)** <u>Conclusion</u> No effect on hazardous waste storage facilities would be anticipated because DOE has contracts in place for disposal of wastes as generated.	**Hazardous Wastes (cont'd)** <u>Conclusion</u> No effect on hazardous waste storage facilities would be anticipated because DOE has contracts in place for disposal of wastes as generated.	**Hazardous Wastes (cont'd)** <u>Conclusion</u>: No effects on hazardous waste facilities.
Low-Level Radioactive Wastes <u>Treatment</u> Projected generation, excluding SNS, 1998–2040: 282,000 m^3/yr (7.45E07 gal/yr). Total capacity available for SNS wastes: 423,920 m^3/yr (1.12E08 gal/yr). Amount generated by SNS: 16,400 m^3/yr (4.33E06 gal/yr). <u>Conclusion</u> No effects on low-level radioactive waste (LLW) treatment facilities would be anticipated. (continued on next page)	**Low-Level Radioactive Wastes** <u>Treatment</u> Projected generation, excluding SNS, 1998–2040: 21,880 m^3/yr (5.78E06 gal/yr). Total capacity available for SNS wastes: 4,600 m^3/yr (1.22E06 gal/yr). Amount generated by SNS: 16,400 m^3/yr (4.33E06 gal/yr). <u>Conclusion</u> Treatment facilities do not have the capacity to treat all of the LLW from the proposed SNS. LLW with accelerator-produced tritium would not meet the waste (continued on next page)	**Low-Level Radioactive Wastes** <u>Treatment</u> Projected generation, excluding SNS, 1998–2040: 413,000 m^3/yr (1.09E08 gal/yr). Total capacity available for SNS wastes: 1.00E06 m^3/yr (2.64E08 gal/yr). Amount generated by SNS: 16,400 m^3/yr (4.33E06 gal/yr). <u>Conclusion</u> No effects on LLW treatment facilities would be anticipated. Tritium discharge would increase from 0.75 Ci/yr to 40 Ci/yr. (continued on next page)	**Low-Level Radioactive Wastes** <u>Treatment</u> Projected generation, excluding SNS, 1998–2040: 190 m^3/yr (50,000 gal/yr). Total capacity available for SNS wastes: 300 m^3/yr (70,000 gal/yr). Amount generated by SNS: 16,400 m^3/yr (4.33E06 gal/yr). <u>Conclusion</u> SNS volume exceeds capacity. Wastes can be processed at a higher rate. Additional treatment capacity may be necessary. (continued on next page)	**Low-Level Radioactive Wastes** <u>Conclusion</u> No effects on LLW facilities.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
11a. Impacts on Waste Management (Construction and Operations) — continued				
Low-Level Radioactive Wastes (cont'd)	**Low-Level Radioactive Wastes (cont'd)** acceptance criteria for the existing LLW treatment facility (RLWTF TA-50). However, a new facility is under construction that will accept these wastes.	**Low-Level Radioactive Wastes (cont'd)**	**Low-Level Radioactive Wastes (cont'd)**	**Low-Level Radioactive Wastes (cont'd)**
<u>Storage</u> Projected generation, excluding SNS, 1998–2040: 2,520 m^3/yr. Total capacity available for SNS wastes: Limited storage available; long-term storage would not be necessary because contracts are in place that would allow for disposal of waste. Amount generated by SNS: 1,026 m^3/yr.	<u>Storage</u> Facilities are present on-site for treatment and disposition; therefore, long-term storage facilities for LLW are not necessary at LANL.	<u>Storage</u> Projected generation, excluding SNS, 1998–2040: 232 m^3/yr. Total capacity available for SNS wastes: 30 m^3 Amount generated by SNS: 1,026 m^3/yr.	<u>Storage</u> Projected generation, excluding SNS, 1998–2040: 283 m^3/yr. Total capacity available for SNS wastes: 270 m^3/yr. Amount generated by SNS: 1,026 m^3/yr.	
<u>Conclusion</u> Additional storage capacity may be necessary to accommodate SNS wastes; however, long-term storage		<u>Conclusion</u> Additional storage capacity may be necessary to accommodate SNS wastes; however, long-term storage	<u>Conclusion</u> Additional storage may be necessary to accommodate SNS wastes; however, long-term storage would not be	<u>Conclusion</u> No effects on LLW facilities.
(continued on next page)	(continued on next page)	(continued on next page)	(continued on next page)	(continued on next page)

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
11a. Impacts on Waste Management (Construction and Operations) — continued				
Low-Level Radioactive Wastes (cont'd) would not be necessary because DOE has contracts in place for disposal of wastes as generated. <u>Disposal</u> No LLW disposal at ORNL.	**Low-Level Radioactive Wastes (cont'd)** <u>Disposal</u> Projected generation, excluding SNS, 1998–2040: 2,500 m^3/yr. Total capacity available for SNS wastes: 35,000 m^3/yr. Amount generated by SNS: 1,026 m^3/yr. <u>Conclusion</u> No effect on LLW disposal facilities would be anticipated.	**Low-Level Radioactive Wastes (cont'd)** would not be necessary because DOE has contracts in place for disposal of wastes as generated. <u>Disposal</u> No LLW disposal at ANL.	**Low-Level Radioactive Wastes (cont'd)** necessary because DOE has contracts in place for disposal of wastes as generated. <u>Disposal</u> No LLW disposal at BNL.	**Low-Level Radioactive Wastes (cont'd)**
Mixed Wastes <u>Treatment</u> No mixed waste treatment facilities at ORNL. (continued on next page)	**Mixed Wastes** <u>Treatment</u> No mixed waste treatment facilities at LANL. (continued on next page)	**Mixed Wastes** <u>Treatment</u> Projected generation rate, excluding SNS, 1998–2040: 215 m^3/yr. Total capacity available for SNS wastes: Not Applicable. (continued on next page)	**Mixed Wastes** <u>Treatment</u> No mixed waste treatment facilities at BNL. (continued on next page)	**Mixed Wastes** (continued on next page)

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
11a. Impacts on Waste Management (Construction and Operations) — continued				
Mixed Wastes (cont'd)	**Mixed Wastes (cont'd)**	**Mixed Wastes (cont'd)** Amount generated by SNS: 18 m^3/yr. Conclusion Design capacity is much greater than anticipated volumes. If necessary, permitted volumes could be increased.	**Mixed Wastes (cont'd)**	**Mixed Wastes (cont'd)**
Storage Projected generation rate, excluding SNS, 1998–2040: 20 m^3/yr. Total capacity available for SNS wastes: Not applicable. Amount generated by SNS: 18 m^3/yr. Conclusion No effect on mixed waste storage facilities would be anticipated because DOE has contracts in place for disposal of wastes as generated.	Storage Projected generation rate, excluding SNS, 1998–2040: 622 m^3/yr. Total capacity available for SNS wastes: Not applicable. Amount generated by SNS: 18 m^3/yr. Conclusion No effect on mixed waste storage facilities would be anticipated because DOE has contracts in place for dis-posal of wastes as generated.	Storage Projected generation rate excluding SNS, 1998–2040: 215 m^3/yr. Total capacity available for SNS wastes: Not applicable. Amount generated by SNS: 18 m^3/yr. Conclusion No effect on mixed waste storage facilities would be anticipated because DOE has contracts in place for disposal of wastes as generated.	Storage Projected generation rate, excluding SNS, 1998–2040: 2 m^3/yr. Total capacity available for SNS wastes: Not applicable. Amount generated by SNS: 18 m^3/yr. Conclusion No effect on mixed waste storage facilities would be anticipated because DOE has contracts in place for disposal of wastes as generated.	Conclusion No effect on mixed waste facilities.
All laboratories have waste certification processes in place to assure LLW and mixed wastes sent to off-site disposal facilities meet the waste acceptance criteria (WAC) of the facility. Because of the uncertainty of the composition of the LLW and mixed waste generated by the SNS, the waste may not meet the current WAC. Pretreatment of the waste at the SNS may be necessary. DOE may have to amend the licenses at the current disposal facilities to allow acceptance of wastes from the SNS.				

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
11a. Impacts on Waste Management (Construction and Operations) — continued				
Sanitary Wastes Treatment Projected generation rate, excluding SNS, 1998–2040: 300,000 gal/day. Total capacity available for SNS wastes: 42,000 gal/day. Amount generated by SNS: 25,900 m^3/yr (18,000 gal/day). Conclusion No effect on sanitary waste treatment. Disposal Projected generation rate, excluding SNS, 1998–2040: 7,645 m^3/yr. Total capacity available for SNS wastes: 1,090,000 m^3/yr. Amount generated by SNS: 1,350 m^3/yr.	**Sanitary Wastes** Treatment Projected generation rate, excluding SNS, 1998–2040: 692,827 m^3/yr. Total capacity available for SNS wastes: 368,000 m^3/yr. Amount generated by SNS: 25,900 m^3/yr (18,000 gal/day). Conclusion No effect on sanitary waste treatment. Disposal Projected generation rate, excluding SNS, 1998–2040: 5,453 m^3/yr. Total capacity available for SNS wastes: Not applicable. Sanitary wastes would be disposed of in off-site landfills. Amount generated by SNS: 1,350 m^3/yr.	**Sanitary Wastes** Treatment Projected generation rate, excluding SNS, 1998–2040: 350,000 gal/day. Total capacity available for SNS wastes: 150,000 gal/day. Amount generated by SNS: 25,900 m^3/yr. (18,000 gal/day). Conclusion No effect on sanitary waste treatment. Disposal Projected generation rate, excluding SNS, 1998–2040 not provided. Total capacity available for SNS wastes: Not applicable. Sanitary wastes would be disposed of in off-site landfills. Amount generated by SNS: 1,350 m^3/yr.	**Sanitary Wastes** Treatment Projected generation rate, excluding SNS, 1998–2040: 800,000 gal/day. Total capacity available for SNS wastes: 1.5 million gal/day. Amount generated by SNS: 25,900 m^3/yr (18,000 gal/day). Conclusion No effect on sanitary waste treatment. Disposal Projected generation rate, excluding SNS, 1998–2040: 1,700 tons/yr. Total capacity available for SNS wastes: Not applicable. Sanitary wastes are disposed of in off-site landfills. Amount generated by SNS: 1,350 m^3/yr.	**Sanitary Wastes** Conclusion No effect on sanitary waste facilities.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
11a. Impacts on Waste Management (Construction and Operations) — continued				
Sanitary Wastes (cont'd) Conclusion No effect anticipated.	**Sanitary Wastes (cont'd)** Conclusion No effect anticipated. Sanitary wastes would be disposed of in off-site landfills.	**Sanitary Wastes (cont'd)** Conclusion No effect anticipated. Solid sanitary wastes would be disposed of in off-site landfills.	**Sanitary Wastes (cont'd)** Conclusion No effect anticipated. Solid sanitary wastes would be disposed of in off-site landfills.	**Sanitary Wastes (cont'd)** Conclusion No effect on sanitary waste facilities.
12a. Impacts on Long-Term Productivity of the Environment (Operations)				
Localized effects on groundwater productivity would occur at the ORNL SNS site but not on the corresponding watershed.	Sustained use of groundwater by the SNS over time could lower water levels in wells and reduce long-term main aquifer productivity.	Localized effects on groundwater productivity would occur at the ANL SNS site but not on the corresponding watershed.	Localized effects on groundwater productivity would occur at the BNL SNS site but not on the corresponding watershed.	No effects on groundwater productivity.
Permanent commitment of 110 acres (45 ha) of forested land to the SNS. This represents less 0.5% of the forested area on the ORR.	Permanent commitment of 110 acres (45 ha) of piñon-juniper habitat to the SNS. This represents approximately 10% of the piñon-juniper habitat in TA-70.	Permanent commitment of 110 acres (45 ha) of land to the SNS. A large portion of this land has been previously disturbed.	Permanent commitment of 110 acres (45 ha) of land to the SNS. This represents less than 2% of the legally established Pine Barrens Protection Area. The proposed SNS site is entirely within the Compatible Growth Area.	No effects on the long-term productive potential of land.
13a. Cumulative Impacts (Construction and Operations)				
The proposed action would contribute to cumulative impacts through localized radionuclide contamination of groundwater.				This proposed action would not contribute to cumulative impacts involving radionuclide contamination of groundwater.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
13a. Cumulative Impacts (Construction and Operations) — continued				
The potential cumulative impact of incremental emissions would be evaluated and permitted on a case-by-case basis by the state and federal air quality agencies at the appropriate juncture in order to protect public health and welfare.				This alternative would not contribute to cumulative impacts on incremental emissions.
No cumulative impacts are predicted for noise.				This alternative would not contribute to cumulative impacts on noise.
The proposed action would not contribute to cumulative impacts on terrestrial resources.	The proposed action would not contribute to cumulative impacts on terrestrial resources.	Clearing 15% of the undeveloped land at ANL for the SNS and APS would significantly decrease the terrestrial wildlife inhabiting ANL. Except for fallow deer, no rare or important game animals would be affected.	The proposed action would not contribute to cumulative impacts on terrestrial resources.	This alternative would not contribute to cumulative impacts on terrestrial resources.
Cumulative impacts on wetlands would be minimal.				This alternative would not contribute to cumulative impacts on wetlands.
No cumulative impacts are anticipated on aquatic resources.				This alternative would not contribute to cumulative impacts on aquatic resources.
Cumulative impacts on protected species would be expected to be minimal.				This alternative would not contribute to cumulative impacts on protected species.
The activities at ORNL account for only about 7% of the employment, wage and salary, and business activities of the area. Cumulative impacts of SNS on the (continued on next page)	The activities at LANL account for about one-third of the employment, wage and salary, and business activities of the area. Some positive benefits would occur in the (continued on next page)	The activities at ANL account for much less than 1% of the employment, wage and salary, and business activities of the area. Cumulative impacts of SNS (continued on next page)	The activities at BNL account for much less than 1% of the employment, wage and salary, and business activities of the area. Cumulative impacts of SNS (continued on next page)	No cumulative impacts on the economy, housing, and community infrastructure.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
13a. Cumulative Impacts (Construction and Operations) — continued				
economy, housing, and community infrastructure would be minimal.	form of new jobs but cumulative impacts of SNS on the economy, housing, and community infrastructure would be minimal overall.	on the economy, housing, and community infrastructure would be minimal.	on the economy, housing, and community infrastructure would be minimal.	
There would be no cumulative impacts involving environmental justice issues.				This alternative would not contribute to cumulative impacts involving environmental justice issues.
The proposed action would not contribute to cumulative impacts on prehistoric cultural resources.	Twenty prehistoric archaeological sites in the 65% surveyed area would be destroyed by construction of the proposed SNS and expansion of LLW Disposal Facility in TA-54. The potential contribution of the other 35% of the proposed SNS site cannot be accurately assessed. If the proposed SNS site is chosen for construction of the SNS, this area would be surveyed and assessed for cumulative impacts on prehistoric cultural resources prior to construction.	Prehistoric site 40DU207, adjacent to the proposed SNS site, may be disturbed or destroyed by SNS construction. ANL has not assessed the NRHP eligibility of this site. Site 40DU189 on the Advanced Photon Source (APS) site was once thought to be potentially NRHP-eligible, but it was later determined to not be a prehistoric cultural resource. If 40DU207 is a cultural resource, the proposed action, along with the APS project, would not contribute to cumulative impacts on prehistoric cultural resources at ANL because 40DU189 is not a prehistoric cultural resource.	The proposed action would not contribute to cumulative impacts on prehistoric cultural resources.	This alternative would not contribute to cumulative impacts on prehistoric cultural resources.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
13a. Cumulative Impacts (Construction and Operations) — continued				
The proposed action would not contribute to cumulative impacts on historic cultural resources.	Implementation of the proposed action within the 65% surveyed area at the proposed SNS site would not contribute to cumulative impacts on historic cultural resources. The potential contribution of the other 35% cannot be accurately assessed. If this site is chosen for construction of the proposed SNS, this area would be surveyed and assessed for cumulative impacts on historic cultural resources prior to construction.	The proposed action would not contribute to cumulative impacts on historic cultural resources.	The proposed action would not contribute to cumulative impacts on historic cultural resources.	This alternative would not contribute to cumulative impacts on historic cultural resources.
The proposed action would not contribute to cumulative impacts on TCPs.	Cumulative impacts on 20 prehistoric archaeological sites (all TCPs) destroyed by construction of the proposed SNS and expansion of LLW Disposal Facility in TA-54. If any prehistoric archaeological sites are located within the unsurveyed 35 percent of the proposed SNS site, these (continued on next page)	The proposed action would not contribute to cumulative impacts on TCPs.	The proposed action would not contribute to cumulative impacts on TCPs.	This alternative would not contribute to cumulative impacts on TCPs.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
13a. Cumulative Impacts (Construction and Operations) — continued				
	TCPs would also be destroyed during construction. Cumulative impacts on water resources are also impacts on TCPs (see related entries under this table heading). Because specific identities and locations of TCPs at sites of the proposed SNS and other analyzed actions are not known, cumulative impacts on such specific resources would be uncertain.			
The proposed action would contribute minimally to cumulative impacts on undeveloped ORR land.	The proposed action would contribute minimally to cumulative impacts on undeveloped LANL land.	The SNS and APS would introduce development to about 160 acres (65 ha) of undeveloped land. This would reduce the already limited area of undeveloped ANL land available for development by about 15%.	The proposed action would contribute minimally to cumulative impacts on undeveloped land at BNL.	This alternative would not contribute to cumulative impacts on undeveloped land.
The proposed action would contribute minimally to cumulative impacts on areas of ORR land in current use categories.	The proposed action would contribute minimally to cumulative impacts on areas of LANL land in current use categories.	The SNS and APS would reduce Open Space land at ANL by 145 acres (59 ha). This would further reduce the already limited area of Open Space ANL land available for development by about 15%.	The proposed action would contribute minimally to cumulative impacts on areas of BNL land in current use categories.	This alternative would not contribute to cumulative impacts on areas of land in current use categories.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
13a. Cumulative Impacts (Construction and Operations) — continued				
The proposed action, CERCLA Waste Disposal Facility, Parcel ED-1, and JINS would reduce the environmental research potential of 981 acres (391 ha) of National Environmental Research Park (NERP) land on the ORR. This cumulative impact would be minimal because only 4.5% of the NERP land on the ORR would be affected. The cumulative impacts of these actions on environmental research projects are uncertain.	The proposed action, construction of a new LLW disposal facility in TA-67, and construction of a new road to support pit production would reduce the environmental research potential of 177 acres (72 ha) of NERP land. This cumulative impact would be Minimal because only 0.6% of the NERP land at LANL would be affected. The land on and in the vicinity of the proposed SNS site is not being used for environmental research projects. As a result, the proposed action would not contribute to cumulative impacts on uses of the land by environmental research projects. Because no future environmental research projects are planned for this land, cumulative impacts on specific future projects cannot be assessed.	No NERP land is present at ANL. Consequently, the proposed action would not reduce the environmental research potential of NERP land. The land on and in the vicinity of the proposed SNS site, including Ecology Plot Nos. 6, 7, and 8, is not being used by environmental research projects. As a result, the proposed action would not contribute to cumulative impacts on the use of land by such projects. Because no future environmental research projects are planned for this land, cumulative impacts on specific future projects cannot be assessed.	No NERP land is present at BNL. Consequently, the proposed action would not reduce the environmental research potential of NERP land. The land on and in the vicinity of the proposed SNS site is not being used by environmental research projects. As a result, the proposed action would not contribute to cumulative impacts on the use of land by such projects. Because no future environmental research projects are planned for this land, cumulative impacts on specific future projects cannot be assessed.	No cumulative impacts on NERP land or environmental research projects.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
13a. Cumulative Impacts (Construction and Operations) — continued				
The SNS and CERCLA Waste Management Facility [White Wing Scrap Yard (high-end scenario)] would be collectively at variance with Common Ground zoning for future use of their sites in Conservation Area Uses.	The proposed action would not contribute to cumulative impacts on zoning of land for future use.	The proposed action would not contribute to cumulative impacts on zoning of land for future use.	The proposed action would not contribute to cumulative impacts on zoning of land for future use.	This alternative would not contribute to cumulative impacts on zoning of land for future use.
The proposed action would contribute minimally to cumulative impacts on recreational land use but not at all on parks and preserves.				This alternative would not contribute to cumulative impacts on parks, preserves, or recreational land uses.
The proposed action would not contribute to cumulative impacts on visual resources.	The proposed action would not contribute to cumulative impacts on visual resources.	The proposed SNS and APS would degrade natural views from interior points within the west side of the Waterfall Glen Nature Preserve.	The proposed action would not contribute to cumulative impacts on visual resources.	This alternative would not contribute to cumulative impacts on visual resources.
Minimal cumulative radiological impacts on human health from normal ORNL and SNS operations.	Minimal cumulative radiological impacts on human health from normal LANL and SNS operations.	Potential for adverse radiological impacts on human health from normal ANL and SNS operations.	Potential for adverse radiological impacts on human health from normal BNL and SNS operations.	This alternative would not contribute to radiological impacts on human health.
Minor increases in traffic due to the proposed SNS project and development of Parcel ED-1 may minimally reduce the level of service on roads.	Minimal cumulative impacts on transportation.	Minimal cumulative impacts on transportation.	Minimal cumulative impacts on transportation.	This alternative would not contribute to cumulative impacts involving transportation.
Minimal cumulative impacts on electric power supply capabilities.	The power demand of the SNS, DAHRT facility, and continued LANL operations would exceed the delivery capacity of the electric power pool that serves the laboratory.	Adequate power is available, but new power lines would need to be installed.	Minimal cumulative impacts on electric power supply capabilities.	This alternative would not contribute to cumulative impacts on electric power supply capabilities.

Table 3.5-1. Comparison of impacts among alternatives (continued).

PROPOSED ACTION				NO-ACTION ALTERNATIVE
ORNL Alternative	**LANL Alternative**	**ANL Alternative**	**BNL Alternative**	
13a. Cumulative Impacts (Construction and Operations) — continued				
Waste management facilities at ORNL have sufficient capacity to handle the waste volume projected for the period 1998–2040, including the wastes from the proposed SNS. Therefore, construction and operation would have a minimal contribution to cumulative impacts on waste management facilities.	Waste management facilities at LANL have sufficient capacity to handle the waste volume projected for the period 1998–2040, including the wastes from the proposed SNS. Therefore, construction and operation would have a minimal contribution to cumulative impacts on management facilities.	Waste management facilities at ANL have sufficient capacity to handle the waste volume projected for the period 1998–2040, including the wastes from the proposed SNS. Therefore, construction and operation would have a minimal contribution to cumulative impacts on waste management facilities.	Waste management facilities at BNL have sufficient capacity to handle the waste volume projected for the period 1998–2040, including the wastes from the proposed SNS. Therefore, construction and operation would have a minimal contribution to cumulative impacts on waste management facilities.	This alternative would not contribute to cumulative impacts on waste management.

CHAPTER 4. AFFECTED ENVIRONMENT

The affected environment includes the physical and natural environment around each of the four potential sites for the proposed Spallation Neutron Source (SNS) and the relationship of people with that environment. Descriptions of the affected environment provide a basis for understanding the potential direct, indirect, and cumulative impacts of construction and operation of the proposed SNS at each of the potential sites. In this chapter, the existing situation for environmental resources that the construction and operation of the proposed SNS could affect is described. The detail presented for each resource varies depending on the relevance of the resource to the construction and operation of the SNS.

4.1 OAK RIDGE NATIONAL LABORATORY

The Chestnut Ridge site is the preferred site for the proposed SNS and is located approximately 1.75 mi (2.8 km) northeast from the center of the Oak Ridge National Laboratory (ORNL). Site access is via Chestnut Ridge Road, across from the 7000 Area at ORNL (Figure 4.1-1). The Chestnut Ridge site extends on a long, wide, and gently sloping ridge top with a broad saddle area at its eastern end. This area planned for the target station would require a minimum of excavation. The linac, transport line, and ring tunnels would be notched into the south side of the ridge using cut-and-fill techniques, providing economical construction and effective shielding strategies. The entire site is currently undeveloped.

4.1.1 GEOLOGY AND SOILS

The Oak Ridge Reservation (ORR) is located in the southwestern portion of the Valley and Ridge Physiographic Province that extends more than 500 mi (800 km) from Alabama northeastward into Virginia. The southwestern portion of the Valley and Ridge Province is about 25 to 50 mi (40 to 80 km) wide. The trend of the valleys and ridges which characterize this province reflects the regional orientation of underlying, deformed bedrock that was intensely folded and faulted by compressional forces from the southeast during the late Paleozoic Appalachian Orogeny. Features that distinguish this province are: (1) parallel ridges and valleys typically oriented from northeast to southwest, (2) topography influenced by alternating weak and strong strata exposed to erosion through a relatively great amount of folding and faulting, (3) a few major transverse streams with subsequent streams forming a trellis-like drainage pattern, (4) many ridges with similar summit levels suggesting former erosion surfaces, and (5) many water and wind gaps through ridges. The scarp (northwest-facing) slopes of these ridges are relatively short, steep, and smooth. The dip slopes (southeast facing) are longer, shallower, and dissected by drainages. Elevation ranges from 738 to 1,345 ft (225 to 410 m) above sea level. Drainage patterns have a dendritic-shape in headwater areas and a trellis shape farther downstream.

Several major ridges, formed from resistant strata, dominate the topography of ORR. Moving from southeast to northwest, prominent ridges are named Copper Ridge, Haw Ridge (south of the ORNL main plant), Chestnut Ridge (separating the ORNL and Y-12 Plant sites), and Pine Ridge (between the Y-12 Plant and the City of Oak Ridge).

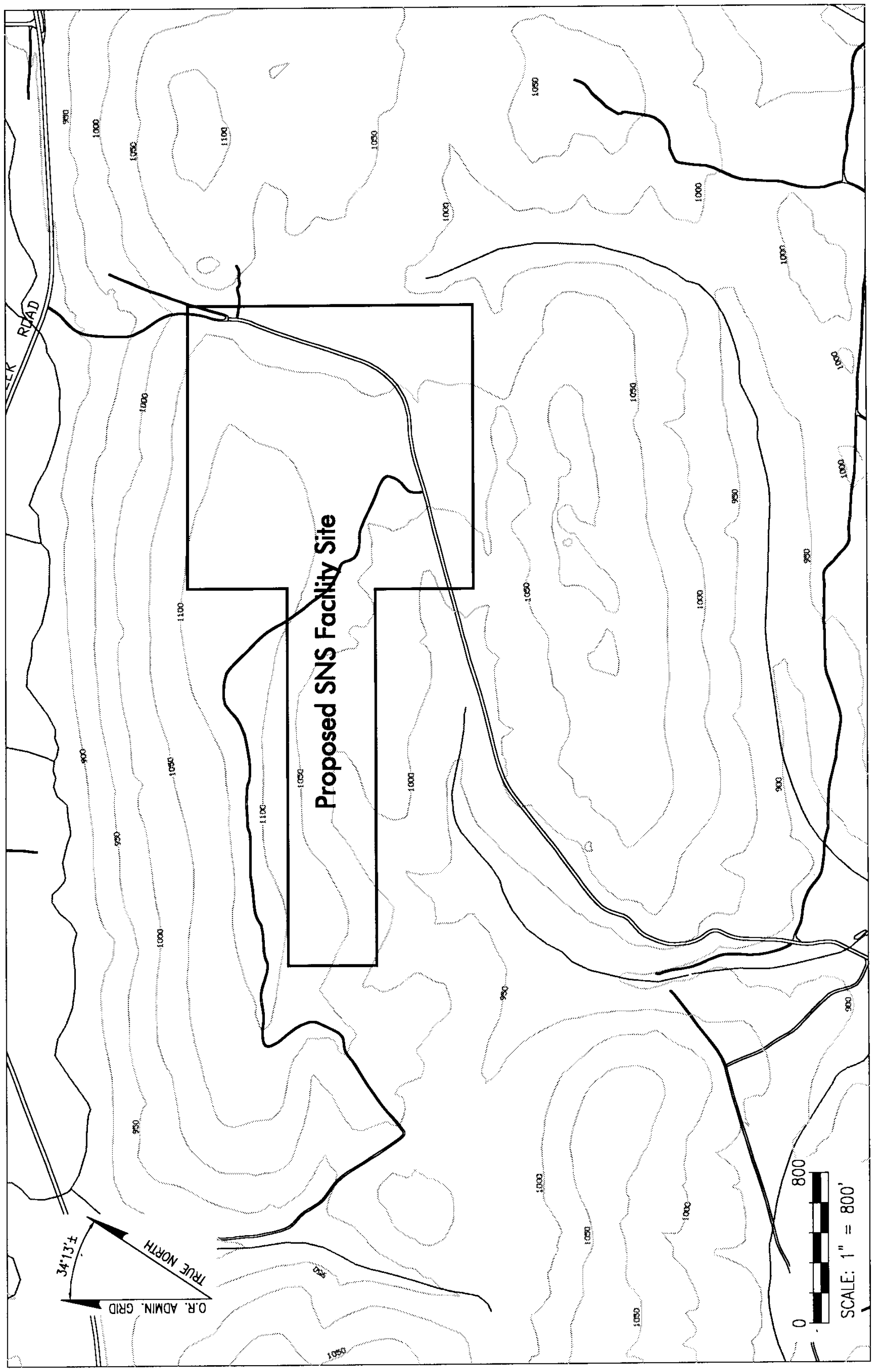


Figure 4.1-1. Proposed SNS site at ORNL.

4.1.1.1 Stratigraphy

Rock units of the stratigraphic section in the ORR range in age from Early Cambrian to Silurian (Figure 4.1.1.1-1). The stratigraphic units compose a complex assemblage of lithologies. The total thickness of the stratigraphic section in the ORR is about 1.6 mi (2.5 km), and each major stratigraphic unit possesses unique mechanical characteristics that respond differently to the strain imparted on these rocks through time.

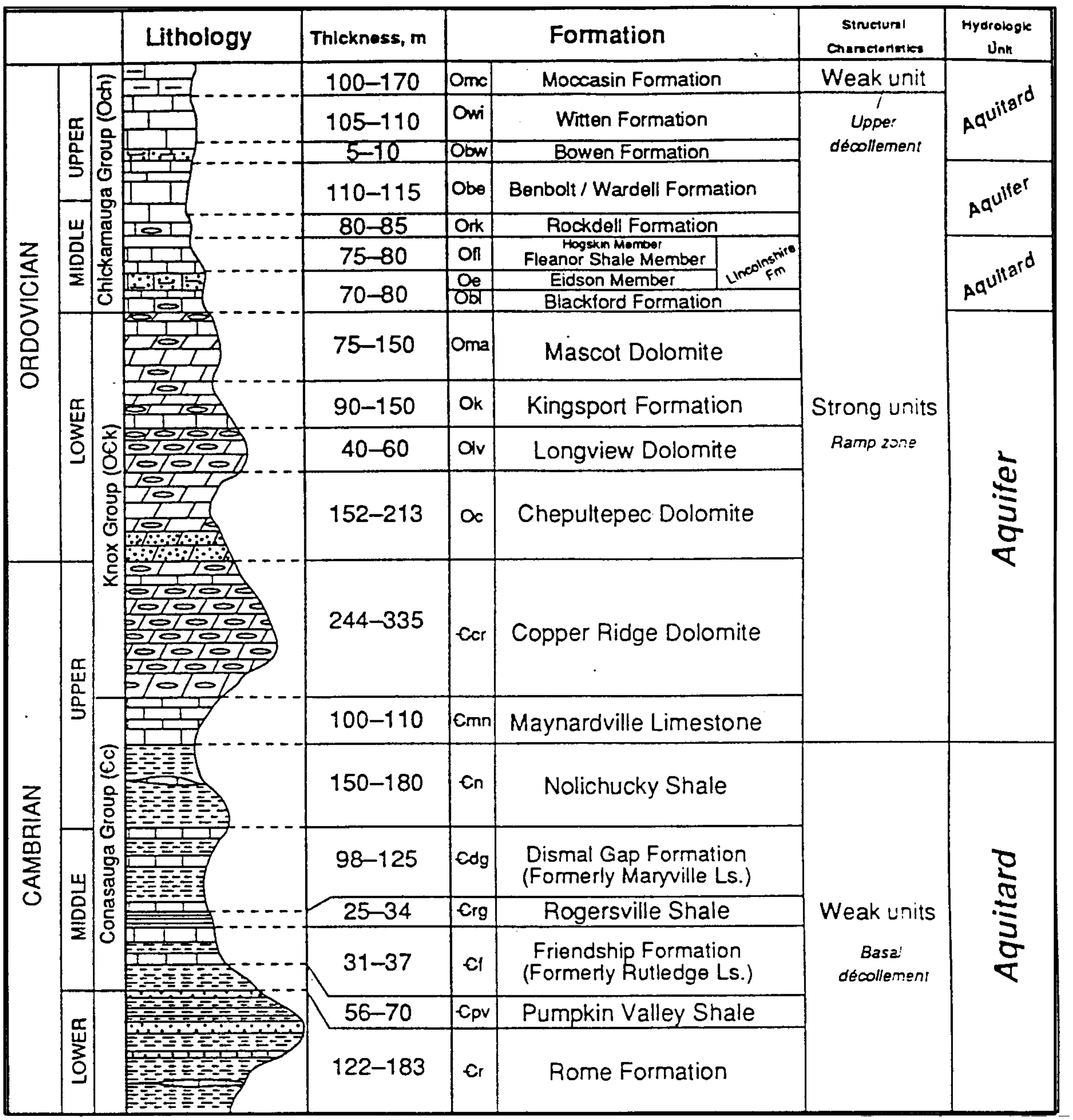


Figure 4.1.1.1-1. ORR Stratigraphy section.

In general, the Cambro-Ordovician age Knox Group and part of the overlying Chickamauga Group form the competent units within the major thrust sheets in the Oak Ridge area. The Knox Group underlies and forms both Chestnut Ridge (preferred site of the proposed SNS facility) and Copper Ridge and dips southward underneath Bethel Valley (Figure 4.1.1.1-2). The Knox Group is composed of a series of medium to thickly bedded, massive, grey, green, and pink dolomite. On the ORR the Knox Group is divided into five separate units: the Copper Ridge Dolomite, the Chepultepec Dolomite, the Longview Dolomite, the Kingsport Formation, and the Mascot Dolomite. Total thickness of the Knox Group ranges between 1,970 and 2,950 ft (600 and 900 m) with the Copper Ridge Dolomite making up roughly one-third of the total. The Chestnut Ridge area encompasses all formation of the Knox Group, but the proposed SNS site boundary overlies the stratigraphic contact between the Copper Ridge and Chepultepec formations at the crest of Chestnut Ridge (Figure 4.1.1.1-3).

The Upper Cambrian Copper Ridge Dolomite is composed of a massively bedded cherty dolomite. It is characterized by medium to coarsely crystalline saccharoidal dolomite and is a common ridge formation in the Valley and Ridge. Sandstone beds in the upper part of the formation are common, and the contact with the Chepultepec Dolomite is mapped at the base of a prominent sandy zone. This formation forms the principal strong unit to support the folding and low-angle thrust faulting that occurs throughout the Valley and Ridge Province in East Tennessee.

Most of the Lower Ordovician Chepultepec consists of light-gray, fine-grained, medium-bedded dolomite. Chert in this formation is less abundant than in the Copper Ridge Dolomite and is characterized by the presence of white oolitic chert beds, dolomitic chert, and a prominent zone of quartz- and dolomite-cemented sandstone at the base.

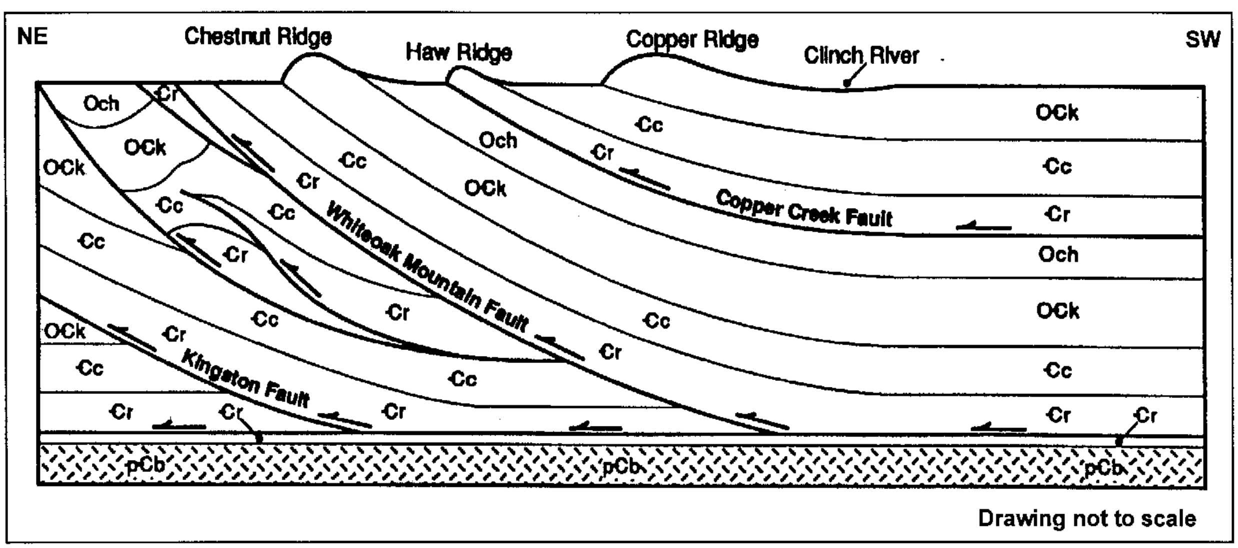


Figure 4.1.1.1-2. Geologic cross section.

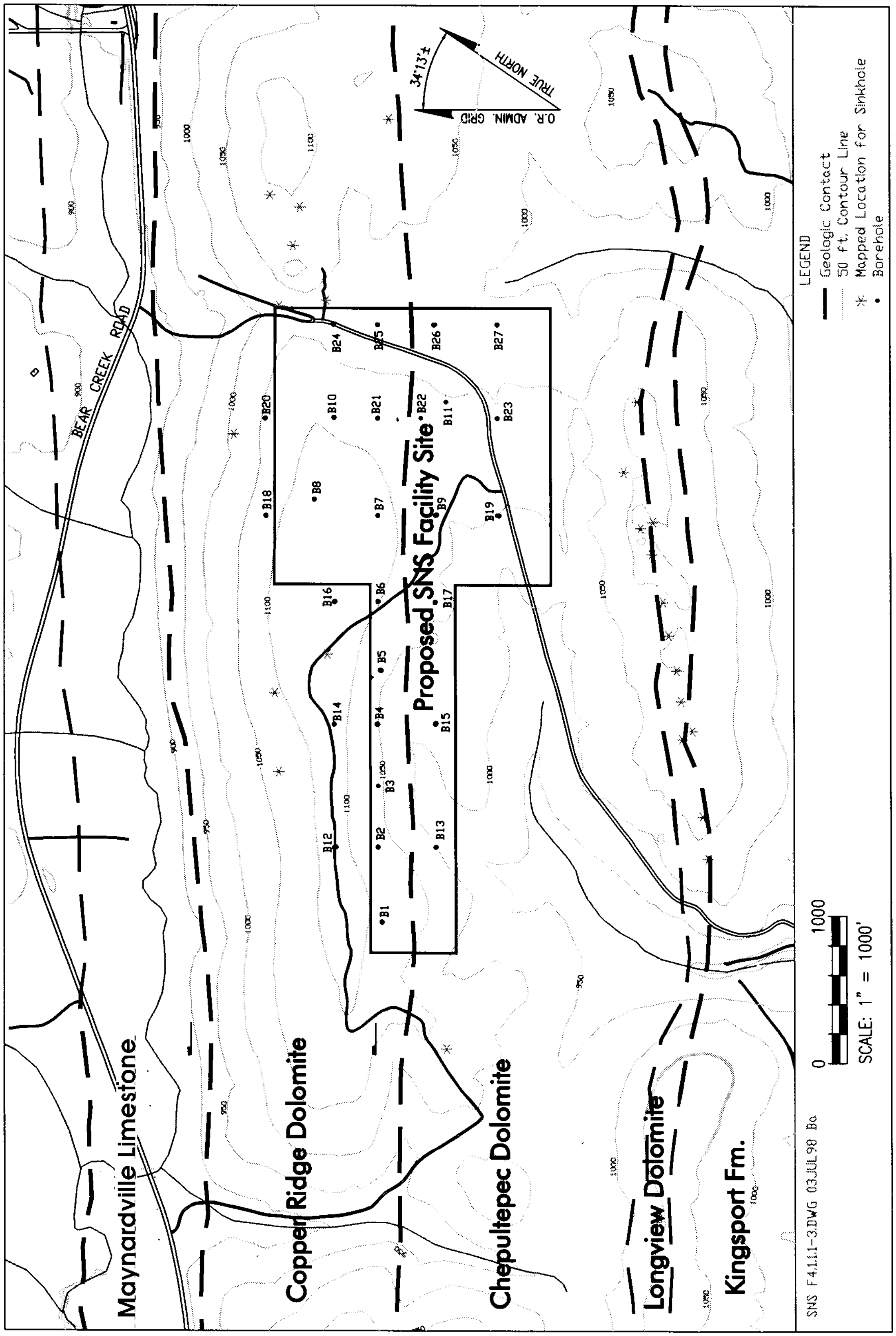


Figure 4.1.1.1-1. Geologic contacts at the SNS site at ORNL.

4.1.1.2 Structure

Strata at the proposed SNS site are oriented (strikes along a northeast-southwest direction with dips 40 to 50° to the southeast) by the compressional tectonics that created the Valley and Ridge Province. These tectonic forces are responsible for two major northeast/southwest trending thrust faults, which dip to the southeast and define the thrust sheets: White Oak Mountain and Copper Creek Fault. Chestnut Ridge and Bethel Valley are underlain by the White Oak Mountain thrust sheet, which is soled by the White Oak Mountain fault (refer to Figure 4.1.1.1-2). Haw Ridge, Melton Valley, and Copper Ridge are underlain by the Copper Creek thrust sheet, which is soled by the Copper Creek thrust fault. Both thrusts are regional thrust faults that demonstrate at least several kilometers of translation. The faults formed during the Permian-Pennsylvanian Age Alleghenian Orogeny and have not been historically active.

Because of the large-scale faulting, all stratigraphic units in the ORR are fractured to varying degrees. Fractures are abundant on rock outcrops, in saprolite, and at shallow depths in fresh bedrock. Fewer open fractures occur at deeper levels, and many are filled or partly filled with secondary minerals. Average fracture densities of 200 per meter have been measured in the saprolite of the Maynardville Limestone and Nolichicky Shale compared with five fractures per meter in fresh rock at depth. Most fractures are from a few centimeters to a meter in length. The areal extent of fractures may be only a few square meters for thin to very thin beds, but the areal extent of bedding-plane fractures may be greater by several orders of magnitude.

4.1.1.3 Soils

The following is a general discussion of the soils underlying the proposed SNS site at ORNL. More detailed information about soils across the ORR can be found in the *Status Report on the Geology of the Oak Ridge Reservation* (Hatcher et al. 1992). Five formations of the Knox Group are commonly identified by their location with respect to formations above and below and by the type of chert they contain. Soil series are designated by the first three digits of a five-digit number: the first number identifies the underlying geologic formation; the second number represents residuum, colluvium, or alluvium; and the third number indicates soil classification. Soil of the Copper Ridge Dolomite and the Chepultepec Dolomite are present under the proposed SNS facility.

Series 400 occurs on convex landforms facing south and west in the residuum of the Copper Ridge Dolomite and contains a high silt content with variable amounts of chert. Series 401 is found in protected, shaded, and cool north slope areas. They have a thicker A horizon and a less distinct E horizon. Series 409 forms at the boundary of the Copper Ridge Dolomite and the Maynardville Limestone. They are found on the lower slope of the western side of Chestnut Ridge. Rock outcrops are common, and depth to bedrock is usually between 3.3 and 4.9 ft (1.0 and 1.5 m).

Series 402 forms in thick saprolite on upland summits and convex side slopes. The A and E horizons have higher chert content. Series 408 was observed only in Walker Branch watershed.

Prime farmland may be considered the best physical and environmental conditions for the production of food crops, livestock, feed, or forage. Prime farmland designation within the City of Oak Ridge boundary and ORR is waived, and other uses are permitted. None of the area affected by the proposed SNS could be valued as prime farmland, although prior to 1942 the area was used for subsistence farming. The proposed SNS site lies on an irregular sloping ridge line covered in secondary forest.

4.1.1.4 Site Stability

In April and May of 1997, Law Engineering (LAW 1997) installed several soil borings and a single rotary drill hole at the proposed SNS site on Chestnut Ridge to test subsurface conditions (refer to Figure 4.1.1.1-3). Testing consisted of four borings that obtained undisturbed samples at various horizons and continuous measurement of the penetration rate (as an indicator of soil strength, density, consolidation, etc.). The borings were taken to depths of approximately 100 ft (33 m) but possibly encountered bedrock at one location. A rotary drill hole was subsequently installed to determine actual depth to solid bedrock; details are forthcoming in a final report. Initial conclusions are that a highly irregular and weathered bedrock surface exists at the site and that large slabs and fragments of chert may occur within the soil mass. Additional borings and geophysical surveys would be conducted in the future to provide a more complete understanding of the subsurface.

Selected soil samples were analyzed for standard engineering characteristics such as grain size, specific gravity, moisture content, and Atterberg limits. The soils tested ranged from clayey sandy silt, gravel-sized chert (Unified Soil Classification System-“GC”) (USACOE 1967) to highly plastic clayey silt (“MH”). Two soil samples yielded unconfined compressive strengths of 3.61 and 2.13 kg/ft^2 (8 and 4.7 lb/ft^2). These soils are typical of the ORR and are not susceptible to liquefaction or mass movement.

Seismicity of the southeastern U.S. was reviewed for the Advanced Neutron Source (ANS) site assessment that was sited approximately 1.9 mi (3 km) south of the proposed SNS site (Blasing et al. 1992). The following summarizes those findings. Historical seismicity in the southeastern U.S. has been traditionally correlated with surficial or shallow geologic features as expressed by physiographic and tectonic provinces. Some large earthquakes in the southeastern U.S. are apparently associated with basement structures, and others have not been correlated with any specific geologic structures. Little is known about the precise relationships between earthquakes and basement structure because the historical record of seismicity is too short and the location and nature of basement structures is not well know. Figure 4.1.1.4-1 displays the location of major earthquakes in relation to known or suspected basement structures.

Five tectonic provinces have experienced significant historical strong-motion earthquakes relevant to the ORR. These provinces are the Appalachian Basin, Piedmont Plateau, Interior Low Plateau, the Mississippi Embayment, and the Atlantic Coastal Plain. The strongest earthquake(s) (#1, 2, 3, 4, 5; year-1812) in the south occurred along the New Madrid Fault in the Reelfoot Rift zone. This fault zone offsets Holocene sediments of the Mississippi Embayment as well as basement rocks. The strongest earthquake within the Atlantic Coastal Plain had its epicenter at Charleston, South Carolina (#5; year-1886), near the rifted continental margin. Rift structures associated

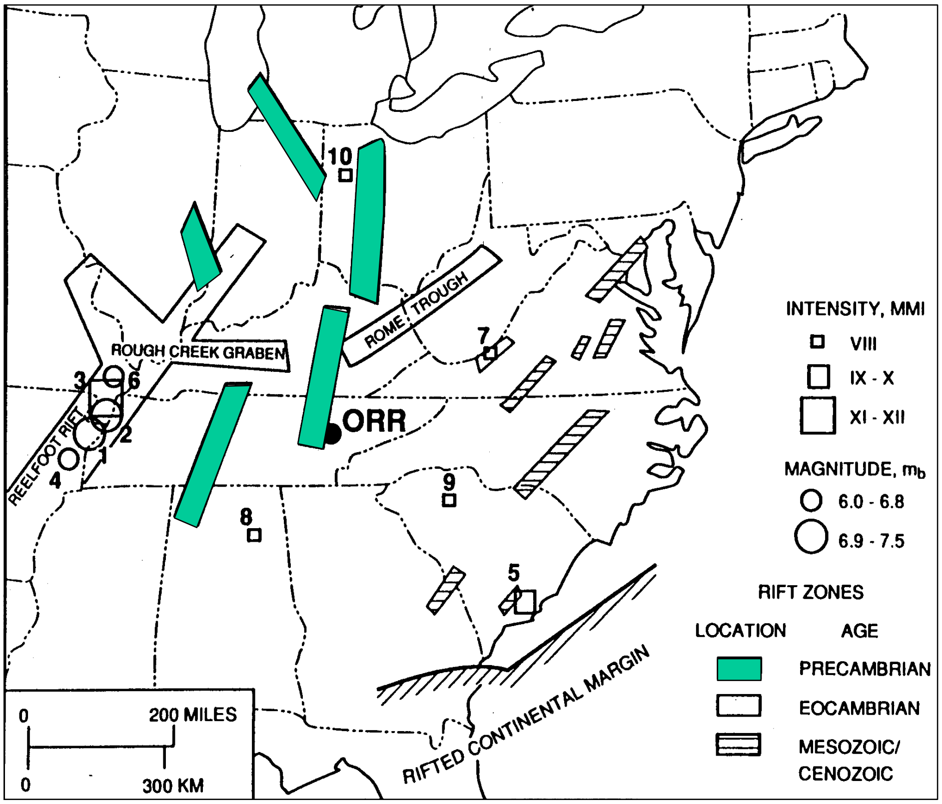


Figure 4.1.1.4-1. Southeast region basement structures and major earthquakes.

with the early opening (Triassic) of the Atlantic Ocean Basin are buried beneath the Atlantic Coastal Plain in Georgia and South Carolina, exposed at the surface in the Piedmont of North Carolina and Virginia, and exposed in the Appalachian Basin from Maryland to Connecticut. It has been suggested that South Carolina earthquakes may occur along reactivated Triassic Basin faults. The nearest Triassic Basin is about 200 mi (320 km) from the ORR. The epicenter of the Giles County, Virginia, earthquake (#7; year-1897) was located on the late Precambrian/early Cambrian basement rift zone beneath Paleozoic Appalachian Basin structures. The Anna Ohio earthquake represents the strongest earthquake in the Interior Low Plateaus Province and had its epicenter (#10; year-1937) near the junction of two Precambrian rift zones. The strongest earthquake of the Piedmont Province (#9; year-1913) was located near Spartanburg, South Carolina, and the strongest earthquake within 60 mi (100 km) of the ORR had an epicenter near Maryville-Alcoa, Tennessee.

The nearest capable faults (with the capacity of seismic movement) are in the New Madrid Fault zone, approximately 480 km (300 mi) northwest of ORR. An exhaustive literature search in the preparation of the Tennessee Valley Authority (TVA) Safety Analysis Review (Blasing et al. 1992) revealed no evidence of capable faults in the Appalachian Basin where the ORR is located. The U.S. Nuclear Regulatory Commission (NRC) (Blasing et al. 1992) affirmed TVA assessment for the Clinch River Breeder Reactor site with the ORR. Furthermore, the depth of earthquakes within the Appalachian Basin is generally greater than 10 km (6.2 mi) for instrumentally recorded earthquakes. Neither earthquake nor outcrop data support the hypothesis that Paleozoic faults exposed at the surface have been reactivated during modern time (Holocene). However, earthquake energies could be transmitted from adjacent physiographic provinces where recent motion events have been observed. Based on historical observations modified for the dampening effect of distance, Table 4.1.1.4-1 presents expected earthquake intensities for the ORR.

4.1.2 WATER RESOURCES

The following section discusses the water resources at ORNL.

4.1.2.1 Surface Water

Surface water at the proposed Chestnut Ridge SNS site consists of a small perennial stream (first order) that acts as headwater to White Oak Creek. This unnamed tributary flows southeast from below the proposed footprint on Chestnut Ridge into the ORNL main plant area. (Figure 4.1.2.1-1). In the lower reaches, the stream has created a floodplain 16 to 33 ft (5 to 10 m) wide with a stream channel up to 6.5 ft (2 m) wide, with overall water depths of about 6 in. (15 cm). Up slope, the tributary forms a deep "V" slope with a channel 3.3 to 6.5 ft (1 to 2 m) wide and with water depths of 2 to 4 in. (5 to 10 cm) during wet-weather base flow. Figure 4.1.2.1-2 displays the combined flow of this stream and two other small tributaries at the weir located well below the proposed SNS site at the foot of Chestnut Ridge (Feb. 97 through Jan. 98). These flows (Salmons 1998b) represent a snapshot of the flow in White Oak Creek from a single recorded measurement for each month shown.

MODIFIED MERCALLI INTENSITY SCALE OF EARTHQUAKE MOTION

I. Not felt except by a few under exceptionally favorable circumstances.
II. Felt by a few persons at rest, especially on upper floors of buildings.
III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Vibration like passing of truck.
IV. Felt indoors by many; outdoors by few during the day. Dishes, windows, door disturbed; walls make creaking sound. Sensation like heavy truck striking building.
V. Felt by nearly everyone, many awakened. Some objects broken; cracked plaster in a few places. Disturbances of trees, poles, and other tall objects sometimes noticed.
VI. Felt by all, many scared and run outside. Some heavy furniture moved. Damages slight.
VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate damage in well built ordinary structures; considerable in poorly built or badly designed structures.
VIII. Damage slight in specially designed structures; considerable in ordinary substantial building with partial collapse; great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, and walls. Sand and mud ejected in small amounts. Changes in well water levels.
IX. Damage considerable in specially designed structures; well designed frame structures thrown out of plumb; great in substantial buildings. Buildings shifted off foundations. Underground pipes broken.
X. Some well-built structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Landslides considerable from river banks and steep slopes.
XI. Few, if any, structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines out of service. Earth slumps and land slips in soft ground.
XII. Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown into the air.

Table 4.1.1.4-1. Maximum expected earthquakes and their peak ground accelerations at ORR.

Province	Maximum Historical Earthquake MMI[a]	Distance to ORR mi (km)	Maximum MMI[b] at ORR
Appalachian Basin	VIII	onsite	VIII
Atlantic Coastal Plain	X	200 (320)	VII
Interior Low Plateaus	VIII	30 (50)	VII
Reelfoot Rift	XI-XII	250 (400)	VII
Piedmont	VII-VIII	125 (200)	V-VI

[a] Blasing et al. 1992.
[b] Modified Mercalli Intensity (MMI) scale.

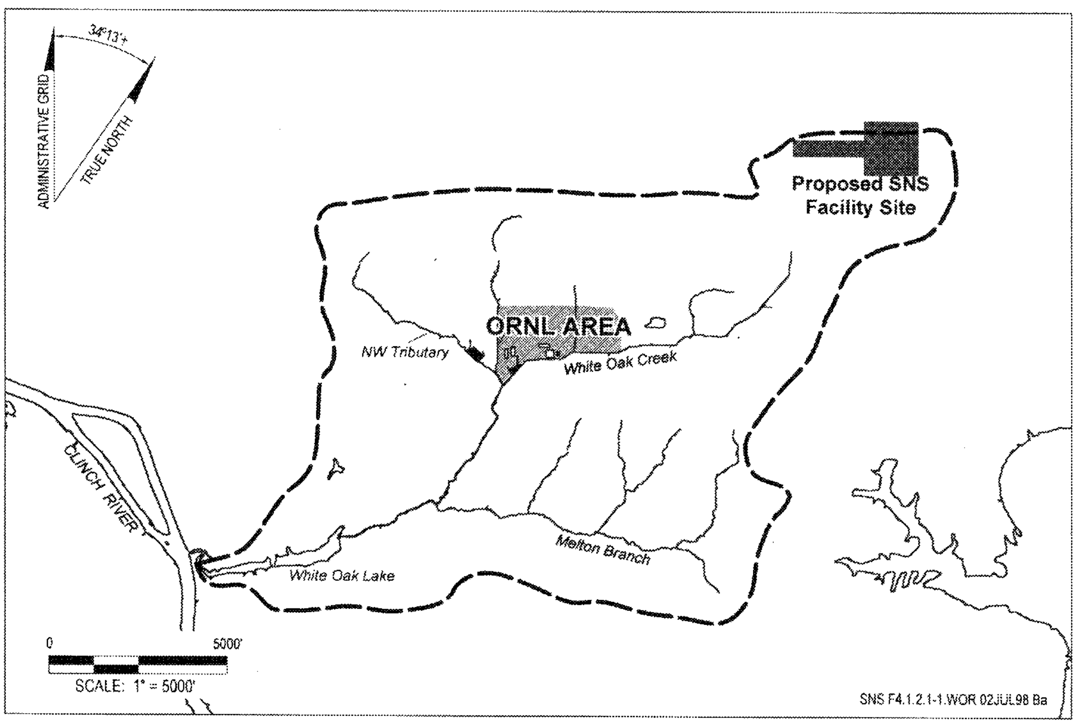


Figure 4.1.2.1-1. White Oak Creek drainage at ORR.

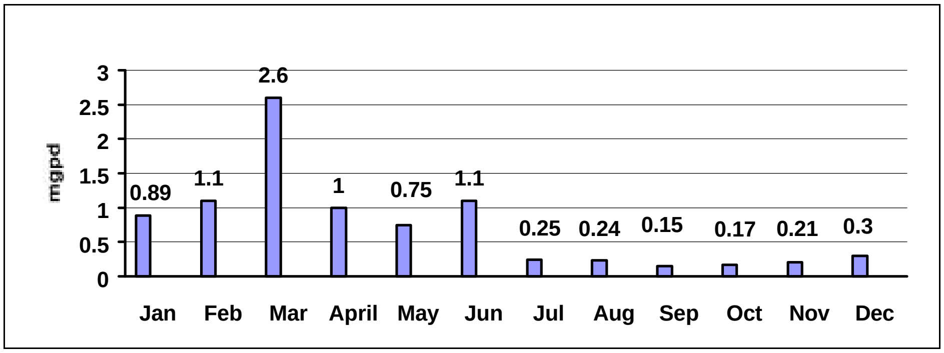


Figure 4.1.2.1-2. White Oak Creek headwater flow at ORR.

Flow diminishes to zero at the elevation of the proposed SNS site. Two additional drainages northeast and southwest of the site dissect the scarp face of Chestnut Ridge and flow northwesterly into Bear Creek. While these drainages may receive runoff from the footprint area, the site boundary does not overlay the actual stream channels.

No known users exist for water from these headwater tributaries. Also, the proposed site is not within a floodplain, nor is widespread flooding likely for a site location several hundred feet above the valley floor.

Water quality of the watershed below the proposed SNS site is frequently monitored and used as a reference site for comparison with the ORNL main plant area. Six sampling events (Salmons 1998a) took place in 1996-1997 at the White Oak Creek Headwater Station (WCK 6.8). For those six sampling events, volatile organic compounds (VOCs) and heavy metal contaminants were not detected. Background concentrations of dissolved metals were observed (i.e., Al, Ba, Ca, Fe, Mg, Mn, P, Na, and Zn).

Six sampling events for radiological monitoring (Salmons 1998a) took place in 1996-1997 at the White Oak Creek Headwater Station (WCK 6.8). Radionuclide levels reflect atmospheric contributions and are far below any level of concern (Table 4.1.2.1-1). Water quality of this stream reflects the nonimpacted character of the watershed.

Table 4.1.2.1-1. Radionuclide activities (Bq/L) at the White Oak Creek Headwaters Monitoring Station.

Radionuclide	Frequency of Detection	Maximum Activity	Average Activity	Minimum Activity
Gross Alpha	2/9	0.044	0.0019	-0.036
Gross Beta	6/9	0.094	0.057	0.016
Be-7	0/1	0.22	0.22	0.22
Co-60	0/9	0.070	0.034	-0.050
Cs-137	0/9	0.050	0.0035	-0.053
H-3	2/9	300.0	41.0	0.0010
TC-99	1/6	0.20	0.055	-0.030
Sr-89,90	1/10	0.099	-0.0039	-0.082
Total Uranium	1/6	0.028	0.013	-0.0020

4.1.2.2 Groundwater

Groundwater at the proposed Chestnut Ridge site is observed at a depth of greater than 60 ft (18 m). Temporary water levels were recorded in open borings by Law Engineering at the site at 67 and 94 ft (20 and 29 m) (B-8 and B-1, respectively). Also, two groundwater monitoring wells (GW-165 and GW-166) located about 3,000 ft (914 m) east of the proposed site (Oak Ridge Administrative Coordinates N27800, E44500) have water levels at depths of greater than 75 ft (23 m). It should be noted that groundwater levels vary significantly depending upon height above the valley floor and seasonal and climatic conditions. No specific groundwater monitoring at the proposed SNS site is available.

Limited site-specific data about the subsurface of the SNS site are currently available. If the Chestnut Ridge alternative is selected, a geophysical, geotechnical, and hydrogeological characterization of subsurface and groundwater conditions will be completed. The following discussion is intended to supply an understanding of the proposed site as deduced from the conceptual regional model.

Two broad hydrologic units are identified in the ORR, each having fundamentally different hydrologic characteristics. The Knox Group and the Maynardville Limestone of the Conasauga Group constitute the Knox aquifer, in which flow is dominated by solution conduits formed along fractures and bedding planes. The remaining geologic units constitute the ORR aquitards, in which flow is dominated by fractures. Subsurface flow in both types of aquifers is recharged mainly on ridges and is discharged into lakes, streams, springs, and seeps.

The hydrology of the ORR has been described by Moore (1989). The subsurface flow system can be divided into the storm flow zone, the vadose zone, and the groundwater zone. Water budget models indicate that 90 percent of the active subsurface flow occurs through the top 3.3 to 6.5 ft (1 to 2 m) of the stormflow zone. Infiltration tests indicate that this zone is as much as 1,000 times more permeable than the underlying vadose zone. During rain events, the stormflow zone partially or completely saturates and transmits water laterally to the surface-water system. A vadose zone exists throughout the ORR except where the water table is at land surface. The thickness of the zone is greatest beneath ridges and thins towards valley floors. Beneath ridges underlain by the Knox aquifer (for example, Chestnut Ridge), the vadose zone is often as much as 164 ft (50 m) thick. Most recharge through the vadose zone is episodic and occurs along discrete permeable features that may become saturated during rain events.

The groundwater zone occurs typically near the transition from regolith to bedrock. This zone can be divided into three intervals: the water table interval, the intermediate interval, and the deep interval. The water table surface lies near the contact between the regolith and weathered bedrock. A large flux has formed regolith at a shallower level by dissolution of the rock cement. Fresh bedrock at deeper levels indicates a smaller water flux. Seasonal declines in water table elevation can nearly drain this interval.

Groundwater movement within the bedrock is dominated by flow through fractures that can be separated into two categories: the larger, well-connected, water-producing intervals and the smaller intervals that make up the matrix. Distinctly different transmissivity values represent two populations of aquifer properties [for example, flowing fractures (mean T=0.23 m²/d) and matrix contributions (mean T=0.0011 m²/d)]. The deeper groundwater zone occurs below any water-producing interval and generally has the same characteristics as matrix intervals within the shallow groundwater zone (SAIC 1994).

The Knox aquifer is a carbonate unit with karst features in which the majority of groundwater flow is controlled by a few cavity systems. In the Knox aquifer, and to a lessor extent in other carbonate rocks of ORR, fractures are enlarged by solution to create well-developed and extensive cavity systems. A survey of the proposed SNS site has mapped the surface expression of locations for possible sinkholes related to karst development (Figure 4.1.1.1-3). Many of these sinkholes occur within the Longview Dolomite southeast of the proposed site, but others are scattered within the general area of the SNS footprint.

In bedrock throughout the ORR, groundwater flow occurs through networks of open, connected fractures and conduits. To understand the significance of karst development within the Knox aquifer, a study of 802 wells in various formations showed that only 97 wells (12 percent) intercepted a cavity. From the population of wells that intercepted cavities, 53 out of 97 (55 percent) encountered only one cavity, while the Knox wells encountered two or more cavities 76 percent of the time. There is also a correlation between formations and the cavity size. The average cavity height at ORNL in the 97 occurrences is 1.8 ft (0.59 m). The largest cavities are generally found in the Knox Group with a mean height of 3.3 ft (1.0 m). In addition, cavities occur at deeper depths in the Knox Group than in other units. Mean depth below ground surface of the cavities in the Knox Group [112 ft (34 m)] is significantly greater than in the Rome Formation [39.3 ft (12 m)], Conasauga Group [27.2 ft (8.3 m)], or the Chickamauga Group [32.2 ft (9.8 m)].

Two wells on the southeast side of Bear Creek Valley are reported to produce greater than 950 gpm (3,596 lpm) of water, and about a dozen large springs discharge water near the base of ridges underlain by the aquifer. A tracer test in the Knox aquifer showed a fluid velocity of 650 to 950 ft/d (200 to 300 m/d) between a swallow hole and a resurgent spring farther downstream. Most wells in the Knox aquifer, however, yield small quantities of water and are not capable of similar flows from those permeable zones.

No groundwater monitoring wells are located in the vicinity of the proposed SNS site to characterize the water quality parameters.

4.1.3 CLIMATE AND AIR QUALITY

The ORR is part of the southeast climatological region of the U.S. and may be broadly classified as humid continental. The region is characterized by a moderate continental forest climate with mild, cool winters and warm, humid summers. The Blue Ridge Mountains to the east and the Cumberland Plateau to the west have a protective and moderating influence on the area's climate. These features divert severe storms and tornadoes; consequently, high-velocity windstorms are rare. Similarly, the mountains divert hot, southerly winds that develop along the south Atlantic Coast. Slow-moving high-pressure cells that may remain stationary for days suppress rain in the fall and provide mild weather.

Precipitation in this portion of the Tennessee Valley is seasonally distributed (Figure 4.1.3-1). Winter storms are generally of low intensity and long duration. Brief, heavy rains associated with thunderstorms are common in the summer. Peaks in precipitation usually occur in winter and early spring and in mid-late summer. The 40-year mean annual precipitation is 53.9 in. (137 cm), and the mean annual snowfall is 10.4 in. (26 cm). Year-round mean temperatures are about 58 °F (14.4 °C) with a January mean of about 38 °F (3.5 °C) and a July mean of about 77 °F (25 °C). Extreme temperatures can dip as low as -24 °F (-31 °C) and peak as high as 100°F (37.8 °C).

The prevailing winds in this area follow the general topography of the surrounding ridges: up-valley winds come from the southwest during the daytime, and down-valley winds come from the northeast during the nighttime (Figure 4.1.3-2). The average wind speed recorded for 1996 was 3.13 mph (5 km/h), with a maximum recorded gust of 50.3 mph (81 km/h) and a predominant wind direction to the southwest (NCDC 1996).

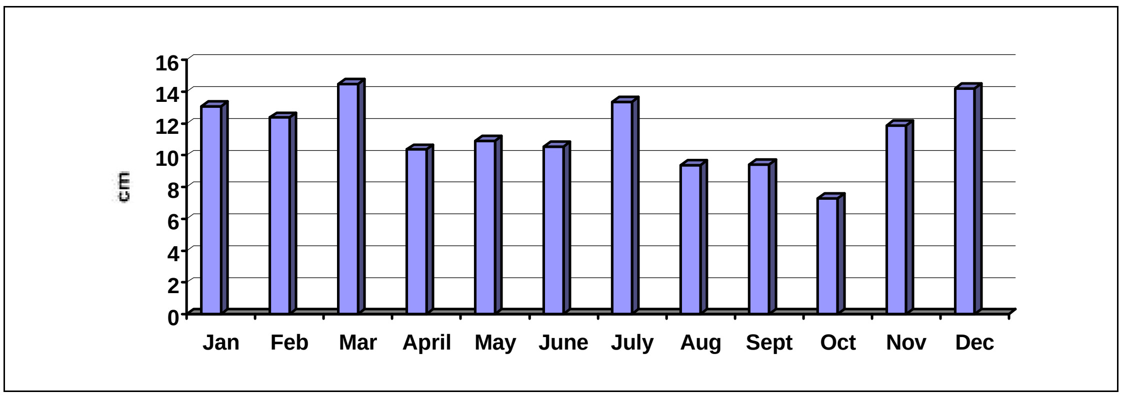


Figure 4.1.3-1. Average monthly precipitation at ORR.

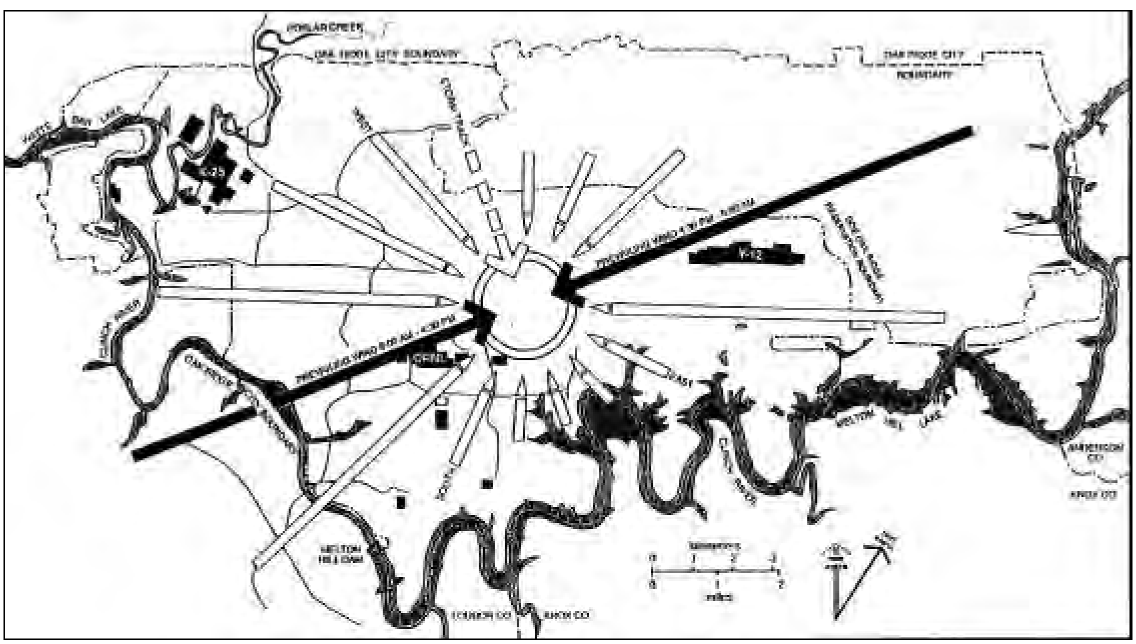


Figure 4.1.3-2. Day and nighttime wind patterns at ORR.

4.1.3.1 Severe Weather

Severe weather in the Oak Ridge area is primarily related to convective thunderstorms with associated hail and lightening. On the average, this area experiences 51.3 thunderstorm events per year. The maximum sustained wind velocity observed at the National Oceanic and Atmospheric Administration (NOAA) meteorological station was recorded January 1959 at 59 mph (95 km/h). An average of 33.6 days is observed with heavy fog restricting visibility to less than 0.25 mi (0.4 km). Historically, snowfalls greater than 1 in. (2.5 cm) have been recorded on only 3.6 days.

East of the Rocky Mountains, East Tennessee has one of the lowest incidences for severe weather involving a tornado (Figure 4.1.3.1-1). Nonetheless, occurrences of such storms are a possibility, as demonstrated by the storm of February 21, 1993. Climatic conditions of this storm spawned a tornado with winds estimated to be in excess of 100 mph (161 km/h). The storm path cut through ORR near the Y-12 Plant. It caused relatively light damage, much in part due to its course and relatively small size. Effects of a tornado on certain key facilities on the ORR have been examined from an emergency-planning standpoint. Numerous approaches to calculating tornado frequencies and recurrent intervals exist. A common approach was initially proposed by H.D.S. Thom in 1963. Based upon historical tornado sightings over a large square (one degree), a point probability can be calculated. The chance of a point, like the proposed SNS location, being struck by a tornado of *any* magnitude in a one-year period is approximately 0.0004. Conversely, the recurrence interval for a tornado striking that point is 1/0.0004 or about once every 2,500 years (Knazovich et al. 1993).

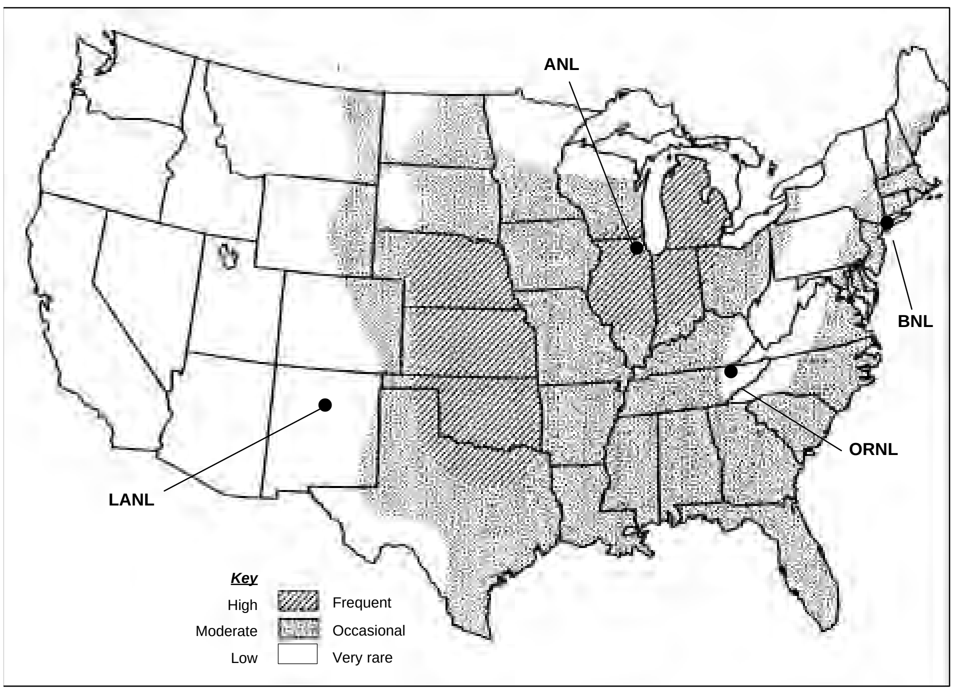


Figure 4.1.3.1-1. Tornado frequency in the U.S.

Other studies by Fujita (1979, 1980), McDonald (1979), and Beavers et al. (1985) (all cited in Knazovich et al. 1993) were performed for the ORR. Based on these studies, the probability of a tornado with wind speeds in excess of 100 mph (161 km/h) occurring at Oak Ridge is approximately 5×10^{-5}, or a recurrence interval of about once every 20,000 years. The estimate of a tornado with higher wind speeds striking Oak Ridge is even lower. The probability of a significant tornado (F2 or higher) striking the Oak Ridge area is on the order of 3×10^{-5} to 1×10^{-7}.

4.1.3.2 Atmospheric Dispersion

Seven meteorological towers provide data on meteorological conditions and on the transport and diffusion qualities of the atmosphere on the ORR. The system consists of two towers at the Y-12 Plant [328 and 216 ft (100 and 66 m) high], three towers at the ORNL main plant area [one 328 ft (100 m) and two 108 ft (33 m) high)], and two towers at the East Tennessee Technology Park (ETTP) site [216 and 108 ft (66 and 33 m) high]. Data are collected at different levels to determine the vertical structure of the atmosphere and the possible effects of vertical variations on releases from facilities. At all towers, data are collected at 33 ft (10 m) and at the top levels. At the 328-ft (100 m) towers, data are also collected from an intermediate 108-ft (33 m) level. At each level, temperature, humidity, wind speed, and direction are measured. Select stations measure barometric pressure, precipitation, and solar radiation.

As mentioned previously, prevailing winds are channeled from the southwest or northeast by the ridges flanking the proposed site, providing limited cross-ridge flow. These conditions dominate over the entire reservation with the exception of the ETTP site, which is located in a relatively open area that has a more varied flow. On ORR, low-speed winds predominate at the surface level. Data from tower levels indicate an increase in wind speed at progressively higher

THE FUJITA SCALE

F-Scale Number	Intensity Phrase/ Wind Speed	Type of Damage Done
F0	Gale tornado: 40-72 mph	Some damage done to chimneys; breaks branches off trees.
F1	Moderate tornado: 73-112 mph	Peel surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off roads; attached garages may be destroyed.
F2	Significant tornado: 113-157 mph	Considerable damage. Roofs torn off frame houses; mobile homes demolished; large trees snapped.
F3	Severe tornado: 158-206 mph	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.
F4	Debasing tornado: 207-260 mph	Well-constructed houses leveled; structures with weak foundations blown off; cars thrown.
F5	Incredible tornado: 261-318 mph	Strong frame houses lifted off foundations and carried considerable distances; automobile-sized missiles fly through the air; trees debarked; concrete structures badly damaged.

elevations. The atmosphere over the reservation is dominated by stable conditions on most nights and in the early morning hours. These conditions, coupled with low wind speeds and channeling effects of the valleys, result in poor dilution of material emitted from facilities. Air stagnation is relatively common in eastern Tennessee. An average of about two air stagnation episodes for periods greater than 24 hours occurs annually, covering an average of eight days per year. August, September, and October are the most likely months for air stagnation episodes.

4.1.3.3 Air Quality

The State of Tennessee has adopted the National Ambient Air Quality Standards (NAAQS), and the Tennessee Department of Environment and Conservation (TDEC) has also adopted regulations to guide the evaluation of hazardous air pollutants and toxics to specify permissible short- and long-term concentrations. Oak Ridge is in an Air Quality Control Region, classified as an "attainment" area for the six NAAQS criteria pollutants.

Existing ambient air quality in the vicinity of ORR is best quantified in terms of recent ambient monitoring data collected by the TDEC at nearby locations. Table 4.1.3.3-1 summarizes these data and is taken from *AIRS Quick Look Report* (TDEC 1998) for 1997. The ORR is located in a Class II prevention-of-significant-deterioration (PSD) area. The nearest Class I PSD area is the Great Smoky Mountains National Park, approximately 35 mi (56 km) southeast of the ORR. Class I PSDs include certain national parks and wilderness areas and permit the least amount of air quality

Table 4.1.3.3-1. Summary of 1997 monitoring data in the vicinity of the ORR.

Pollutant Averaging Time	Nearest Monitor Location	Maximum 1st	2nd	3rd	4th	NAAQS TAAQS	Number of Exceedances
PM-10	Knox Co.						
24-hour		69.0	67.0	61.0	60.0	150.0 μg/m³	0
Annual		33.0				50.0 μg/m³	0
TSP	Knox Co.					150.0 Sec.	
24-hour		107.0	87.0	77.0	77.0	260.0 Pri. μg/m³	0
Ozone	Anderson Co.						
1-hour		0.109	0.107	0.106	0.105	0.12 ppm	0
NO_x	Loudon Co.						
Annual		0.015	—	—	—	0.05 ppm	0
SO_2	Anderson Co.						
3-hour		0.152	0.125	—	—	0.5 ppm	0
24-hour		0.032	0.025	—	—	0.14 ppm	0
Annual		0.005	—	—	—	0.03 ppm	0
CO	Knox Co.						
1-hour		10.3	9.6	—	—	35.0 ppm	0
8-hour		4.9	4.8	—	—	9.0 ppm	0
Lead	Roane Co.						
Quarterly		0.13	0.11	0.07	—	1.5 μg/m³	0

Source: TDEC 1998. TAAQS - Tennessee Ambient Air Quality Standards.

deterioration for baseline concentrations of particulate matter, sulfur dioxide, and nitrogen dioxide. All areas not designated as Class I PSDs are supplied with a Class II determination.

4.1.4 NOISE

The SNS site is proposed for a wooded section of the ORR that is roughly 0.75 mi (1.2 km) from the nearest public-use highway (Bethel Valley Road) and about 1 mi (0.6 km) from the nearest concentration of onsite workers (ORNL). A site-specific survey has not been conducted, but ambient noise levels in a rural setting such as this are typically in the 35-45 dB range. Because of its remote location, the proposed site would be protected by distance from sources of noise and removed from any sensitive populations. The proposed SNS site would be situated about 3 mi (4.8 km) from residential population centers within the City of Oak Ridge and dispersed populations within Knox County.

4.1.5 ECOLOGICAL RESOURCES

This section provides a general description of the ecological resources for the proposed SNS site and the surrounding area. The discussions are based on information readily available from other sources. Site-specific surveys were done for protected species and wetlands. All other information was obtained from existing publications. For the most part, the impacts from construction and operation of the proposed SNS would be minor. Therefore, much of the information presented here is summary in nature. Greater detail can be obtained from the references compiled for this section.

4.1.5.1 Terrestrial Resources

ORR is an area of primarily natural vegetation surrounded by dramatically different land uses.

Since 1942, when the land was purchased for the Manhattan Project, the 34,516-acre (13,980 ha) reservation has been undisturbed except for project development of the U.S. Department of Energy (DOE) and its predecessors and for forest management. The original forests on the ORR were extensively cleared, and the land was cultivated or partially cleared and used for rough pasture during settlement. Except for the very steep slopes, most of the forest had been cut for timber, though not necessarily cleared and put into cultivation. Cultivation on the ORR ended in 1942, and cultivated fields have developed into forest, either through natural selection or planting of pines. Many of these old abandoned fields support mixed hardwood forests. Between 1948 and 1954, many of the abandoned fields that were not developing into forest were planted with loblolly, shortleaf, and white pine trees. Most of these plantations have been maintained with little or no invasion of hardwoods. Most pine stands that currently exist are on lower slopes; relatively level, wide ridge tops; and well-drained bottomlands.

Based on information from the Forest Compartment Maps for the ORR, over half of the proposed site is covered with a mixed hardwood forest, composed of red oak, white oak, chestnut oak, poplar, and hickory. Approximately 20 percent of this area is covered with loblolly pines, the majority of which were planted in the 1940s and 1950s. Approximately 20 percent of the proposed site is labeled as “Beetle Kill cut over” (clear cutting for control of the pine bark beetle). The remaining 10 percent of the vegetative cover is old field scrub.

Only general information on wildlife in the vicinity of the proposed SNS site is available. Wildlife in this area is typical for forests in East Tennessee. Numerous small mammals occupy the hardwood/mixed-hardwood habitat, including flying squirrels, southeastern shrews, eastern moles, white-footed mice, and eastern chipmunks. Birds commonly found in forest areas include the yellow-shafted flicker, red-bellied woodpecker, hairy woodpecker, downy woodpecker, blue jay, Kentucky warbler, pine warbler, yellow-breasted chat, ovenbird, Carolina chickadee, tufted titmouse, and scarlet tanager. Hawks, including red-shouldered, red-tailed, and broad-winged, are commonly found on the ORR, as are wild turkeys. Amphibians and reptiles found in the forest habitat include the dusky salamander, American toad, eastern box turtle, ground skink, worm snake, black racer, rat snake, black king snake, milk snake, and copperhead.

Pine plantations are essentially barren of both small and large mammals due primarily to the dense canopy that shade out most undergrowth. The pine warbler and white-throated sparrow are birds commonly found, but in general few bird species prefer this type of habitat. Reptiles and amphibians make little use of this habitat.

Right-of-ways for power line, gas pipeline, and water pipeline run through or adjacent to the proposed site. In addition, there are several dirt roads running through the site.

4.1.5.2 Wetlands

A field survey, conducted in September 1997, describes the wetlands within the vicinity of the proposed SNS site (Rosensteel et al. 1997). Eight wetland areas were identified (Table 4.1.5.2-1), five within the White Oak Creek watershed and two in the upper reach of White Oak Creek, upstream of an existing power line right-of-way. One wetland area is in the riparian zone of Bear Creek south tributary 4 downslope of the proposed SNS site. Wetland area locations are shown in Figure 4.1.5.2-1.

A small emergent wetland (WONT2-1) was identified along a tributary of White Oak Creek. An old overgrown road crosses the tributary near its confluence with White Oak Creek. The emergent wetland has developed in a low spot in the road where it crosses the stream. Surface runoff and seasonal flood waters collect in and flow through the wetland area. Species in the wetland include smartweed *(Polygonum sp.)*, false nettle *(Boehmeria cylindrica)*, microstegium *(Microstegium vimineum)*, and sedges *(Carex spp.)*.

Table 4.1.5.2-1. Wetlands in the vicinity of the proposed SNS site at ORNL.

Wetland No.	Watershed	Estimated Area acres (ha)	Wetland Class
WOM14	White Oak Creek	0.03 (0.012)	PEM1
WOM15	White Oak Creek	0.09 (0.036)	PEM1F
WOM16	White Oak Creek	1.60 (0.648)	PFO1C
WOM17	White Oak Creek	0.15 (0.061)	PFO1C
WOM18	White Oak Creek	<0.03 (<0.012)	PEM1C
WONT1-1	White Oak Creek	2.7 (1.093)	PFO1C
WONT2-1	White Oak Creek	<0.01 (<0.004)	PEM1
BCST2-1	Bear Creek	0.35 (0.142)	PFO1C/PEM1C

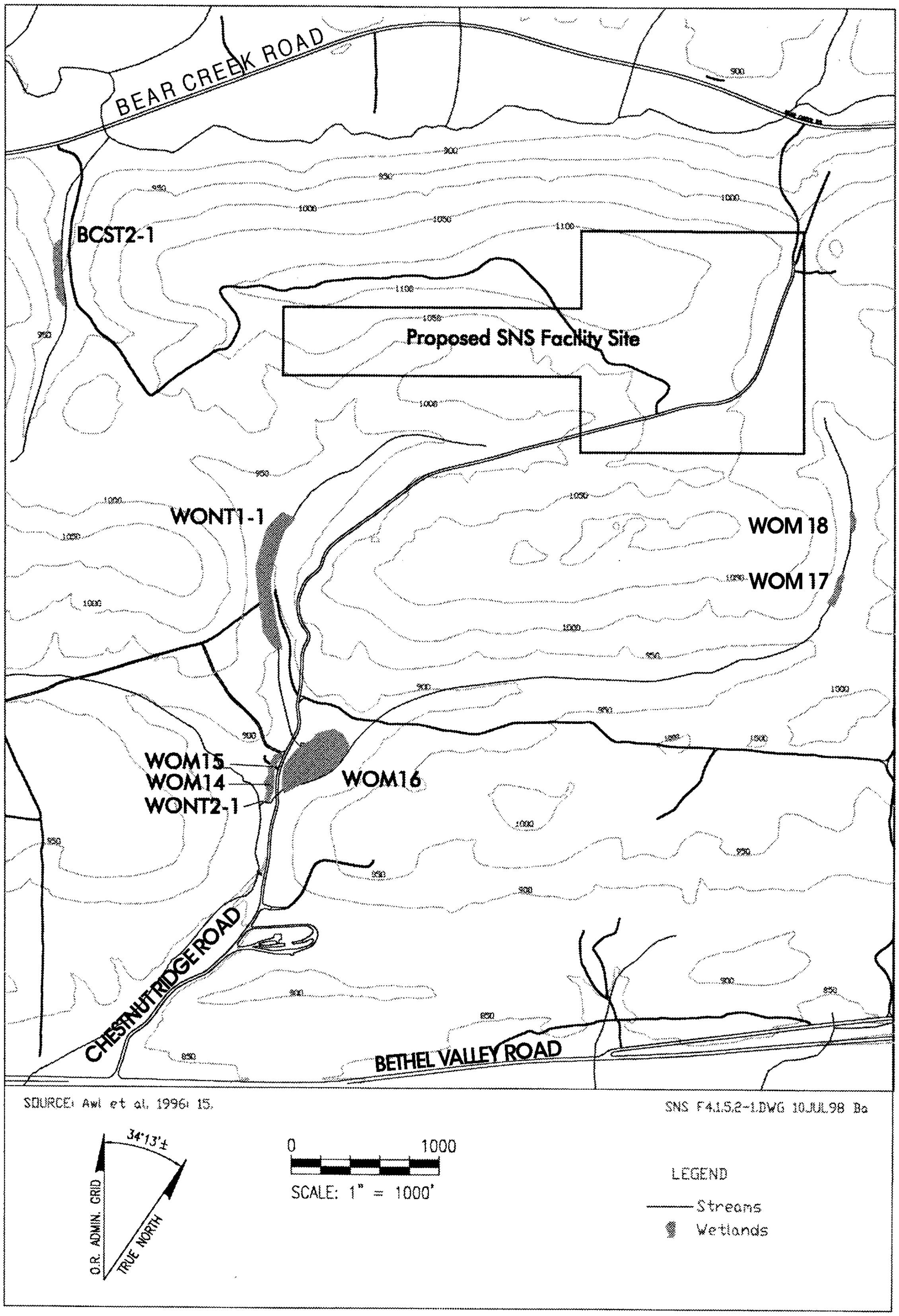


Figure 4.1.5.2-1. Wetland areas within and adjacent to the proposed SNS site at ORNL.

Wetland Classification

Wetlands identified within the vicinity of the proposed SNS site at ORNL were classified with a hierarchical system developed in 1979 by Cowardin et al. (as cited in Rosensteel et al. 1997). Wetlands are described by system, class, and subclass. Additional modifiers are used for water regime, chemistry, soil and disturbances.
The systems are marine, estuarine, riverine, lacustrine, and palustrine. The marine and estuarine systems are oceanic and coastal and do not occur on the ORR. The lacustrine and riverine systems encompass freshwater lakes and streams. The palustrine system includes nontidal wetlands dominated by trees, shrubs, or emergent vegetation. These wetlands are traditionally called marshes, swamps, or ponds.

The palustrine system includes five classes that are vegetated and that are considered as wetlands under the U.S. Army Corps of Engineers definition (1987): (1) aquatic bed, (2) moss-lichen, (3) emergent (dominated by herbaceous plants that rise above the water surface), (4) scrub-shrub (dominated by shrubs and sapling trees), and (5) forested. Subclasses of the vegetation classes indicate differences in vegetative form. Water regime modifiers include: (A) temporarily flooded, (B) saturated, (C) seasonally flooded (F), semipermanently flooded, and (H) permanently flooded. (As cited in Rosensteel et al. 1997.)

An emergent wetland swale (WOM15) lies immediately adjacent to Chestnut Ridge Road near the White Oak Creek crossing. Discharge from the spring flows through the swale on the side of the road and empties into White Oak Creek. Shrubs such as alder *(Alnus serrulata)* and elderberry *(Sambaucus canadensis)* grow along one side of the swale. The swale is vegetated with numerous wetland species including watercress *(Nasturtium officinale*), great lobelia *(Lobelia siphilitica*), cardinal flower *(Lobelia cardinalis*), turtlehead *(Chelone glabra*), smartweed *(Polygonum.* sp.), and sedges *(Carex* spp.). The estimated size of the wetland is less than 0.1 acre (0.04 ha).

An emergent wetland (WOM14) was identified in an isolated depression, adjacent to the wetland swale (WOM15) but separated by a vegetated berm. The berm may have been made during road construction. The depression does not appear to have a surface outlet to the swale or to White Oak Creek. There was no water in the depression on the day of the survey, but it is likely that it holds precipitation and surface runoff during the winter and spring and during periods of rain in the summer. The soil has hydric characteristics. Species in the emergent wetland are fescue *(Festuca arundinaceae)*, false nettle *(Boehmeria cylindrica*), smartweed, Frank's sedge *(Carex frankii*), and other sedges.

A forested wetland (WOM16) is located in a seep area along White Oak Creek, immediately adjacent to the east side of Chestnut Ridge Road. This wetland area had initially been designated a Research Park Reference Area but is now within Research Park Natural Area 55. *Carex leptalea* and *Bartonia paniculatum*, two species that are uncommon in East Tennessee, occur in this wetland. Dominant or common plant species in this wetland include sycamore *(Platanus occidentalis*), red maple *(Acer rubrum*), green ash *(Fraxinus pennsylvanica*), spicebush *(Lindera benzoin*), microstegium, false nettle, cardinal flower, bugleweed *(Lycopus*

Wetlands as defined by the U.S. Army Corp of Engineers (USACOE): Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. The USACOE uses three characteristics of wetlands when making wetland determinations:

Vegetation indicators - Plant types known as hydrophytic (a perennial vascular aquatic plant having its overwintering buds under water) vegetation exists in the area.

Soil indicator - Existence of soils that are hydric, having characteristics that indicate they were developed in conditions where soil oxygen is limited by the presence of saturated soil for long periods during the growing season.

Hydrology indicators - Wetland hydrology exists when the presence of water at or above the soil surface for a sufficient period of the year significantly influences the plant types and soils that occur in the area.

Unless an area has been altered or is a rare natural situation, wetland indicators of all three characteristics must be present during some portion of the growing season for an area to be characterized as a wetland by the USACOE.

virginicus), smartweed, and hog peanut *(Amphicarpa bracteata).*

A forested wetland (WOM17) and a small, fringe, emergent wetland (WOM18) were identified in the upper reach of White Oak Creek. The forested wetland occurs in a seep area that appears to contribute a significant portion of the base flow of upper White Oak Creek during the fall. The stream channel is dry upstream from the right-of-way for about half the length of this portion of the stream. Upstream of this dry reach, there is flowing water that is contributed by springs and seeps along this part of the stream bottom. The stream channel is once again dry in the upper most reach, a short distance upstream of WOM18. Water levels in these headwater streams are expected to be at or near their lowest level at this time of year. At other times of year, the entire stream channel is expected to have flowing water. The dominant vegetation species in this wetland include sweetgum, red maple, ironwood, smartweed *(Polygonum punctatum)*, cardinal flower, microstegium, false nettle, and poison ivy *(Toxicodendron radicans*). The area is saturated, and there is flowing water in surface channels.

There is a narrow fringe [2 to 3 ft (0.6 to 0.9 m) wide] of emergent wetlands on the edge of the stream channel (WOM18). This section of stream contained flowing water. Dominant species include microstegium, cardinal flower, smartweed, bugleweed, and sensitive fem *(Onoclea sensibilis*).

A forested wetland (WONT1-1) is located in the riparian zone of a tributary of White Oak Creek. This tributary drainage is in Natural Area 55. The tributary is located in a forested drainage on the west side of Chestnut Ridge Road north of the power line right-of-way. The stream crosses the power line, flows through a culvert under Chestnut Ridge Road, and empties into White Oak Creek in the WOM16 wetland area south of the power line right-of-way. The wetland is located along the middle reach of the stream.

The primary water source for this wetland is groundwater in the form of perennial seeps and a seasonal high water table. Overbank flooding is a seasonal, but not a sustaining, source of water. Dominant species include sycamore, red maple, sweetgum *(Liquidambar styracifolia*), green ash, bugleweed, cardinal flower, and cinnamon fem *(Osmunda cinnamomea*). At a perennial seep, which spreads out over a wide area, the dominant species include smartweed, watercress, bugleweed, cutgrass *(Leersia oryzoides*), leathery rush *(Juncus coriaceous*), avens *(Geum* sp), and sticktights *(Bidens* sp).

In the riparian zone of Bear Creek south tributary 4, there are three small areas of forested wetlands and emergent wetlands at stream side seeps. These three areas are close together along the stream and were combined into one wetland area (BCST2-1) for purposes of mapping and description. The approximate size of the wetland area is 0.3 acre (0.1 ha). It is downslope of, but not within, the site boundary. Dominant species include green ash, red maple, spicebush, microstegium, poison ivy, woodreed *(Cinna arundinacea*), and Virginia knotweed *(Tovara virginiana).*

4.1.5.3 Aquatic Resources

The proposed site lies within the White Oak Creek watershed (refer to Figure 4.1.5.2-1). White Oak Creek is a second-order stream with a watershed area of approximately 0.85 mi^2 (2.2 km^2), bordered by a young-to-mature forest and disturbance vegetation. The stream contains substantial aquatic vegetation, primarily watercress and peppermint. A rich and diverse assemblage of benthic invertebrates and a stable fish community occur in this area. At White Oak Creek kilometer 6.8, upstream of discharges from ORNL but downstream of the proposed SNS site, small numbers of the central stoneroller (*Campostoma anomalum),* blacknose dace (*Rhinichthys atratulus*), creek chub *(Semotilus atromaculatus*), and banded sculpin (*Cottus carolinae*) have been collected. Historically, operations at ORNL have had an adverse ecological effect on White Oak Creek and it tributaries, First Creek and Fifth Creek. The mean number of different kinds of taxa per sample (species richness) of benthic macroinvertebrates (bottom-dwelling invertebrates capable of being seen with the naked eye) is less downstream of ORNL than upstream. The number of pollution-intolerant benthic macroinvertebrate taxa is also less downstream of ORNL than upstream.

4.1.5.4 Threatened and Endangered Species

DOE is in the process of consulting with the U.S. Fish and Wildlife Service (USFWS) and TDEC regarding whether or not construction and operation of the proposed SNS at ORNL would jeopardize the habitat of any threatened or endangered species and regarding appropriate mitigation measures. The USFWS responded with a list of federally listed or proposed endangered or threatened species that they believe may occur on the proposed SNS site. The TDEC has yet to respond. Appendix C presents the letters of consultation.

Surveys of the proposed SNS site for the presence or evidence of state and federally listed plant and animal species were conducted in 1997 (Rosensteel et al. 1997). No suitable habitat was identified for listed species of fish that have been previously documented on the ORR or for other listed fish known to occur in the region. No suitable habitat was identified on or adjacent to the proposed site for any federally listed wildlife species. Suitable habitat was found for

Threatened and Endangered Species: Animals, birds, fish, plants, or other living organisms in jeopardy of extinction by human-produced or natural changes in their environment are considered threatened or endangered. Requirements for declaring species threatened or endangered are contained in the *Endangered Species Act of 1973*.

This Act protects animal and plant species currently in danger of extinction (endangered) and those that may become endangered in the foreseeable future (threatened). The Act provides for the conservation of ecosystems upon which threatened and endangered species of fish, wildlife, and plants depend, both through Federal action and by encouraging the establishment of state programs. Section 7 of this Act requires federal agencies to ensure that all federally associated activities within the U.S. do not harm the continued existence of threatened or endangered species or designated areas (critical habitats) important in conserving those species.

species listed as threatened, in need of management by the State of Tennessee, or as federal species of concern.

Previous studies have provided an indication of protected species that may occur on this site (Mitchell et al. 1996). Table 4.1.5.4-1 provides a list of species potentially occurring on the proposed site, their preferred habitat, and their status. Suitable habitat was located for nine species listed by the State of Tennessee as in need of management, one species listed as state threatened, and one federally listed species of concern. Figure 4.1.5.4-1 illustrates the locations of potential habitat for each of these species. Appendix D contains additional details of each of these listed species.

Table 4.1.5.4-1. List of species potentially occurring on the ORNL site.

Species	Habitat on the proposed SNS and Status	Preferred Habitat
Sharp-shinned hawk (*Accipter striatus*)	Power line corridors In need of management	Mixture of woods and open country
Cooper's hawk (*Accipiter cooperii*)	Powerline corridors In need of management	Mixed woods with openings
Cerulean Warbler (*Dendroica cerulea*)	Mature hardwood forest on ridgetop Federal Species of Concern	Mature hardwood forests
Grasshopper Sparrow (*Ammodramus savannarum*)	Powerline corridors In need of management	Grassy fields and farmlands
Yellow-bellied sapsucker (*Sphyrapicus varius*)	Possible in most areas except pine stands In need of management	Open deciduous woods
Rafinesque's big-eared bat (*Plecotus rafinesquii*)	Abandoned building along C-17 Road In need of management	Unoccupied man-made structures and caves
Southeastern shrew (*Sorex longirostris*)	Pine plantations and tributaries In need of management	Pine woods and stream banks
Northern Pine Snake (*Pituophis m. melanoleucus*)	Ridgetops and powerline corridors State Threatened	Pine woods, dry ridges, and old fields
Eastern Slender Glass Lizard (*Ophisaurus attenuatus longicaudus*)	Ridgetops and powerline corridors In need of management	Dry upland areas, brushy cut-over woodlands
Mole salamander (*Ambystoma talpoideum*)	Depression with temporary pools In need of management	Moist low-lying woodland areas with ponds
Four-toed salamander (*Hemidactylium scutatum*)	Tributaries of White Oak Creek In need of management	Hardwood forest wetlands

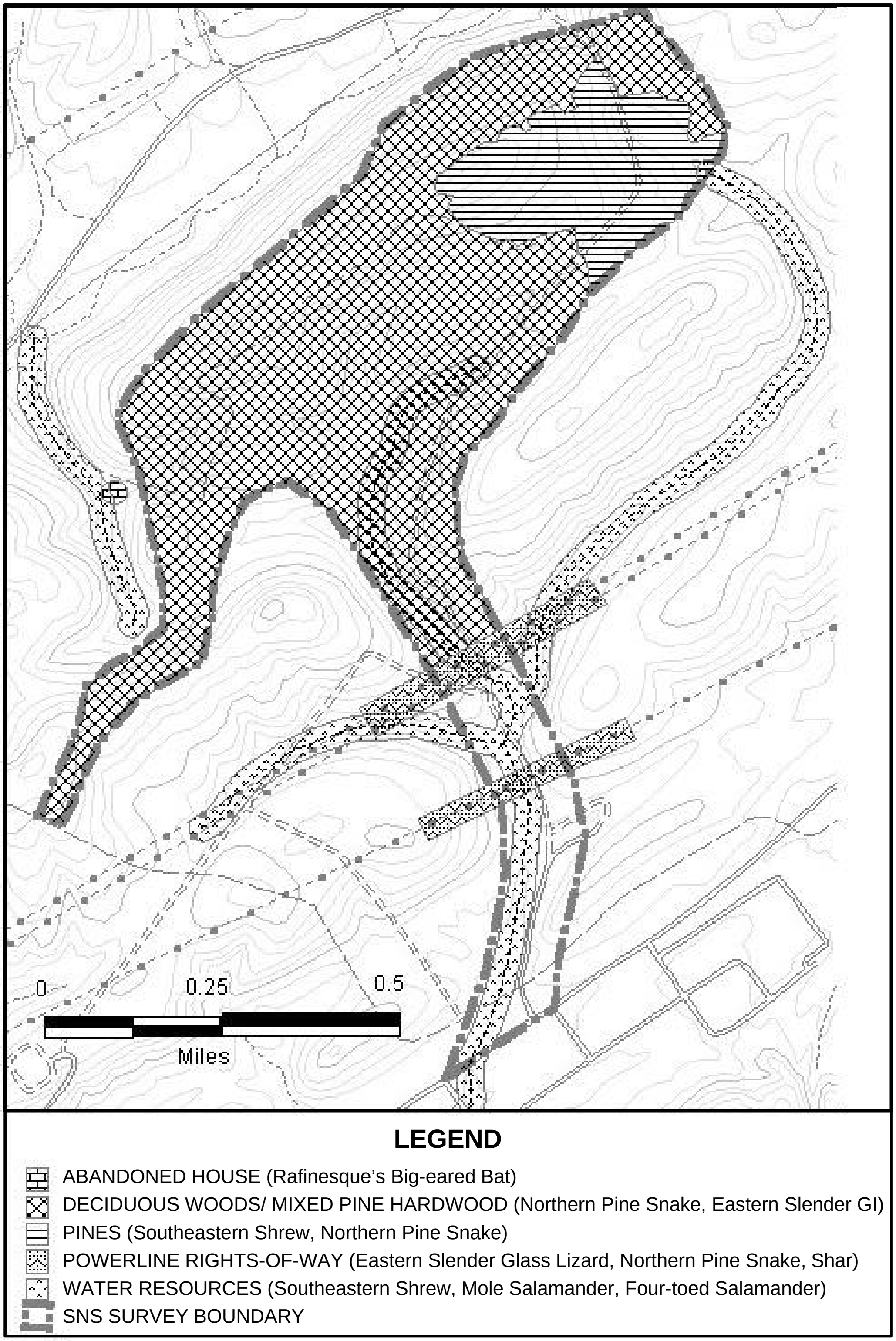


Figure 4.1.5.4-1. Potential habitat areas for threatened and endangered animal species within the ORNL site.

The proposed SNS site contains the following vegetation types and landscape elements associated with the occurrence of protected plants on the ORR: deciduous forests, mixed deciduous and pine forests, overmature/ successional pine plantations, wetlands and stream bottoms, limestone outcrops, and springs and seeps. The proposed site encroaches on a National Environmental Research Park (NERP)-designated Natural Area, NA52 (Awl et al. 1996).

Ten protected plant species were recognized as potentially occurring within the proposed SNS site (Table 4.1.5.4-2). Pink lady's slipper and American ginseng were found at three locations (Figure 4.1.5.4-2) during the 1996 site surveys. An additional species verified to be located on the proposed site during previous surveys, Howe's Sedge (*Carex howei)*, was removed from protection status by the State of Tennessee in 1997. Of the remaining species potentially occurring on this site, two are classified as having high potential for occurrence, while the remaining six are classified as having low potential for occurrence.

Table 4.1.5.4-2. Threatened and endangered plant species potentially occurring within the proposed SNS site at ORNL.

Species	Common name	Habitat on ORR	Status[a]	Verification Time Frame	Potential for Occurrence within the Proposed SNS Site
Cypripedium acaule	Pink lady's slipper	Dry to rich woods	E-CE	Apr.-July	Verified onsite
Delphinum exaltatum	Tall larkspur	Barrens and woods	(C2), E	Aug.-Sept.	High
Fothergilla major	Mountain witch-alder	Woods	T	Apr.-May	Low
Hydrastis canadensis	Golden seal	Rich woods	S-CE	April-July	Low
Juglans cinerea	Butternut	Slope near stream	(C2), T	no time frame	Low
Lilium canadense	Canada lily	Moist woods	T	June-July	High
Liparis loeselii	Fen orchis	Forested wetland	E	May-July	Low
Panax quinquifolius	Ginseng	Rich woods	S-CE	May-Oct.	Verified onsite
Platanthera flava var. herbiola	Tuberculed rein-orchid	Forested wetland	T	May-Aug.	Low
Platanthera peramoena	Purple fringeless orchid	Wet meadow	T	July-Aug.	Low

[a] Status based on 1997 TN State List:
(C2) Special Concern, was listed under the formerly used C2 candidate designation. More information needed to determine status.
E Endangered in Tennessee.
T Threatened in Tennessee.
S Special Concern in Tennessee.
CE Status due to commercial exploitation.

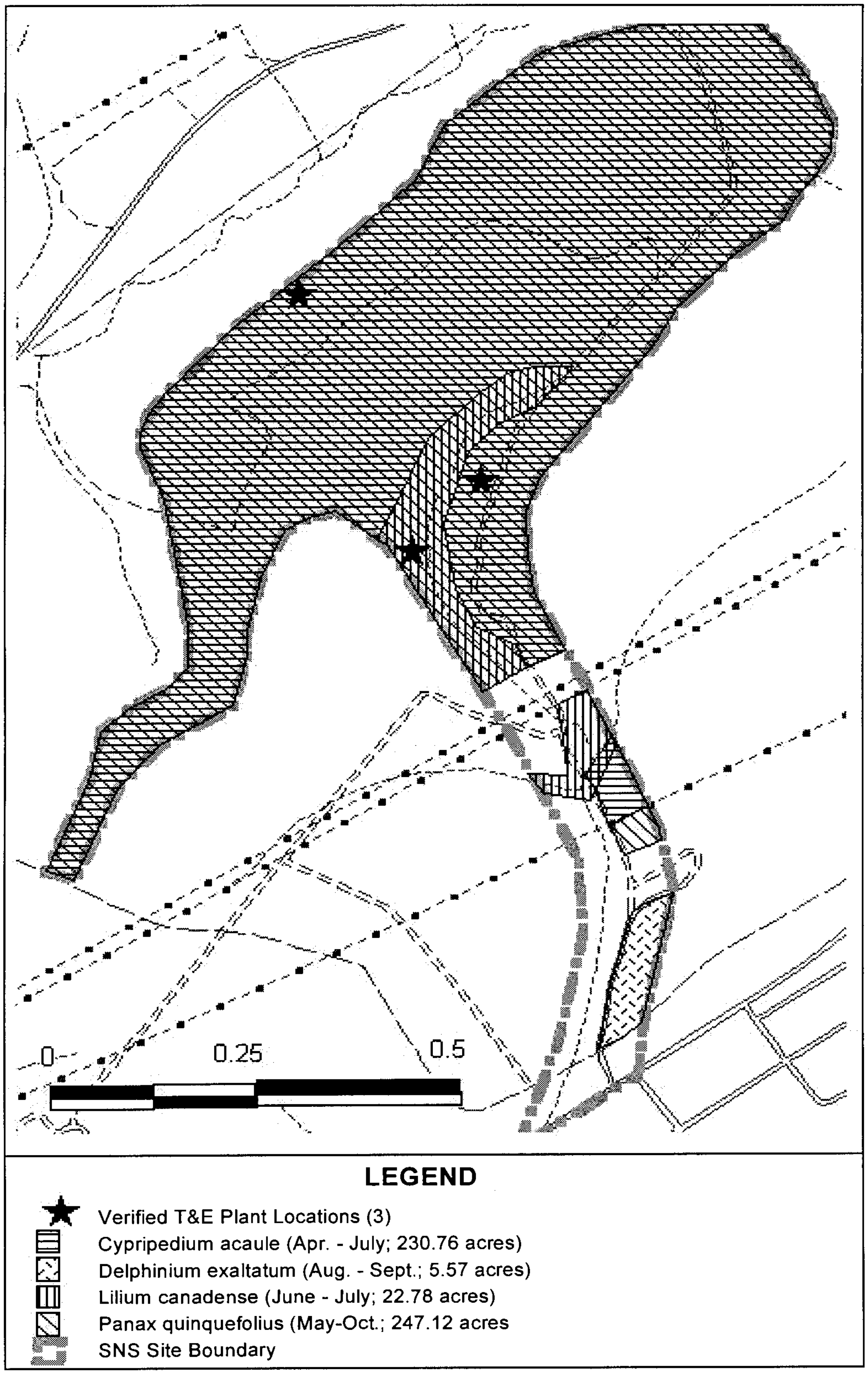


Figure 4.1.5.4-2. Threatened and endangered plant locations and potential habitat areas within the ORNL SNS site.

NERP Natural Areas have been established on the ORR to protect federally or state-listed species that occur on the reservation. Each natural area consists of a core area, the actual location of the protected plant, and a buffer area for habitat protection. Aquatic Natural Areas are used for study and reference areas as part of the Biological Monitoring and Abatement Program (BMAP), required by the National Pollutant Discharge Elimination System (NPDES) permit for ORNL, or environmental remediation efforts. Many of the Aquatic Natural Areas represent nonimpacted streams or reaches of streams that are comparable in terms of size and potential fauna to streams or reaches that are monitored for impacts.

4.1.6 SOCIOECONOMIC AND DEMOGRAPHIC ENVIRONMENT

The region of influence (ROI) for the SNS at the proposed ORR site includes Anderson, Knox, Loudon, and Roane Counties, as shown in Figure 4.1.6-1. Approximately 90 percent of ORR employees reside in this region. The region includes the cities of Clinton, Oak Ridge, Knoxville, Loudon, Lenoir City, Harriman, and Kingston.

This section provides a description of the following socioeconomic and demographic characteristics:

- Demographics
- Housing
- Infrastructure
- Local economy
- Environmental justice

4.1.6.1 Demographic Characteristics

Population trends and projections for each of the counties in the ROI are presented in Table 4.1.6.1-1. Of the four counties, Knox has the largest population, with 70 percent of the 1995 regional population of 517,604. Anderson County accounted for 14 percent of the regional population, Roane County for 9 percent, and Loudon County accounted for the remaining 7 percent. The region represents approximately 10 percent of the state's population. The Tennessee Department of Economic and Community Development has indicated that the population in the region will likely decline to 512,399 by year 2000 and then increase slightly by year 2005. Roane County is the exception to this trend, as it is projected to grow 28 percent.

Population data for the cities in the region are presented in Table 4.1.6.1-2. Between 1980 and 1995, the populations of the four-county region and the state both grew at about one percent per year. Projections in Table 4.1.6.1-1 show that regional and state populations are expected to grow by less than half of one percent annually through the year 2005.

Population by race and ethnicity for the region is presented in Table 4.1.6.1-3. The 1990 census data reflect racial and ethnic compositions in the four counties. There is little variation among the four counties, and Caucasians make up more than 90 percent of the combined population. African-Americans compose seven percent of the population.

4.1.6.2 Housing

Regional housing characteristics are presented in Table 4.1.6.2-1. In 1990, vacancy rates in the region ranged between a low of six percent in Loudon County to a high of nine percent in Roane County. Among all occupied housing units in the region, approximately two-thirds were owner occupied.

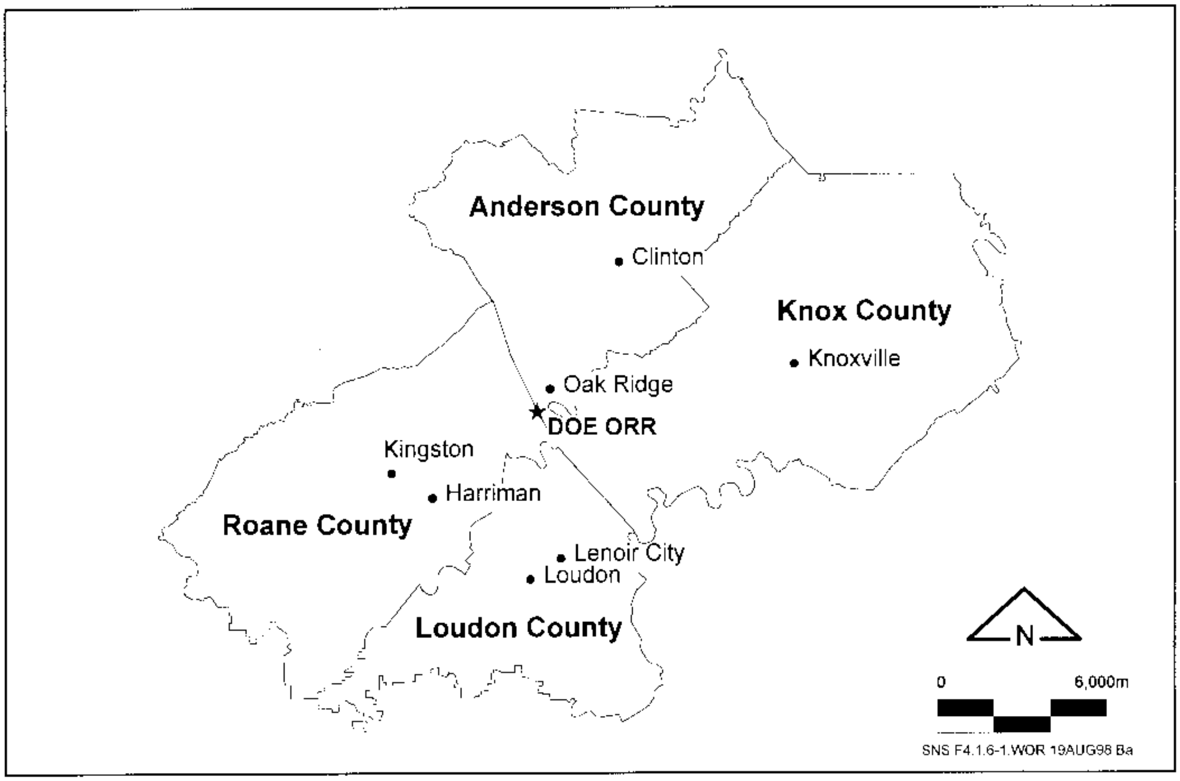


Figure 4.1.6-1. Map showing the socioeconomic ROI at ORR.

Table 4.1.6.1-1. Regional population trends and projections at ORNL.

County	1980	1990	1995	2000	2005
Anderson	67,346	68,250	71,663	68,181	66,347
Knox	319,694	335,749	361,407	353,721	360,833
Loudon	28,553	31,255	35,927	34,149	36,458
Roane	48,425	47,277	48,607	56,348	61,984
Region	464,018	482,531	517,604	512,399	525,622
State	4,591,023	4,877,185	5,235,358	5,178,587	5,305,137

Sources: U.S. Bureau of Census 1990; U.S. Bureau of Census 1996; TEDC 1994-1997.

Table 4.1.6.1-2. Population for incorporated areas within the ORR region.

Communities	1990	1996	Percent growth
Clinton	8,972	9,320	3.9
Oak Ridge	27,310	27,742	1.6
Knoxville	169,761	167,535	-1.3
Loudon	4,288	4,544	6.0
Lenoir	6,147	8,890	44.6
Harriman	7,119	7,006	-1.6
Kingston	4,552	4,935	8.4

Source: U.S. Bureau of Census 1990; Tennessee Department of Economic and Community Development 1998.

Table 4.1.6.1-3. 1990 population by race and ethnicity for the ORR region.

All Persons, Race/ Ethnicity	Anderson		Knox		Loudon		Roane		Total	
	Number	%[a]	Number	%[a]	Number	%[a]	Number	%[a]	Number	%[a]
All Persons	68,250	100	335,749	100	31,255	100	47,277	100	482,531	100
Caucasian	64,745	95	301,788	90	30,762	98	45,422	96	442,717	92
African-American	2,681	4	29,299	9	362	1	1,534	3	33,876	7
American Indian[b]	195	<1	996	<1	46	<1	87	<1	1,324	<1
Asian/ Pacific Islander	540	<1	3,136	<1	55	<1	177	<1	3,908	1
Hispanic of any race[c]	582	1	1,935	1	107	<1	273	1	2,897	1
Other races	89	<1	530	<1	30	<1	57	<1	706	<1

[a] Percentages may not total to 100 due to rounding.
[b] Numbers for Aleuts and Eskimos were placed in the "other" category, given their small number.
[c] In the 1990 Census, Hispanics classified themselves as White, Black, Asian/Pacific Islander, American Indian, Eskimo, or Aleut. To avoid double counting, the number of Hispanics was subtracted from each of the race categories.
Sources: U.S. Bureau of Census 1990; U.S. Bureau of Census 1996.

Table 4.1.6.2-1. Housing summary for the ORR region, 1990, by county.

	Anderson County		Knox County		Loudon County		Roane County	
	Number	%[a]	Number	%[a]	Number	%[a]	Number	%[a]
Total Housing Units	29,323	100	143,582	100	12,995	100	20,334	100
Occupied	27,384	93	133,639	93	12,155	93	18,453	91
Vacant	1,939	7	9,943	7	840	6	1,881	9
Median Home Value	$55,100	NA	$63,900	NA	$51,000	NA	$48,700	NA
Gross Rent	$342	NA	$351	NA	$280	NA	$287	NA

NA - Not applicable.
[a] May not total 100 due to rounding
Sources: U.S. Bureau of Census 1990; U.S. Bureau of Census 1996.

Housing vacancy rates for selected regional cities and towns are similar to county rates. In 1990, the county vacancy rate for all units was seven percent, while the combined vacancy rate for the seven selected communities (refer to Table 4.1.6.2-1) was eight percent. There were a total of 14,600 vacant units throughout the four-county region.

Median home value was similar in Roane, Loudon, and Anderson Counties, ranging between $48,700 to $55,100. Knox County median home values were higher at $69,900. Rents ranged from $280 to $351 across the ROI.

4.1.6.3 Infrastructure

The Infrastructure section characterizes the region's community services with indicators such as education, health care, and public safety.

4.1.6.3.1 Education

Tennessee is divided into 140 school districts, eight of which are within the four-county ROI. Information regarding school districts within the region is presented in Table 4.1.6.3.1-1.

The school districts in the region receive funding from local, state, and federal sources, but the percentage received from each source varies. Local funding varies from a low of 30 percent in Roane County to a high of 52 percent in Knox County. State funding varies between 43 percent in Knox County to 63 percent in Roane County, and federal funding ranges between a low of 5 percent in Knox County and a high of 13 percent in Anderson County.

4.1.6.3.2 Health Care

There are eight hospitals currently serving the region. Table 4.1.6.3.2-1 presents data on hospital capacity and usage. Average statistics for the hospitals indicate that there are approximately 2,400 acute-care hospital beds in the region, about 45 percent of which are available on any given day. This capacity is considered adequate to serve the health needs of the local population.

4.1.6.3.3 Police and Fire Protection

The Knoxville Police Department has 400 officers with an approved fiscal year (FY) 1998 budget of $26.4 million. In addition, the Oak

Table 4.1.6.3.1-1. Public school statistics in the ORR region, 1995-1996 school year.

County	Number of Schools	Student Enrollment[a]	Teachers[a]	Teacher/ Student Ratio (1998)	Per-Student Operational Expenditures
Anderson	27	7,422	810	1:9	$4,900
Knox	88	56,935	3,035	1:19	$4,756
Loudon	10	4,739	455	1:10	$4,181
Roane	13	6,265	314	1:20	$4,839

[a] Full-time equivalent figures.
Source: Tennessee Department of Education 1996.

Table 4.1.6.3.2-1. Hospital capacity and usage in the ORR region.

Hospital	Number of Hospitals	Number of Beds[a]	Annual Bed-Days Used[b] (%)
Anderson	1	281	62
Knox	5	1,948	53
Loudon	1	62	28
Roane	1	85	53

[a] The number of acute-care beds.
[b] Based on the number of people discharged and the average length of stay divided by total beds available annually.
Sources: The American Hospital Directory, Inc. 1998; Tennessee Department of Health 1996.

Ridge Police Department has 45 officers with an approved FY 1996 budget of $2.3 million. The Knoxville County Fire Department has 13 fire stations, staffed by 118 Fire Department personnel. The Oak Ridge Fire Department provides fire suppression, medical/rescue, wildland fire suppression, and fire prevention services to both ORNL and the Oak Ridge community.

4.1.6.4 Local Economy

This subsection provides information on the economy of the region, including employment, education, income, and fiscal characteristics.

4.1.6.4.1 Employment

Regional employment data for 1997 are summarized in Table 4.1.6.4.1-1. Since 1991, unemployment has decreased in the four counties within the region, and the largest reductions in unemployment occurred in Knox County (from 4.6 percent in 1991 to 2.6 percent in 1997) and Loudon County (from 7.2 percent in 1991 to 4.2 percent in 1997). The 1997 unemployment rate for the ROI was 4.3 percent.

Table 4.1.6.4.1-2 presents employment by industry for the region. Government, manufacturing, retail trade, and services are the principal economic sectors in the region.

Table 4.1.6.4.1-1. ORR regional employment data, 1997.

County	Civilian Labor Force	Employed	Unemployed	Unemployment Rate
Anderson	36,800	35,270	1,530	4.2
Knox	197,420	192,280	5,140	2.6
Loudon	19,330	18,510	820	4.2
Roane	26,640	25,050	1,590	6.0
Region	280,190	271,110	9,080	3.2

Source: Tennessee Department of Employment Security 1998.

Table 4.1.6.4.1-2. Employment by industry for the Oak Ridge region of influence, by county and for the State of Tennessee (1995).

Economic Character	Anderson County	Knox County	Loudon County	Roane County	Region of Influence	State of Tennessee
Employment by Industry (1995)						
Farm	616	1,534	1,309	635	4,094	98,298
Agriculture Services	256	2,050	255	149	2,710	27,225
Mining	132	528	18	20	698	7,228
Construction	5,351	15,187	878	937	22,353	176,116
Manufacturing	11,307	25,207	3,173	5,774	45,461	553,865
Transportation and Public Utility	1,843	11,080	777	640	14,340	160,068
Wholesale Trade	596	15,924	280	433	17,233	151,126
Retail Trade	(D)	46,304	2,148	(D)	48,452	535,549
Finance, Insurance, and Real Estate	1,777	14,245	632	513	17,167	180,867
Services	(D)	75,131	3,621	(D)	78,752	848,610
Government	5,364	37,063	1,690	3,970	48,087	401,059

(D) - Data withheld to avoid disclosure when there are less than four businesses in an industry classification.
Source: U.S. Bureau of Census 1990.

Services employment is the largest employment sector in Anderson, Knox, and Roane counties. In Loudon County, the largest employment sector is manufacturing. While retail trade employs the second highest number in Knox, Loudon, and Roane Counties, retail trade employment in Anderson County is relatively low, and manufacturing and construction are the second and third highest employment sectors.

4.1.6.4.2 Income

In 1995, total regional income was approximately $11.5 billion, and six percent of this ($680,000,000) was paid to the ORR workforce (14,500 individuals, including contractors) residing in the region. Per capita income data for the region and the state are presented in Table 4.1.6.4.2-1. Over the period 1991-1995, per capita incomes in each ROI county grew by an approximate average of 22 percent to nearly $21,000. This rate of growth substantially exceeded the state-wide increase in income of only 18 percent. The number of persons in the region with income below the poverty level was 15 percent in 1990.

4.1.6.4.3 Fiscal Characteristics

Municipal and county general fund revenues in the ROI are presented in Table 4.1.6.4.3-1. The general fund supports the ongoing operations of local governments as well as community services such as police protection and parks and recreation.

The State of Tennessee does not have state or local personal income tax. Under Tennessee constitutional law, property taxes are assessed as follows:

- Residential Property equals 25 percent of appraised value.
- Commercial/Industrial Property equals 40 percent of appraised value.
- Personal Property equals 30 percent of appraised value.

The largest revenue sources for the counties' general fund has traditionally been local taxes (which includes taxes on property, real estate, hotel/motel receipts, and sales) and intergovernmental transfers from the federal or state government. Over 80 percent of the 1997 general fund revenue came from these combined sources.

Table 4.1.6.4.2-1. Measures of per capita income for the ORR region.

Area	Per Capita Income		Percent Increase
	1991 ($)	1995 ($)	
Anderson County	18,004	21,621	20
Knox County	18,911	23,107	22
Loudon County	15,671	19,606	25
Roane County	15,530	18,749	21
State of Tennessee	16,962	21,060	24

Sources: U.S. Bureau of Economic Analysis 1985-1995; TNDEC 1994-1997.

Table 4.1.6.4.3-1. Municipal and county general fund revenues in the ORR region, FY 1997.

	Anderson County		Knox County		Loudon County		Roane County	
Revenue by Source	**$(1000)**	**%[a]**	**$(1000)**	**%[a]**	**$(1000)**	**%[a]**	**$(1000)**	**%[a]**
Local Taxes[a]	12,732	40	232,145	56	4,147	68	22,970	45
Licenses and Permits	34	<1	1,633	<1	178	3	102	<1
Fines and Forfeitures	56	<1	3,086	1	157	3	302	1
Charges for Service	2,640	8	21,811	5	43	1	1,167	2
Intergovernmental[b]	14,483	45	145,582	35	638	11	22,826	45
Interest	1,285	4	10,982	3	—[c]	NA	1,183	2
Miscellaneous Income	680	2	483	<1	911	14	2,474	5
Total	31,910	100	415,722	100	6,074	100	51,024	100

N/A - Not available.
Percentages may not total 100 due to rounding.
[a] Local taxes include real and personal property taxes, hotel/motel taxes, and local sales taxes.
[b] Intergovernmental includes state transfers and federal funds.
[c] Interest revenue not identified separately for Loudon County.
Source: Comprehensive Annual Financial Reports 1997a.

4.1.6.5 Environmental Justice

Figures 4.1.6.5-1 and 4.1.6.5-2 illustrate distributions for minority and low-income populations residing within 50 mi (80 km) of ORR. The definitions of minority and low-income populations and the methodology for assessing potential environmental justice effects are given in Section. 5.2.6.5.

Approximately 880,000 people live within a 50-mi (80-km) radius of the proposed ORR site. Minorities compose 6.1 percent of this population. In 1990, minorities composed 24.1 percent of the population nationally and 17 percent of the population in Tennessee. There are no federally recognized Native American groups within 50 mi (80 km) of the proposed site. The percentage of persons below the poverty level is 16.2 percent, which compares with the 1990 national average of 13.1 percent and a statewide figure of 30 percent (U.S. Census 1990).

4.1.7 CULTURAL RESOURCES

Cultural resources are any prehistoric or historic sites, buildings, structures, objects, or districts considered to be important to a culture, subculture, or community for scientific, traditional, or religious purposes, or for any other reason. They constitute the human legacy associated with a particular place.

The first known cultural resources study in the Lower Clinch River Basin was an archaeological survey reported by Cyrus Thomas in 1894. Since this report was published, approximately 29 archaeological and historical studies have been conducted in this area, and more than 20 studies were on the ORR (DOE 1996c: 4-29). Nearly 90 percent of the ORR has been surveyed for cultural resources at the reconnaissance

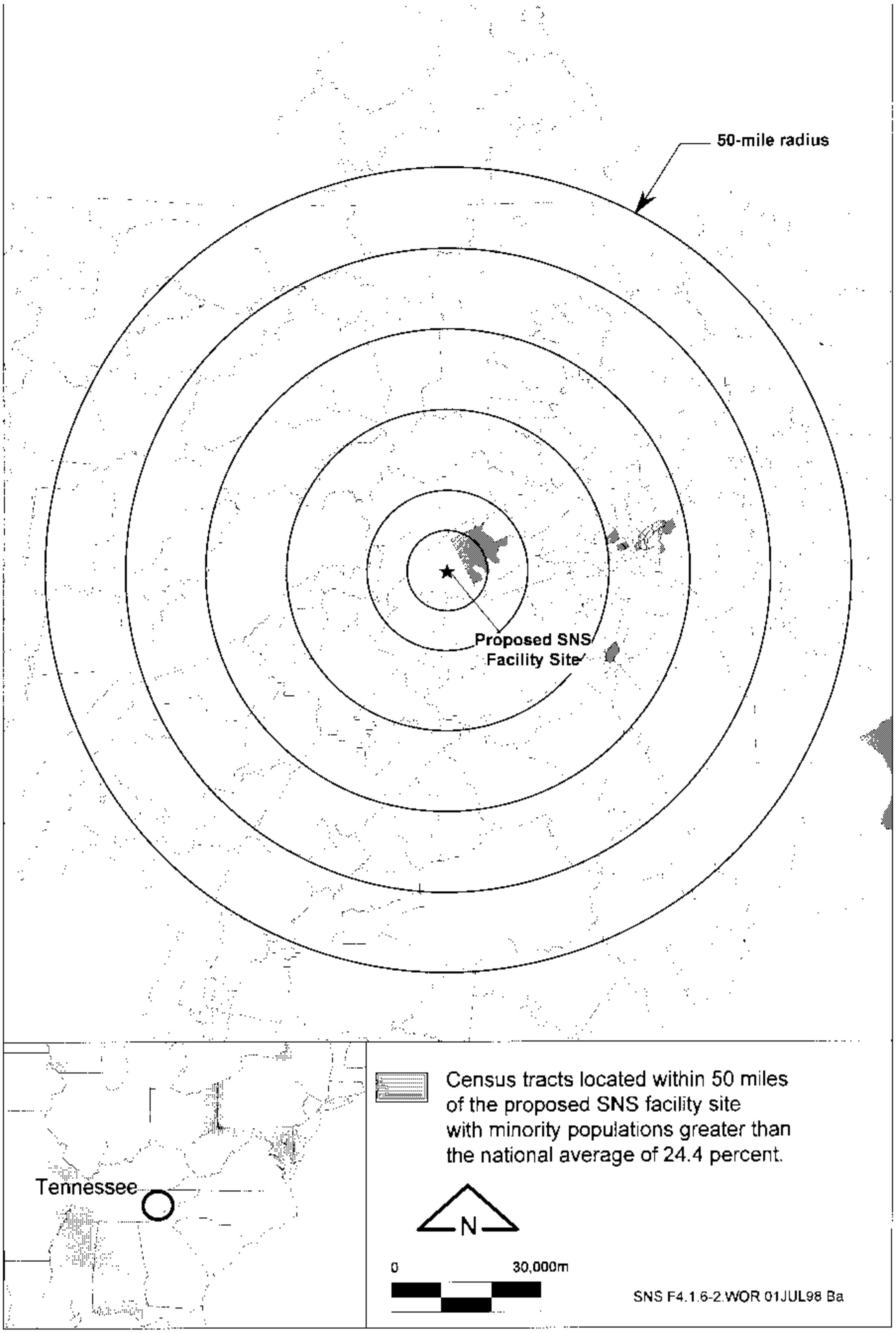


Figure 4.1.6.5-1. Distributions of minority populations at the ORR.

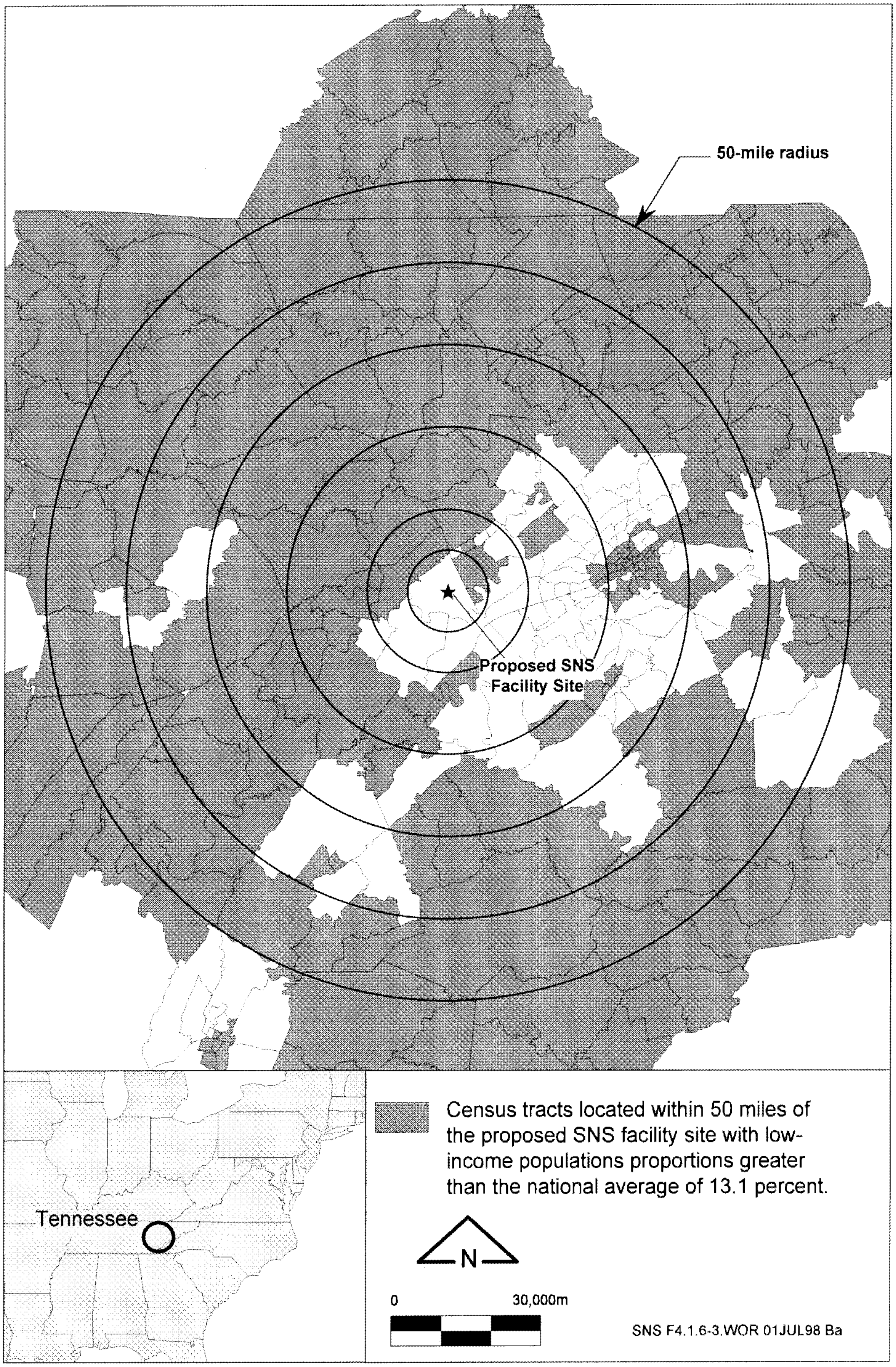


Figure 4.1.6.5-2. Distribution of low-income populations at the ORR.

level, but less than 5 percent of it has been intensively surveyed (DOE 1996c: 2-29).

Cultural resource surveys of the ORR have identified more than 45 prehistoric archaeological sites. Thirteen of these sites are considered to be potentially eligible for listing on the National Register of Historic Places (NRHP). The remaining sites have not been evaluated for potential NRHP eligibility (DOE 1996c: 4-29).

More than 240 historic resources have been identified through surveys of the ORR. These resources consist of Historic Period (A.D. 1600-Present) cemeteries, structures, and archaeological remains. Thirty-one cemeteries, all established prior to 1942, are located on the reservation. Historic structures include log cabins, barns, churches, grave houses, spring houses, storage sheds, smokehouses, log cribs, privies, henhouse, and garages that predate U.S. government acquisition of the reservation from private land owners in 1942. In addition, the historic structures include many of the buildings and equipment items associated with the Manhattan Project (A.D. 1942-1945) and Cold War Period (A.D. 1946-1989) activities on the reservation. These structures include three security checking stations and the Graphite Reactor at ORNL. Most of the historic archaeological remains consist of structure foundations; trash scatters and subsurface features, usually associated with foundations and standing structures; and roads. Thirty-eight of these historic resources are considered to be potentially eligible for listing on the NRHP (DOE 1996c: 4-29 to 4-30).

Surveys conducted prior to 1997 located a number of cultural resources in the vicinity of the proposed SNS site. Additional prehistoric and historic remains were identified during a cultural resources survey conducted by DuVall & Associates, Inc., from July 26 to August 5, 1997 (Pace 1997). This survey included extensive background research, a pedestrian survey of the proposed SNS site and adjacent areas, and systematic shovel testing of landforms with less than 15 percent slope.

The SNS design team has not established the areas where construction or improvement of utility corridors would be necessary to support the proposed SNS at ORNL. In addition, the complete route for one of the two access roads (southwest access road) to the proposed SNS site has not been determined. As a result, such areas could not be surveyed for cultural resources by DuVall & Associates, Inc., in 1997. However, the eventual establishment of these areas would proceed in such a manner as to avoid known cultural resource locations. If the proposed SNS site at ORNL were chosen for construction, the established utility corridors and road improvement zones would be surveyed for cultural resources prior to the initiation of construction-related activities in these areas.

The cultural resources in the vicinity of the proposed SNS site are described in this section of the Environmental Impact Statement (EIS). However, the precise locations of these resources are not indicated in the descriptions. To protect these sites, DOE and Lockheed Martin Energy Research Corporation do not reveal the locations of cultural resources in documents available to the general public. Because several of the original reports cited in this section show the locations of cultural resources on the ORR, they are not included in the DOE public reading rooms established as part of the SNS EIS process.

4.1.7.1 Prehistoric Resources

No prehistoric archaeological sites were identified on the proposed SNS site at ORNL. However, three isolated occurrences of prehistoric artifacts were encountered at three other locations that may be subject to activities under the proposed action. Locus FN-1 is in the bed of a current dirt service road leading into the proposed SNS site and is very close to a proposed switchyard. Locus FN-1A is very close to the extreme southwest corner of the proposed SNS site and is near the proposed location of a retention basin. Locus FN-7 is located a substantial distance south of the proposed SNS site in an area slated for road improvements.

An Early Archaic Period *Big Sandy* projectile point/knife (ca. 8000-7000 B.C.) was found at Locus FN-1. One chert flake of indeterminate age was found at each of the other loci. Each locus may contain a low-density scatter of chert waste from the shaping or sharpening of prehistoric stone tools. Because no artifact-bearing subsurface deposits were encountered during shovel testing, these isolated occurrences are considered insufficient to define a significant cultural resource, and their loci of occurrence are not considered to be eligible for listing on the NRHP (Pace 1997: 21).

Site 40RE488 is a multicomponent archaeological site located a substantial distance south of the proposed SNS site in an area slated for road improvements under the proposed action. As defined by shovel tests, 40RE488 measures about 230 to 262 ft (70 to 80 m) north/south by 67 ft (20 m) east/west and may extend further to the west beyond the test limits. The east edge of this site is only about 26 ft (8 m) from the bed of the existing road that would be improved. Shovel tests revealed past disturbance of the site by grading, filling, scalping of topsoil, and downslope redeposition of soils. The artifacts recovered during the shovel testing indicated at least one prehistoric component at the site (ORNL-2: 21-24).

No prehistoric artifacts were recovered on the ground surface at 40RE488. The 13 prehistoric artifacts recovered at the site came from the plow zone and disturbed (spolic) layers in 5 of 10 shovel test units. These artifacts consisted of seven chert flakes, or flake fragments, and six pieces of chert debris. The date and prehistoric cultural context of this component could not be determined from these remains (Pace 1997: 24).

The prehistoric component at 40RE488 can be characterized as a low-density lithic scatter of unknown date and cultural affiliation. Given the occurrence of all prehistoric artifacts in the plow zone or other disturbed soil zones, the presence of well-preserved archaeological context with subsurface features and midden deposits is unlikely. As a result, the surveyed portion of this component is not considered to be a significant archaeological resource with potential for listing on the NRHP (Pace 1997: 27).

4.1.7.2 Historic Resources

No Historic Period cultural resources listed on or eligible for listing on the NRHP have been identified on the proposed SNS site at ORNL. A Historic Period archaeological component has been identified at 40RE488. As previously noted in Section 4.1.7.1, this site is located substantially south of the proposed SNS site in an area subject to road improvements under the proposed action.

Thirteen historic artifacts were recovered from the same five shovel test units that yielded the prehistoric artifacts at 40RE488. These artifacts were 3 wire nails, 2 wire brads, 3 cut nail fragments, 3 miscellaneous metal fragments, and 2 pieces of container glass. While the cut nails could indicate a 19^{th} century occupation of the site, the other artifacts suggest an occupation dating from the turn of the century to 1942 (Pace 1997: 24).

Fielder et al. identified a farm outbuilding (standing log crib) at 40RE488, which was designated as Historic Inventory #15A in his survey (Fielder et al. 1977: 47). This structure is no longer present at the site (DuVall 1994, as cited in Pace 1997: 16). In addition, historical records indicate that another structure no longer standing but presumably associated, was located to the north of the log crib in 1935. Both structures were in a 190-acre (77-ha) tract of land purchased by the U.S. government from Luther and Edith Duncan in 1942 (Fielder et al. 1977: 47). These findings suggest that the historic component at 40RE488 is part of a late 19^{th} to early 20^{th} century farmstead. Given significant past soil disturbance of indeterminate origin at this site and its spatial divorcement from the larger farmstead setting, this Historic Period component is not considered potentially eligible for listing on the NRHP (Pace 1997: 24-27).

4.1.7.3 Traditional Cultural Properties

A Traditional Cultural Property (TCP) is a significant place or object associated with the historical and cultural practices or beliefs of a living community. It is rooted in the community's history and is important for maintaining the continuing cultural identity of the community. A TCP may include a prehistoric or historic archaeological site, natural resource, traditional use area, shrine, sacred place, trail, spring, river, traditional hunting area, cemetery or burial, or rock art. In addition, it may include a rural community or urban neighborhood with a unique cultural tradition and identity. The term is not limited to ethnic minority groups. All Americans have properties to which they ascribe traditional cultural value.

Portions of the Tennessee, Clinch, Hiwassee, and Little Tennessee River valleys were occupied by the Overhill Cherokee during the 18^{th} century. Most of the Cherokee people were relocated to the Oklahoma Territory via the infamous Trail of Tears in 1838. However, some of the Cherokee remained in western North Carolina and others have returned from Oklahoma over the years (DOE 1996c: 4-30). Currently, the Eastern Band of the Cherokee occupies the Qualla Reservation in Cherokee, North Carolina, and maintains an interest in the traditional Overhill Cherokee lands in East Tennessee.

DOE Oak Ridge Operations (DOE-ORO) Office has consulted with the Eastern Band of the Cherokee concerning the presence of TCPs on the ORR. No TCPs of special sensitivity or concern to the Cherokee are known to exist on the proposed SNS site or at other locations on the ORR.

4.1.7.4 Consultation with the State Historic Preservation Officer

Section 106 of the National Historic Preservation Act (NHPA) requires a review of proposed federal actions to determine whether or not they would impact properties listed on or eligible for listing on the NRHP. DOE-ORO has consulted with the State Historic

Preservation Officer (SHPO) in Tennessee concerning the occurrence of such properties within the area of potential impact of the proposed SNS at ORNL. Based on cultural resources survey information provided by DOE, the SHPO has determined that no such properties occur within this area. The consultation letter received from the SHPO at the Tennessee Historical Commission is provided in Appendix C.

4.1.8 LAND USE

Described in this section are land uses for the vicinity of the ORR; within the boundaries of the reservation, which include ORNL; and on the proposed SNS site. The descriptions cover past, current, and future uses of the land in these areas. In addition, they include descriptions of environmentally sensitive land areas that have been set aside for public use, environmental protection, or research. These areas include parks, natural areas, environmental education centers, and public recreation areas. The section concludes with a discussion of visual resources.

4.1.8.1 Past Land Use

The land surrounding the ORR was predominantly forested wilderness prior to the 18^{th} century. During the late 18^{th} and early 19^{th} centuries the area was settled by emigrants, who were primarily from North Carolina and Virginia. During this settlement period, three major uses of the land were established: forestry, agriculture, and residential. Commercial, mining, transportation, waterways, and industrial land uses gradually developed.

The land that composes the ORR was purchased from private landowners by the federal government in 1942. At that time, the predominant land uses were forestry, agriculture, and residential. However, government activities during World War II changed the overall pattern of land use on the reservation. The establishment of the X-10 Plant (ORNL), Y-12 Plant, K-25 Site (ETTP), and various support facilities added industrial land use to the reservation. With the exception of some agriculture-related research activities in later years, agricultural use of the land nearly disappeared. Because much of the reservation was allowed to revert to an increasingly natural state after its purchase by the government, the amount of land covered in forest expanded. Residential land use ended over most of the reservation. However, residential and commercial land uses increased rapidly in the north corner of the reservation. In the late 1950s, this area was politically separated from the reservation and was incorporated as the City of Oak Ridge. The current land use pattern on the reservation and at ORNL gradually evolved between 1942 and the present day.

The proposed SNS site remained largely undeveloped after its purchase by the federal government and was not a focus of waste disposal activities. As a result, no contaminated sites were created at this location.

The U.S. Environmental Protection Agency (EPA) placed the reservation on the National Priorities List in December 1989. This list specifies contaminated sites that are subject to regulation under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and are a high priority for cleanup. In 1996, DOE initiated detailed investigations of reservation land areas that were never used for activities involving hazardous materials. This process was aimed at releasing their use from regulation under existing cleanup laws. The proposed SNS site location is within an area of land scheduled for release approval by the Federal Facilities Agreement partners (DOE, EPA Region IV, and TDEC) in FY 1998 (Kendall 1998).

4.1.8.2 Current Land Use

The current uses of land in the vicinity of the ORR are forestry, agriculture, residential, commercial, industrial, mining, transportation, waterways, and several other uses. The largest use is commercial forestry, followed in order by agriculture, other uses, residential, waterways, and transportation. The remaining uses are quite small, each accounting for less than 7,410 acres (3,000 ha) of land. The predominant land use in most urban areas is residential (MMES 1994: 1-27).

The closest urban center to the reservation is the City of Oak Ridge. In fact, with the exception of a very small area of land in the northwest corner of the reservation, the city limits include the entire reservation. The total incorporated area of the city is 57,541 acres (23,296 ha). More than 60 percent of the land in the city is designated for forestry, agricultural, industrial, and research use. This high percentage is a function of having 34,516 acres (13,970 ha) of DOE land within the city limits. Less than 10 percent of the land in Oak Ridge is used for residential purposes, and most of this land is located in the northeast section of the city. The University of Tennessee owns 2,250 acres (911 ha) of land in Oak Ridge. This land is used for research, public education, and recreation. TVA owns 2,395 acres (969 ha) of land within the city for industrial and recreational purposes (MMES 1994: 1-27; DOE-ORO 1996: 3-1).

The reservation contains 34,516 acres (13,794 ha) of land, and approximately 64 percent of this land is undeveloped. Despite being within the City of Oak Ridge, the use of ORR land is controlled entirely by DOE. DOE classifies land use on the reservation according to five primary categories: Institutional/ Research, Industrial, Mixed Industrial, Institutional/Environmental Laboratory, and Mixed Research/Future Initiatives. The Institutional/Research category applies to land occupied by the central research facilities at ORNL. Land in the Industrial category includes the Y-12 Plant and is used for defense support, manufacturing, and storage. The Mixed/ Industrial category includes the ETTP and is used for environmental management and reindustrialization of DOE land by private sector businesses. The Oak Ridge Institute for Science and Education, operated by Oak Ridge Associated Universities, provides training and research support to DOE and uses the land within the boundaries of the Institutional/ Environmental Laboratory category. The Mixed Research/Future Initiatives category applies to land currently used or available for use in field research and land reserved for future DOE initiatives, including new research facilities. Figure 4.1.8.2-1 shows the distributions of these land use categories across the reservation and the relative amounts of land within each category (LMER and LMES 1998: 7).

A large number of reservation-wide land uses overlay the primary land use categories and are officially designated as mixed uses. The largest mixed use is biological and ecological research in the Oak Ridge NERP. This mixed use overlays most of the land in the Mixed Research/Future Initiatives category (Figure 4.1.8.2-1). The other mixed uses are environmental research and demonstration areas,

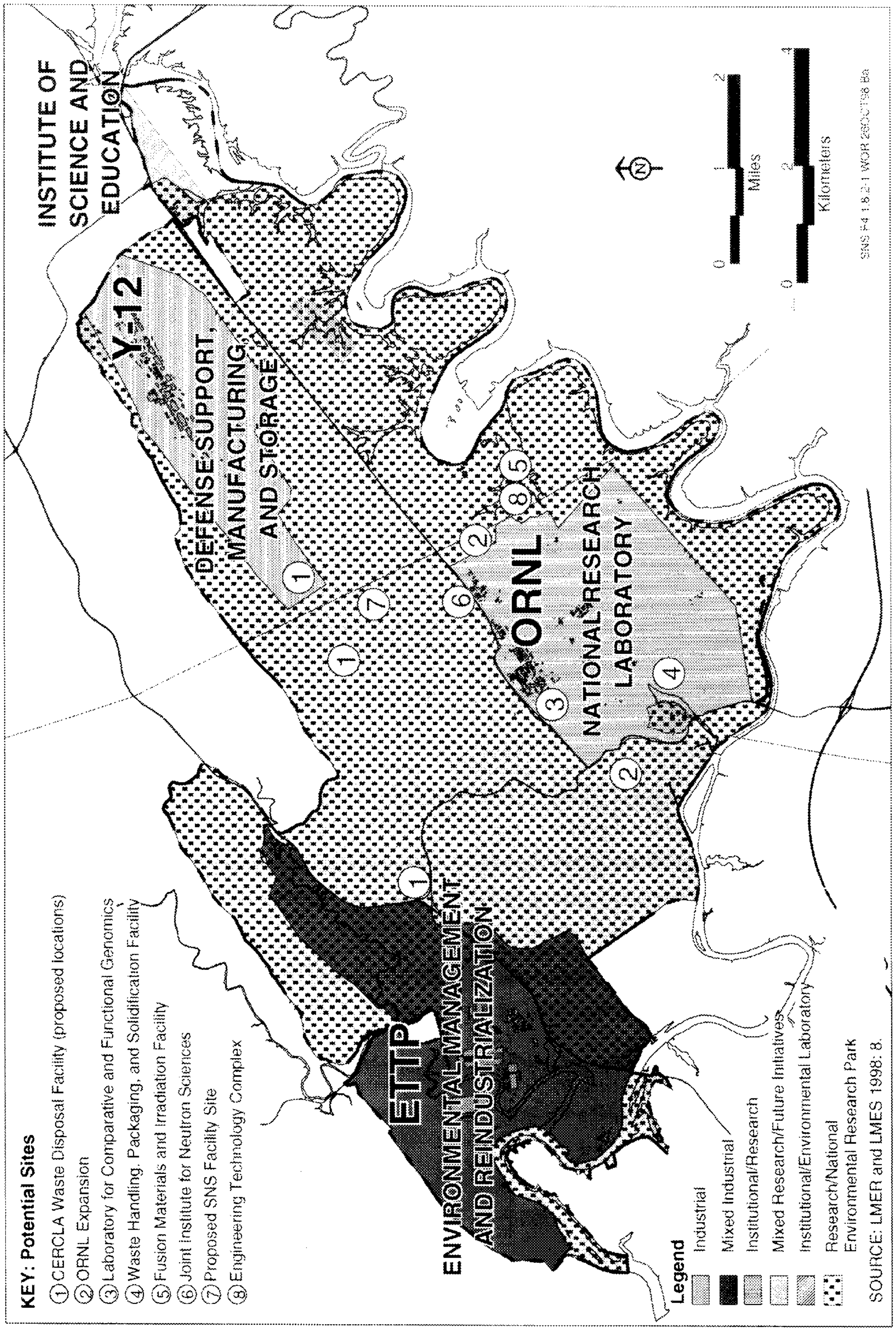


Figure 4.1.8.2-1. Map of current and potential future land uses on the ORR.

safety training facilities and associated safety buffers, transportation, utilities, public use areas, ecological resource management, land application of biosolids, education, waste management, environmental monitoring, wetlands mitigation, environmental restoration, protection of cultural resources, emergency response planning zones, and conservation of unique ecological resources. The latter use includes state natural areas, the Oak Ridge Wildlife Management Area, Nature Conservancy biodiversity ranked areas, Nature Conservancy landscape complexes, NERP endangered species habitats, NERP endangered species potential habitats, wetlands, and the Oak Ridge National Environmental Research Park Biosphere Reserve (LMER and LMES 1998: 7-8).

The proposed SNS site and adjoining land would be located within a portion of the Mixed Research/Future Initiatives category that is within the NERP (refer to Figure 4.1.8.2-1), which means that the land is either being used for environmental field research or is available for such use. Currently, the proposed site is not being used for environmental research. However, long-term environmental monitoring and research efforts are under way at locations in its vicinity.

Several of these efforts are being conducted in the headwaters of White Oak Creek, which drain the proposed SNS site area. Additional environmental monitoring and research projects are ongoing in the Walker Branch Watershed to the east of the proposed SNS site. The use of these land areas and the waters that flow through them for environmental monitoring and research is described in the succeeding sections.

Headwaters of White Oak Creek

Downstream portions of the White Oak Creek Watershed receive effluent discharges from ORNL. These discharges are regulated at the federal level under the Clean Water Act and by state regulations issued by TDEC. Operating under authorization from the EPA, TDEC has issued a NPDES permit to regulate the ORNL discharges to White Oak Creek.

The NPDES permit for ORNL mandates the implementation of a Biological Monitoring and Abatement Program (BMAP) on White Oak Creek and its tributaries. The objective of the BMAP is to evaluate the effects of the discharges on the aquatic integrity of the White Oak Creek Watershed and to demonstrate that the permitted effluent limitations protect classified stream uses (ORNL, OR Y-12, and ETTP 1997: 4-48). The program involves studying the bioaccumulation of contaminants in fish and performing detailed ecological surveys of fish and benthic macroinvertebrate communities. Observed changes in the key indicators of stream integrity are compared with effluent discharge conditions and are charted through time to provide a historical perspective on stream conditions and dynamics (ORNL, OR Y-12, and ETTP 1997: 4-51 to 4-52).

The headwater tributaries of White Oak Creek near the proposed SNS site drain largely undeveloped land that has been reverting towards a natural state since its purchase by the U.S. government in 1942. No effluent discharges occur in this area. For this reason, the White Oak Creek Headwaters Monitoring Station, located approximately 3,400 ft (1,036 m) southwest of the proposed site, and several other stations immediately downstream have been used to gather baseline reference data for the ORNL BMAP, general NPDES permit compliance, and support of downstream environmental restoration efforts. The headwaters of White Oak Creek are also used as a baseline reference site for current environmental monitoring activities in McCoy Branch, which drains the south side of Chestnut Ridge approximately 3 mi (5 km) east of the proposed SNS site. This research is being conducted under the Environmental Restoration Integrated Water Quality Program (Huff 1998: 1; Peterson 1998: 1; Smith 1998: 1-2).

Use of the White Oak Creek headwaters as a reference site began in 1984, when baseline data were used to support environmental research involving Bear Creek (Smith 1998: 2). These headwaters were used to support the ORNL BMAP efforts that began in 1985, and have continued until the present day (ORNL, OR Y-12, ETTP 1997: 4-51). As a result, the headwaters of White Oak Creek have become one of the oldest and most well recorded reference sites on the reservation.

The headwaters of White Oak Creek are used to support other research projects, apart from their function as a reference site. The Environmental Sciences Division (ESD) at ORNL is currently using the headwaters as a source of algae and invertebrates for two environmental research projects funded by DOE. One of these projects is "Autotrophic Biofilms for Removing Contaminants from Industrial Wastewater." This project is investigating the potential use of autotrophic biofilms to sorb contaminants and clean industrial wastewater. The other project, "Ecological Effects of UV-B Radiation," is studying the ecological effects of current and increasing levels of ultraviolet B (UV-B) radiation, which is caused by destruction of the earth's ozone layer (Hill 1998a: 1; Hill 1998b: 1).

Walker Branch Watershed

The Walker Branch Watershed is a major research area located approximately 0.75 mi (1.2 km) east of the proposed site. The central research area consists of approximately 247 acres (100 ha) of land covered with temperate deciduous forest and drained by two perennial streams. It is completely surrounded by a very large buffer zone, which was delineated to protect the research efforts in the area. This zone was formally established in 1990 after an evaluation process and approvals by the Reservation Management Organization (RMO) and the Oak Ridge Operations (ORO) Land Use Committee (Parr 1998b: 3-10; Parr 1998c: 1). The Walker Branch Watershed and its buffer zone are shown in Figure 4.1.8.2-2.

The Walker Branch Watershed has been the focus of ecological research by ORNL-ESD and NOAA, Atmospheric Turbulence and Diffusion Division (ATDD) since 1967. Their projects in this area have contributed to a greater understanding of how forest watersheds function, and they have provided insights into the solution of energy-related problems associated with air pollution, contaminant transport, and forest nutrient dynamics. The Walker Branch Watershed is one of the few sites in the world characterized by long-term, intensive environmental studies (ORNL 1997d: 1 and 4).

The NOAA/ATDD is conducting the Temperate Deciduous Forest Continuous Monitoring Program (TDFCMP) in the Walker Branch Watershed. This program is measuring the continuous exchange of carbon dioxide (CO_2),

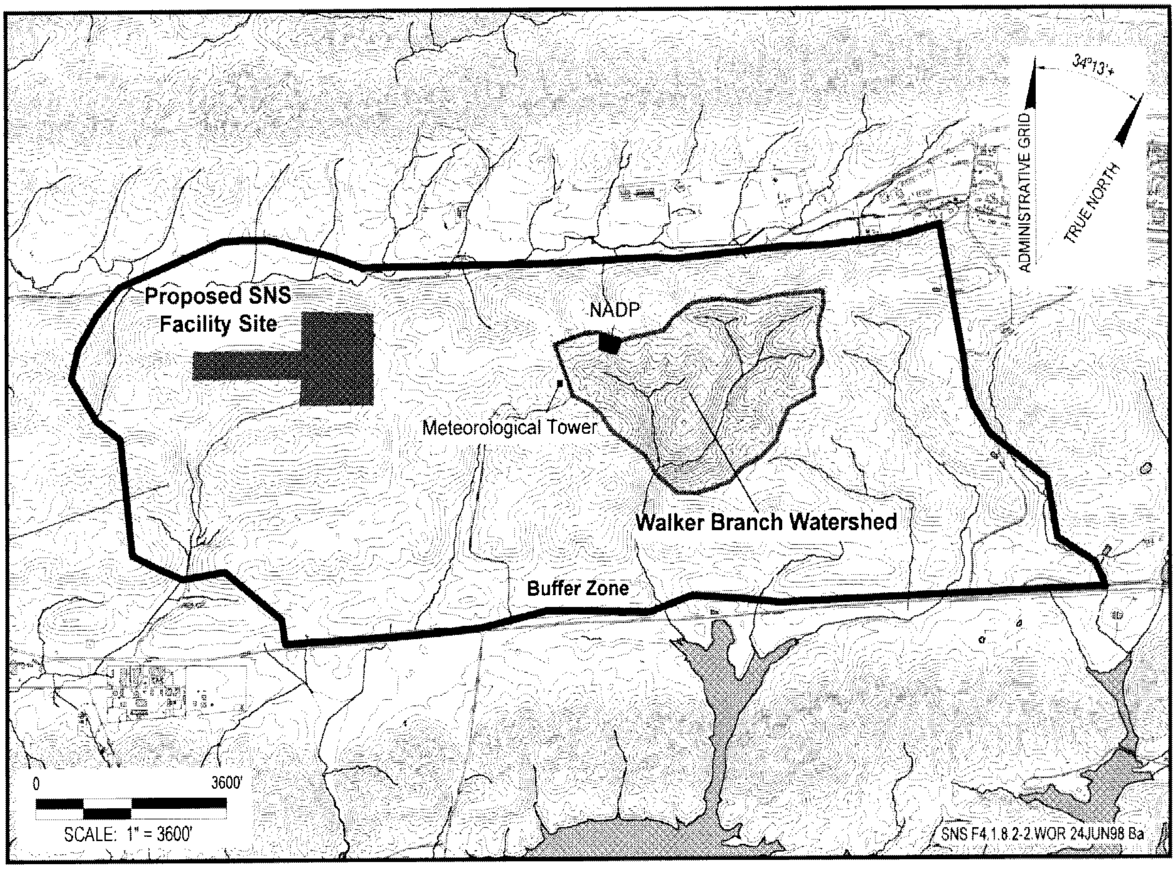


Figure 4.1.8.2-2. Walker Branch Watershed research areas and buffer zone on the ORR.

water vapor, and energy between the deciduous forest in the Walker Branch Watershed and the atmosphere. The aim of the program is to continuously monitor these exchanges over a long period of time. This monitoring is needed because few direct, long-term measurements of CO_2 exchange over a whole ecosystem have been done. Their purpose is to examine the uptake, use, and loss of carbon by components of the plant community within the intact Walker Branch Watershed ecosystem. Most published reports on carbon exchange over temperate forests are derived from limited (two to three week) studies conducted during the summer growing season. When the Walker Branch Watershed study began on October 24, 1994, a research team at Harvard University had conducted the only other long-term measurements of CO_2 over forest canopies in the U.S. Ultimately, the Walker Branch Watershed study is expected to result in a better understanding of local, regional, and global carbon budgets and the effects of elevated atmospheric CO_2 on temperate forests worldwide (ORNL 1997d: 2 and 8; NOAA 1998: 1).

The TDFCMP is measuring very small changes in CO_2 exchange between the atmosphere and the Walker Branch Watershed forest ecosystem. These changes are measured around a local background CO_2 level of 668 mg/m^3 (668,000 μg/m^3) of air. The measured changes are being associated with physical, chemical, and biological activity in the forest biomass and soils.

The monitoring instruments for the TDFCMP are located near the west periphery of the Walker Branch Watershed, on and near the base of a 144-ft (44-m) meteorological tower, and within the National Atmospheric Deposition Program Wet/Dry Deposition Monitoring Site (ORNL 1997d: 2 and 8). These locations are approximately 0.75 mi (1.2 km) east of the proposed SNS site. The prevailing winds blow from the direction of the proposed site to the east-northeast towards the Walker Branch Watershed during the daytime hours (refer to Section 4.1.3).

The ESD at ORNL is currently using Walker Branch Watershed land for nine major ecological research projects. Each of these projects is identified and briefly described in Table 4.1.8.2-1. A more detailed description of each project is provided in Appendix E.

4.1.8.3 Future Land Use

The current pattern of land use in the vicinity of the ORR is likely to continue into the foreseeable future. Urban development within the City of Oak Ridge will continue as the city gradually acquires control of reservation land for residential, commercial, and industrial purposes.

The missions of DOE have priority for the future use of land on the ORR. The zoning of reservation land for future use is shown in Figure 4.1.8.2-1. This zoning is the same as the current land use pattern, which reflects DOE plans to use the land in ways compatible with the current pattern of use.

A number of major, mission-related projects are now planned for the ORR. These include the proposed SNS Project; expansion of ORNL; Laboratory for Comparative and Functional Genomics; Waste Handling, Packaging, and Solidification Facility; Joint Institute for Neutron Science (JINS); Engineering Technology Complex; Fusion Materials Irradiation Facility; and CERCLA Waste Disposal Facility. Future land use on the ORR would also include large-scale environmental process research, continuing reindustrialization and commercial development in the Mixed/Industrial use area, and continued environmental research activities in the NERP. Additional uses for the NERP are discussed in the *ORNL Land and Facilities Use Plan* (LMER and LMES 1998: 11).

As indicated in Figure 4.1.8.2-1, many of these projects would be sited in the general vicinity of ORNL and on land zoned as Institutional/Research and Mixed Research/ Future Initiatives. The land in the Institutional/Research zone is already heavily developed, and this zoning reflects plans for its continued development. The Mixed Research/Future Initiatives zone is largely undeveloped land that is zoned for a balanced mixture of future environmental field research in the NERP with new facility development (Parr 1998a: 2). The preferred site for the proposed SNS is located entirely within the Mixed Research/Future Initiatives zone.

Headwaters of White Oak Creek

The environmental compliance monitoring programs at ORNL plan to continue using the headwaters of White Oak Creek as a baseline reference site for the BMAP, NPDES permit compliance, and other research projects, as long

Table 4.1.8.2-1. Current ORNL-ESD ecological research in the Walker Branch Watershed.

Project No.	Project	Description	Duration
C-1	Throughfall Displacement Experiment	Experimentation at the forest stand level to understand how forest ecosystems respond to changes in regional rainfall and how this relates to a warming global climate.	Long-Term (>10 years)
C-2	Long-Term Ecological Measurements of Ecosystem Response	Long-term project to monitor forest biomass and species composition, water inputs and outputs, and soil chemistry. These measurements are being made to quantify the response of the forest ecosystem to changes in climate and atmospheric deposition that are expected to occur. They support DOE's local, regional, and global research and provide baseline measurements for environmental restoration activities. The current measurement record spans 30 years.	Long-Term (>10 years)
C-3	Terrestrial Feedbacks to Regional Hydrologic Budgets	Continuous, multiyear measurement of climate variables, soil water conditions, and tree/forest evapotranspiration to enhance understanding of how closed canopy, deciduous forest stands contribute to local and regional hydrologic budgets. Project data will be used by the GEWEX Continental-Scale International Project (GCIP) to test climatic models. The Walker Branch Watershed is one of five primary project sites in the Ohio-Tennessee Watershed.	Completion by FY 2005
C-4	Nitrogen Uptake, Retention, and Cycling in Stream Ecosystems: An Intersite ^{15}N Tracer Experiment	A conservative radioisotope of nitrogen is being used as a tracer to study water use; nutrient uptake; stream metabolism; and nitrogen uptake, retention, and recycling in a stream ecosystem. Data from the Walker Branch Watershed study will be used with data from eight other sites to test hypotheses about the relationships between nitrogen uptake, cycling, and turnover and the hydrology, chemistry, and metabolism of streams.	Completion in FY 1999
C-5	Development of Gene Probes for Nitrate Reduction in Environmental Media: A Tool to Evaluate Nitrogen Retention in Watersheds	Development and field testing of molecular detection and quantification methods to evaluate nitrogen retention in watersheds.	Completion in FY 1999
C-6	Experimental and Theoretical Studies on the Seasonal, Annual, and Interannual Exchange of Water Vapor and Energy Exchange by a Temperate Forest Ecosystem in the Mississippi River Basin	Using micrometeorological, physiological, and hydrological methods to quantify the seasonal and interannual rates of water vapor and energy exchange over a temperate, broad-leaved forest and ecosystem in the Mississippi River Basin. This study illustrates the impact of periodic biotic events, ecological factors, and environmental factors on intra-and interannual variations in water vapor exchange at three scales: tree, canopy, and watershed.	Completion in FY 2000

Table 4.1.8.2-1. Current ORNL-ESD ecological research in the Walker Branch Watershed - Continued.

Project No.	Project	Description	Duration
C-7	Theoretical Studies of the Annual Exchange of CO_2 and Energy by a Temperate Forest Ecosystem	A detailed model of deciduous forest ecosystem physiology and physics is being used to simulate response of the forest in the Walker Branch Watershed to air temperature, rainfall, wind speed, solar irradiance, humidity, and atmospheric CO_2. The model will be tested against actual measurements in the Walker Branch Watershed. The aim of model development and testing is to predict land ecosystem responses to increasing atmospheric CO_2 concentrations and any associated climate change. This capability is important because land ecosystem responses to global environmental change may be significant to the global carbon cycle and climate.	Completion in FY 1999
C-8	Use of Multiscale Biophysical Models for Ecological Assessment: Applications in the Southeast	Data on primary productivity, soil carbon, and nitrogen dynamics in the Walker Branch Watershed are being used to test ecological models that evaluate variability in four fundamental factors of ecosystem condition.	Completion in FY 1999
C-9	Global Carbon Cycle Studies–Forest Carbon Dynamics: Field Experiments and Model Validation	Investigating the storage and properties of forest soil organic matter along an elevation/climate gradient in the Southern Appalachian Mountains. The Walker Branch Watershed is one of six sites where measurements relevant to this study are taken.	Long-Term (>10 years)

Source: Shriner 1998:2-6.

as the physical, chemical, and ecological conditions of the stream reflect baseline conditions. These plans include continued use of the headwaters area as a unique reference site and source of organisms for research in proposals. Its use to collect data pertinent to environmental restoration programs downstream is expected to continue. Ideally, from the ORNL research perspective, the current environmental conditions that support these land uses need to persist indefinitely.

Walker Branch Watershed

The buffer zone for the Walker Branch Watershed was designed to function as a land use zoning overlay on the major land use zones in this area of the ORR. Its purpose is to exclude from its boundaries any future activities that could adversely impact environmental monitoring and experiments in the Walker Branch Watershed. The proposed location of the SNS at ORNL is entirely within this buffer zone.

Seven types of proposed activities within the buffer zone must be reviewed by the RMO and approved by the ORO Land Use Committee. They are:

- Application or disposal of any chemicals or materials that might enter groundwater streams.
- Alteration of surface topography.
- Actions that result in the generation of dust or gases that are released into the atmosphere.
- Drilling of wells.
- Application of pesticides or herbicides.
- Application of limestone, asphalt, or other materials in maintenance of infrastructure.
- Changes in the nature of activities conducted within the research area.

However, the establishment of the buffer zone and the designation of restricted activities within it are not considered to be irrevocable actions. Both actions are subject to future reconsideration by the ORO Land Use Committee, if priorities dictate a different course of action (Parr 1998b: 3-10).

The TDFCMP in the Walker Branch Watershed was established as a long-term research effort. To meet the overall objectives of the program, the established monitoring activities would need to continue for many years into the future.

Eight of the nine current ORNL-ESD ecological research projects in the Walker Branch Watershed would extend into the future in some form. Three are long-term monitoring projects that are planned to continue for many years into the future. Two projects would continue into FY 2000 and 2005. Another three projects are scheduled to end in FY 1999; one project involves a subject slated for future long-term research, and the other two projects are expected to result in related follow-on work. According to the current proposed SNS project schedule, the ongoing and anticipated work on all eight projects would occur while the SNS is being constructed and operated. These projects and current plans concerning them are indicated in Table 4.1.8.3-1.

The ORNL-ESD has plans for a number of additional ecological research projects in the Walker Branch Watershed, and these projects fall into two categories. The first is research for which proposals are currently pending. These projects are identified and described in Table 4.1.8.3-2, and more detailed information on

Table 4.1.8.3-1. Planned continuation of current ORNL-ESD ecological research projects in the Walker Branch Watershed.

Project No.	Project	Plans
C-1	Throughfall Displacement Experiment	Long-term project (>10 years)
C-2	Long-Term Ecological Measurements of Ecosystem Response	Long-term project (>10 years)
C-3	Terrestrial Feedbacks to Regional Hydrologic Budgets	Follow-on work possible beyond FY 2005 completion
C-4	Nitrogen Uptake, Retention, and Cycling in Stream Ecosystems: An Intersite ^{15}N Tracer Experiment	Nitrogen dynamics is a priority for future long-term research beyond FY 1999 completion
C-6	Experimental and Theoretical Studies on the Seasonal, Annual, and Interannual Exchange of Water Vapor and Energy Exchange by a Temperate Forest Ecosystem in the Mississippi River Basin	Continue project into FY 2000
C-7	Theoretical Studies of the Annual Exchange of CO_2 and Energy by a Temperate Forest Ecosystem	Anticipate proposal to continue project beyond FY 1999 completion
C-8	Use of Multiscale Biophysical Models for Ecological Assessment: Applications in the Southeast	Follow-on work possible beyond FY 1999 completion
C-9	Global Carbon Cycle Studies--Forest Carbon Dynamics: Field Experiments and Model Validation	Long-term project (>10 years)

Source: Shriner 1998: 2-6.

Table 4.1.8.3-2. Future ORNL-ESD research projects in the Walker Branch Watershed (proposals pending).

Project No.	Project	Description	Duration
F-1	Ecosystem Effects of Climate Change: Experimental Alteration of the Spatio-Temporal Pattern of Net Primary Productivity in a Deciduous Forest Ecosystem	This project would experimentally simulate the large-scale effects of atmospheric changes on the NPP of an eastern deciduous forest and its streams. It would focus on the ecosystem impacts of spatial and temporal variability in NPP that would result from the manipulation. The proposed experiment is a multidisciplinary collaboration with the University of Tennessee, which is submitting a separate proposal to address ecological responses.	Long-term (up to 10 years)
F-2	Ecosystem Effects of Climate Change: Responses to Experimental Alteration of the Spatio-Temporal Pattern of Net Primary Productivity in a Deciduous Forest	This study would evaluate the responses to altered NPP at several levels of the food chain in the terrestrial and aquatic portions of the ecosystem. Plant responses at the canopy, subcanopy, and herbaceous levels would be quantified using a variety of methods, including satellite imagery. Animal responses would be evaluated using forest floor, canopy, and stream invertebrates, as well as small mammal populations. This would be a companion effort to the previously described project and would be dependent upon it.	Long-term (up to 10 years)
F-3	Retention and Fate of Atmospheric Nitrogen Deposition in Forests: Tracer ^{15}N Addition Experiments in Forests of Contrasting Nitrogen Status	The retention and fate of atmospheric nitrogen deposition to forests would be studied by conducting ^{15}N addition experiments in two forests of contrasting nitrogen status. The Walker Branch Watershed forest would be used as a nitrogen deficient forest in contrast to the nitrogen-saturated Noland Divide forest in the Great Smoky Mountains National Park.	Project completion by FY 2001. A priority subject for long-term research in the Walker Branch Watershed.
F-4	The Effect of Field-Scale Climate Manipulation on the Dynamics of Dissolved Organic Matter in Soil: Implications for Soil Carbon Pools	Comparisons of paired control- and climate-manipulation regimes would be used to assess differences in the chemical nature and concentrations of DOM in soil and shallow groundwater, determine decomposition rates of DOM, measure differences in the flow of DOM from soil through stormwater, and evaluate the interactive effects of altered CO_2, precipitation, and temperature on the fate and transport of DOM in soil.	Project completion in FY 2001. A priority subject for long-term research in the Walker Branch Watershed.

DOM - Dissolved organic matter.
NPP - Net primary productivity.
Source: Shriner 1998: 6-8.

them may be found in Appendix E. The second category covers ecological research activities that are part of ORNL-ESD strategic planning goals and objectives. Proposals for this research have not been written, and no funding has been committed. Future work on all of these projects and initiatives would overlap the timeline for construction and operation of the proposed SNS.

The ORNL-ESD Strategic Plan identifies Large-Scale Environmental Process Research as a priority area in the future of the division. This priority is based in large part on the historical record of research and the understanding of the ecological processes regulating ecosystem structure and function on the NERP, which includes the Walker Branch Watershed. The NERP is the cornerstone for large field experiment campaigns in this area for decades to come. Future strategic initiatives would include:

- Large-scale manipulation of interacting factors affecting climate change, such as temperature, precipitation, CO_2, and nutrient status.
- A major initiative to gain a better understanding of the physical, biological, and chemical environment of the below-ground ecosystem.
- Terrestrial and aquatic climate warming manipulations.
- Nitrogen dynamics of a deciduous forest.
- Soil carbon management and use in forest ecosystems.

The baseline of research and monitoring activities on the Walker Branch Watershed is intended to contribute to a new national, interagency program for long-term ecosystem monitoring. The Oak Ridge NERP would serve as an index site in the monitoring network.

Common Ground Process and End Uses of ORR Land

DOE-ORO has actively sought public perspectives on future ORR land use through a process called Common Ground and through the End Use Working Group. The Common Ground process has resulted in public recommendations for future use of all reservation land. The End Use Working Group has been in the process of determining end use recommendations for areas of land with contaminated sites. When their deliberations are completed, the results are expected to be presented to DOE in the form of final community land use guidelines and recommendations for the end use of contaminated land in specific watersheds.

The proposed SNS site at ORNL is located in an area DOE has zoned for a combination of environmental research and development of new facilities. As part of the Common Ground process, the Nature Conservancy was retained to assess the biological significance of land areas on the reservation. This assessment was done using ORNL data to rank the biodiversity of land areas. Most of the land on the proposed SNS site was given a preliminary biodiversity significance ranking (BSR) of 3 (High Significance). A small area in the northeast corner of the site was given a preliminary BSR of 2 (Very High Significance), which is the highest category in the rating system. Furthermore, the proposed SNS site lies within a preliminarily defined landscape complex, which is a broad area encompassing several BSR areas (Figure 4.1.8.3-1). Consequently, the Common Ground process has recommended a future land use category, Conservation Area Uses, for the land on and adjacent to the proposed SNS site (Figure 4.1.8.3-2). This category includes environmental protection, research sites,

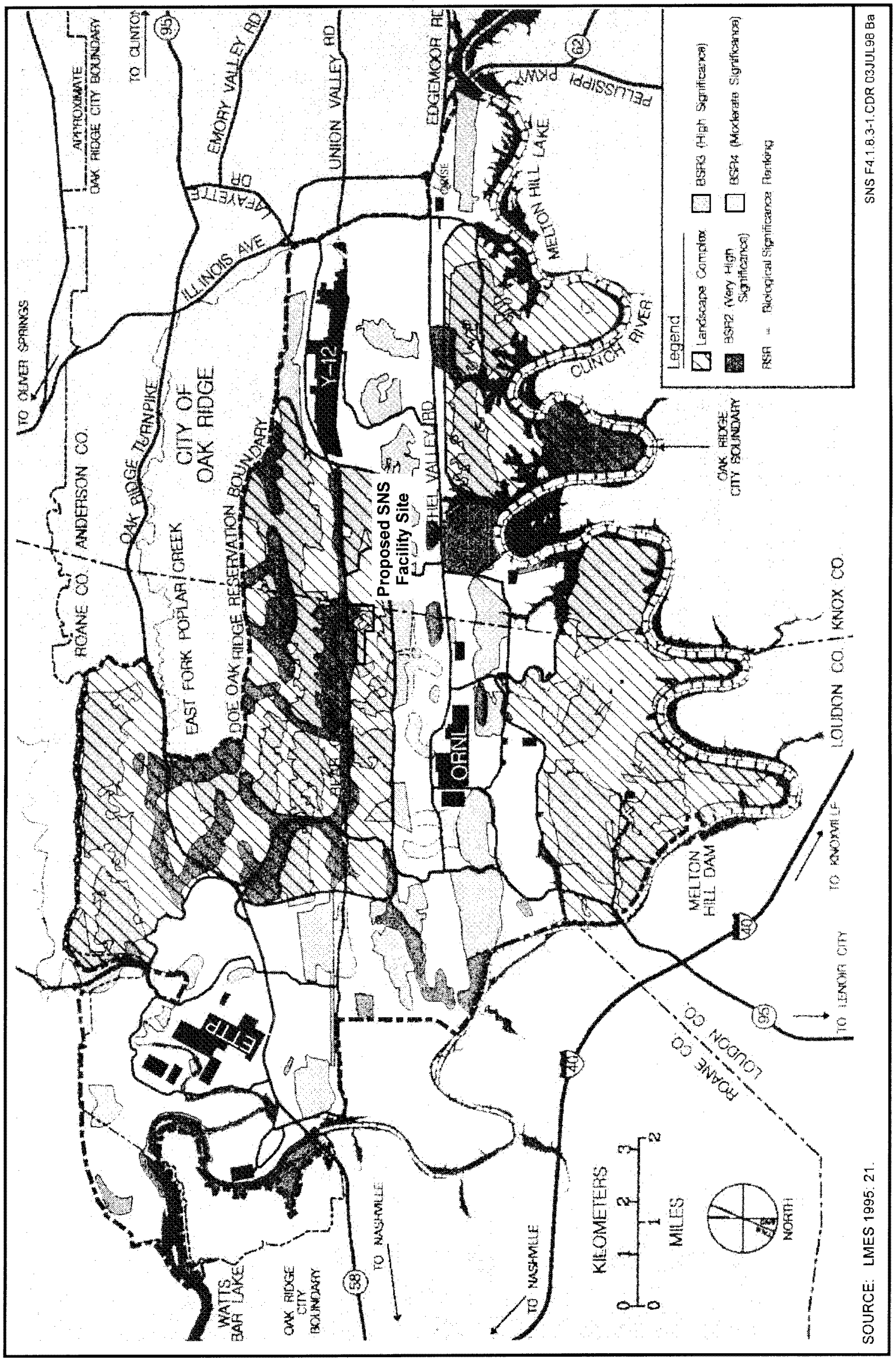
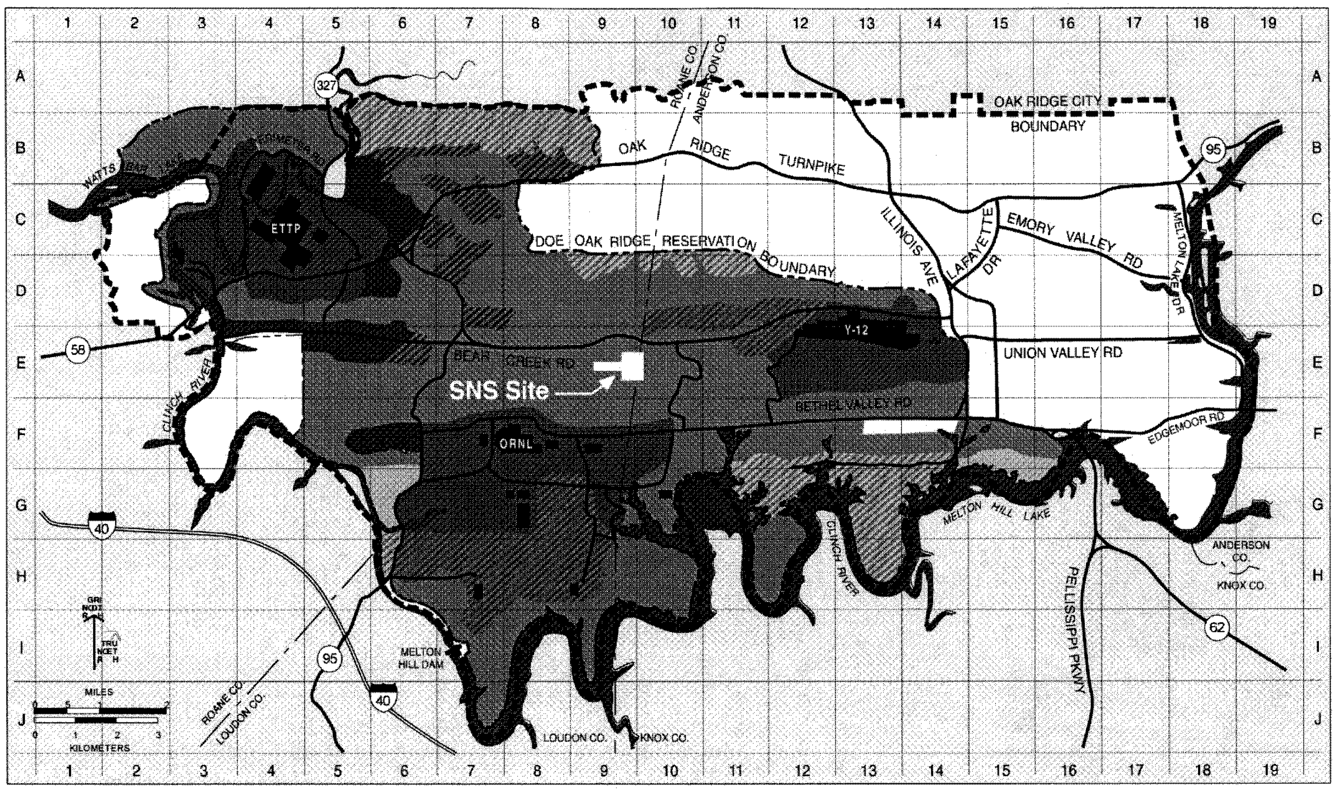


Figure 4.1.8.3-1. Map of preliminary conservation sites on the ORR.



Note: Grid shown is Oak Ridge administrative grid.

SNS Map BWSC#16701daw6/1/98

MAP LEGEND

Primary Industrial Area Uses

- Industrial
- Research
- Office and Business
- Employee Health Care
- Waste Storage/Treatment/

Time Frame
Short-term (0-to-25 years) and long-term (26-to-100 years) strategic plans should be developed. Implementation should begin as soon as possible.

Primary Potential Industrial Area Uses

- Industrial
- Research
- Office and Business
- Institutional

Time Frame
Primary focus is on the short-term (0-to-25 years) to attract new industrial prospects before the skilled labor force decreases and transportation and utility systems decline.

Secondary Potential Industrial Area Uses

- Medium-to-light Industrial
- Research
- Recreational

Time Frame
Focus on short-term (0-to-25 years) plans to be developed on an as-needed basis to respond to major Oak Ridge Reservation initiatives and market opportunities.

Conservation Area Uses

- Environmental Protection
- Research Sites
- Forestry and Agricultural
- Passive Recreational

Time Frame
Short-term (0-to-25 years) and long-term (26-to-100 years)

Conservation Transition Area Uses

- Light Industrial and Research
- Office and Business
- Institutional
- Passive Recreational
- Forestry and Agricultural Research
- Conservation

Time Frame
Short-term (0-to-25 years) and long-term (26-to-100 years)

City of Oak Ridge

DOE Oak Ridge Reservation Boundary
(Note: Boundary follows shaded areas of Revervation)

Oak Ridge City Boundary

Figure 4.1.8.3-2. Map of ORR Common Ground future land use recommendations.

forestry, agricultural research, and passive recreation (LMES 1995: 20-21 and 33).

The End Use Working Group has drafted community guidelines for land use on the ORR. These guidelines recommend the siting of additional DOE facilities on brownfield sites instead of greenfield sites. Brownfield sites consist of previously developed land or contaminated land that has been remediated to accommodate certain uses. Greenfield sites consist of uncontaminated and previously undeveloped land. The proposed SNS site and areas adjacent to it are greenfields.

4.1.8.4 Parks, Preserves, and Recreational Resources

The University of Tennessee Arboretum is located approximately 0.25 mi (0.4 km) northeast of the ORR. This facility contains 250 acres (101 ha) of land and functions as a living botanical education center for the general public. Several trails with botanical themes run throughout the arboretum and are open to the public for hiking. The University of Tennessee operates a forest experiment station on 2,000 acres (810 ha) of land adjacent to the arboretum (LMES 1996: 2-49). This area is not open to the public.

Large portions of the ORR are devoted to nature preservation and biological research. About 21,980 acres (8,899 ha) of undeveloped and geographically fragmented areas of reservation land comprise the Oak Ridge NERP (ORNL, OR Y-12, and ETTP 1997: 1-8). The NERP is used by the U.S. scientific community as an outdoor environmental science laboratory to study the current and future environmental consequences of the DOE mission in Oak Ridge (LMES 1995: 7). Numerous areas within the NERP are designated for the protection of rare species. A number of reference areas have been established to serve as examples of regional plant communities and unique biotic features (Pounds et al. 1993).

The Clark Center Recreational Park occupies 90 acres (36 ha) of land within the east corner of the reservation. It is open to the public for swimming, picnicking, fishing, pleasure boating, and athletic activities such as softball.

Several public recreation areas are located along Melton Hill Lake, which is outside the ORR but adjacent to a large portion of the reservation's southeast boundary. This body of water is a TVA reservoir that was formed by impounding the Clinch River with Melton Hill Dam. The body of water on the downstream side of this dam is Watts Bar Lake, which is adjacent to the southwest boundary of the reservation.

Melton Hill Dam is located approximately 2.7 mi (4.3 km) southwest of the central ORNL plant, but land used for laboratory activities extends south to the shore of the lake. A large TVA public recreation area is located at the dam on the opposite shore from ORNL land. This area is used for pleasure boating, fishing, swimming, and picnicking. Other TVA recreational areas with similar uses are located along Melton Hill Lake upstream from the dam and ORNL, including 1,051 acres (425 ha) of recreational lands within the city limits of Oak Ridge (MMES 1994: 1-27). A TVA boat ramp is located on the ORNL side of Watts Bar Lake, approximately 1.5 mi (2.4 km) downstream from Melton Hill Dam. Watts Bar Lake is used for pleasure boating, fishing, and swimming.

A portion of the reservation is operated as the Oak Ridge Wildlife Management Area through a cooperative agreement between DOE and the Tennessee Wildlife Resources Agency (DOE-ORO 1996: 3-1). In 1984, this agreement was initiated to reduce traffic accidents involving deer by opening the reservation to hunting by the public (Saylor et al. 1990: 8-2). The proposed SNS site at ORNL is located entirely within a currently designated hunting zone (MMES 1994: 2-119).

4.1.8.5 Visual Resources

The steep, linear ridges, intervening valleys, and lakes in the vicinity of ORNL create beautiful natural scenery. However, many parcels of rural land are used for agricultural and residential purposes. As a result, the visual field at many locations includes various combinations of houses, barns, roads, and utility features. In heavily developed areas of Oak Ridge, views are predominated by these features, along with numerous commercial structures, industrial plants, and public service buildings.

The ORR was primarily in agricultural use when it was purchased by the federal government in 1942. Since that time, much of it has been allowed to return to its natural state. Consequently, natural scenery abounds on the reservation. However, many views of the landscape in developed areas of the reservation, such as those in the vicinity of ORNL, are a mixture of natural features with buildings, roads, and utility features. On the reservation, there are no well-established and frequently visited visual resources, such as overlooks, that include the proposed SNS site.

The proposed SNS site would be located on top of Chestnut Ridge and approximately 1 mi (1.6 km) northeast of the central ORNL plant. Its location is visible from Bear Creek Road to the north and Chestnut Ridge Road to the east. Viewed from these locations, the proposed site appears to be completely forested. Standing at points within the interior of the proposed site, the trees shroud panoramic views of the surrounding landscape. Signs of human activity are apparent in the form of a few dirt utility roads and evidence of recent surveying and core drilling activity. From points on the east periphery of the proposed site, Chestnut Ridge Road and a utility corridor are visible.

4.1.9 RADIOLOGICAL AND CHEMICAL ENVIRONMENT

This section describes the radiological and chemical environment at ORNL.

4.1.9.1 Radiological Environment

Facilities that contribute the majority of radioactive emissions from the ORR include the Y-12 Plant; ORNL facilities, specifically the 2026 Radioactive Materials Analytical Laboratory, 3020 Development Facility, 3039 Central Off-Gas and Scrubber System, High Flux Isotope Reactor, and Radiochemical Engineering Development Center; and the Toxic Substance Control Act (TSCA) Incinerator at ETTP.

Four offsite facilities were identified as potential contributors to radiation exposure of the public around the ORR. These facilities include a waste-processing facility located on Bear Creek Road, a depleted uranium processing facility located on Illinois Avenue, a decontamination facility located on Flint Road in Oak Ridge, and a waste processing facility located on Gallaher Road in Kingston. Airborne emissions from these facilities (based on information supplied by the facilities) should not cause any individual to receive an annual effective dose equivalent (EDE) greater than 3.8 mrem. When combined with impacts caused by emissions, no individual should receive an EDE in excess of EPA or DOE limits. No information was obtained about waterborne releases, if any, from these facilities.

4.1.9.1.1 Air

DOE maintains a perimeter air monitoring network to perform surveillance of airborne radionuclides at the reservation perimeter and to collect reference data from remote locations. This network consists of eight stations spread throughout the ORR and one regional (offsite reference) station that samples levels of alpha-, beta-, and gamma-emitting radionuclides; tritium; beryllium; and total radioactive strontium. A comparison of the perimeter station data with the regional station data indicates that the ORR operations do not significantly affect local air quality (ORNL, OR Y-12, and ETTP 1997).

Station 37 in this network is centrally located within the ORR in Bear Creek Valley. It is the closest station to the proposed SNS site and monitors the overlap of the Y-12 Plant, ORNL, and the ETTP site emissions. Table 4.1.9.1.1-1 provides radiochemical results for Station 37 and the two offsite reference stations (Station 51—Norris Dam, Station 52—Ft. Loudon Dam). No significant difference can be discerned between airborne radionuclide activities on the reservation or offsite. (Note: Station 51 is no longer used).

Each ORR facility has a comprehensive air pollution control and monitoring program to ensure that airborne discharges meet regulatory requirements and do not adversely affect ambient air quality. During 1996, the effects of radionuclides released to the atmosphere from ORR operations were evaluated by calculating the EDE to maximally exposed offsite individuals and to the entire population residing within 50 mi (80 km) of the center of the ORR. A total of 47 emission points, each of which includes one or more individual sources, on the ORR were modeled during 1996. This total includes seven points at the Y-12 Plant, 27 points at ORNL, and 13 points at ETTP.

The EDE received by the hypothetical maximally exposed individual for the ORR was calculated to be about 0.45 mrem, which is below the National Emissions Standards for Hazardous Air Pollutants (NESHAP) standard of 10 mrem and well below the 300 mrem that the average individual receives from natural sources of radiation. The maximally exposed individual is located about 0.7 mi (1.13 km) north-northeast

Table 4.1.9.1.1-1. Comparison of radionuclide levels (Ci/ml) between air monitoring stations at ORR and reference locations.[a]

Monitor Station	Be-7	Co-60	Cs-137	H-3	U-234	U-235	U-238	Gross Alpha	Gross Beta
Station 37	1.6E-13	8.3E-17	1.3E-17	9.3E-12	2.0E-17	7.2E-19	2.1E-17	2.8E-15	5.7E-15
Station 51	1.6E-13	2.4E-17	2.2E-17	9.2E-12	8.5E-18	3.8E-19	7.2E-18	2.7E-15	5.2E-15
Station 52	1.5E-13	5.0E-17	1.1E-17	6.6E-12	9.4E-18	1.4E-18	9.3E-18	1.8E-15	4.2E-15

[a] ORNL, OR Y-12, ETTP 1997.
Values: 1.6 E-13 = 1.6 X 10^{-13} Ci/ml.

of the Y-12 Plant release point, about 5.8 mi (9.3 km) northeast of the 3039 stack at ORNL, and about 8.11 mi (13 km) east-northeast of the K-1435 (TSCA Incinerator) stack at ETTP. The calculated collective EDE to the entire population within 50 mi (80 km) of the ORR (about 879,546 persons) was about 9.9 person-rem, which is approximately 0.004 percent of the 264,000 person-rem that this population could have received from natural sources of radiation.

4.1.9.1.2 Water

Radionuclides discharged to surface waters from the ORR enter the Tennessee River system by way of the Clinch River and various feeder streams. Discharges from the Y-12 Plant enter Clinch River by way of Bear Creek and East Fork Poplar Creek, both of which enter Poplar Creek before it enters the Clinch River, and by direct discharge from Rogers Quarry into Melton Hill Lake. Discharges from ORNL enter the Clinch River by way of White Oak Creek and White Oak Lake. Discharges from ETTP enter the Clinch River by way of Poplar Creek.

Based on three years of data, Bear Creek downstream from the Y-12 Plant Burial Grounds has the highest levels of gross alpha activity, total uranium, and uranium isotopes. The highest levels of gross beta, total radioactive strontium, and tritium have been at Melton Branch downstream from ORNL, White Oak Creek at White Oak Dam, and White Oak Creek downstream from ORNL.

The potential radiological impacts of these discharges to persons who drink water, eat fish, swim, boat, and use the shoreline at various locations along the Clinch and Tennessee Rivers are evaluated annually. When all pathways are considered, the maximum EDE resulting from waterborne radionuclide discharges could have been about 1.5 mrem: 1.2 mrem from use of offsite waters, plus 0.3 mrem from drinking Kingston water. The collective EDE to the 50-mi (80-km) population was estimated to be about 2.0 person-rem. These are small percentages of individual and collective doses attributable to natural background radiation, 0.5 percent and 0.0008 percent, respectively.

4.1.9.1.3 Soil

Soil samples were collected from eight perimeter stations and the remote station at Norris Dam. Sampling results indicate the presence of uranium isotopes and gross alpha activity. Individual uranium isotopes were detected at less than 1 pCi/g compared to a nondetect at the Norris Dam reference locations. Gross alpha levels averaged 2.4 pCi/g at the eight locations compared to 2.3 pCi/g at Norris Dam. No readings were significantly above background levels.

4.1.9.1.4 Ambient Gamma Radiation

The ORNL continuously monitors external gamma radiation from six ambient air stations in and around the ORR. The furthest station is located at Norris Dam, 26 mi (41.9 km) northeast of the ORR. Six ambient air stations monitor external gamma radiation. The median external radiation value for the ORR in 1996 was estimated to be 67 mR/yr compared to 81mR/yr for cities across the U.S.

4.1.9.2 Chemical Environment

This section describes the levels of nonradiological contaminants in air and water at

ORNL. Soil is not routinely monitored for nonradiological contaminants at ORNL.

4.1.9.2.1 Air

The Y-12 Plant releases nonradiological contaminants into the atmosphere as a result of plant processes, maintenance, waste management operations, and steam production. More than 90 percent of the Y-12 Plant's emissions are attributable to the operation of the Y-12 Steam Plant. The steam plant is monitored for SO_x, NO_x, carbon monoxide, particulates, and VOCs. Other common pollutants from the Y-12 Plant include refrigerants (freon) and miscellaneous chemicals (methanol, HCl).

For ORNL, the steam plant and two small oil-fired boilers contribute the majority of nonradiological air pollutants, contributing 98 percent of allowable emissions. In 1996, no noncompliance infractions occurred.

The major sources of criteria air pollutants at ETTP consist of the three remaining steam-generating units at the K-1501 Steam Plant and the TSCA Incinerator. Signature pollutants of steam plants include sulfur dioxide, nitrogen oxides, carbon monoxide, particulates, and VOCs. The TSCA Incinerator is monitored for lead, beryllium, mercury, fluorine, chlorine, sulfur dioxide, and particulates.

4.1.9.2.2 Water

To assess the water quality of the surrounding surface water resources, surface water samples are collected from 22 locations around the ORR. Out of 79 parameters analyzed at each of the 22 sites, chromium at White Oak Dam, arsenic at the Melton Hill Reservoir at the Oak Ridge Marina, zinc at White Oak Creek upstream from ORNL, and mercury at the water supply intake for Knox County are the only parameters that exceeded a reference value in 1996.

In 1996, more than 200 surface water samples were collected from three areas bordering the Y-12 Plant. Results indicate that only mercury and zinc were detected at values exceeding criteria maxima. The source of zinc is believed to be a zinc additive in the once-through cooling water. The sample location that produced these results is located in East Fork Poplar Creek near the junction of Scarboro and Bear Creek Roads.

In 1996, over 10,000 surface water samples were collected from the ORNL property at various process discharge points, as required by the ORNL NPDES Permit. Of the samples collected, only a small number were noncompliant with NPDES permit limits. Parameters exceeding permit limits included fecal coliform, iron, and total suspended solids. ORNL has a fairly extensive mercury monitoring program. In 1996, 78 samples were collected from 13 locations. The highest value reported was 0.55 µg/L near the Outfall 207 in White Oak Creek. Average concentrations ranged from 0.13 to 0.36 µg/L.

Discharge monitoring from ETTP in 1996 indicates one excursion for total petroleum hydrocarbons and three for unpermitted discharges. Aside from those four noncompliance episodes, all discharges into receiving waters were within NPDES permit limits.

4.1.9.2.3 Soil

Soil is not routinely monitored for nonradiological contaminants at ORR.

4.1.10 SUPPORT FACILITIES AND INFRASTRUCTURE

The Support Facilities and Infrastructure section characterizes the local vehicular transportation routes around the proposed SNS site. The existing utilities that are available to provide needed services to support the operation of the proposed SNS are also described.

4.1.10.1 Transportation

The proposed SNS facility would be located between ORNL and the Y-12 Plant near the City of Oak Ridge, Tennessee. Figure 4.1.10.1-1 gives the location of the proposed SNS facility site and the transportation routes around the site.

Major transportation routes to the ORR are via two interstate highways, I-40 and I-75, and U.S. highways 11, 25W, and 70. State highways that service the area include 58, 61, 62, 95, and 162 (Pellissippi Parkway). These highways lead to Bear Creek Road and Bethel Valley Road, which border the site to the north and south, respectively. Primary access to the proposed SNS facility would be from Chestnut Ridge Road via Bethel Valley Road. Chestnut Ridge Road is constructed of gravel and laterite material and is unable to accommodate heavy vehicle loads. Traffic flow on Chestnut Ridge Road is light.

The Phase I Environmental Report for the ANS at ORNL (Blasing et al. 1992) contains a detailed traffic analysis of the effects of construction and operation of the ANS. This analysis is the basis for the SNS analysis at Oak Ridge because of the proximity of the respective sites considered. The major public access roads examined for the ANS traffic analysis are the same as the SNS analysis (State Road 62, State Road 95, and Bethel Valley Road) making the data and analysis directly applicable. These roadways and associated traffic flows are provided in Table 4.1.10.1-1.

4.1.10.2 Utilities

This section provides a description of the utility infrastructure at ORNL. The following is based upon existing documentation and discussions with select ORNL staff.

4.1.10.2.1 Electrical Service

ORNL purchases its electricity from TVA. Power is brought to the site via two 161-kV transmission lines, currently owned by DOE, which terminate into a main substation approximately 6,000 ft (1,800 m) west of the proposed site. At the substation, power is stepped down to 13.8 kV before distribution to the laboratory via overhead and underground lines. The existing 161-kV transmission lines cross Chestnut Ridge approximately 3,000 ft (914 m) west of the proposed site and have been determined to be adequate for future electrical energy demands (Schubert 1997). Currently, there are no electrical power lines or facilities onsite.

4.1.10.2.2 Steam

ORNL produces steam for its operations from the steam plant located on the far west end of the laboratory. The plant consists of five boilers, with a sixth boiler currently being installed. Four of the boilers are coal fired, each with a 50,000-lb/hr capacity. The fifth and sixth boilers are natural gas fired, each with a 100,000-lb/hr capacity. Approximately 90 percent of the steam is used for building heating systems; the other 10 percent is used for evaporators and

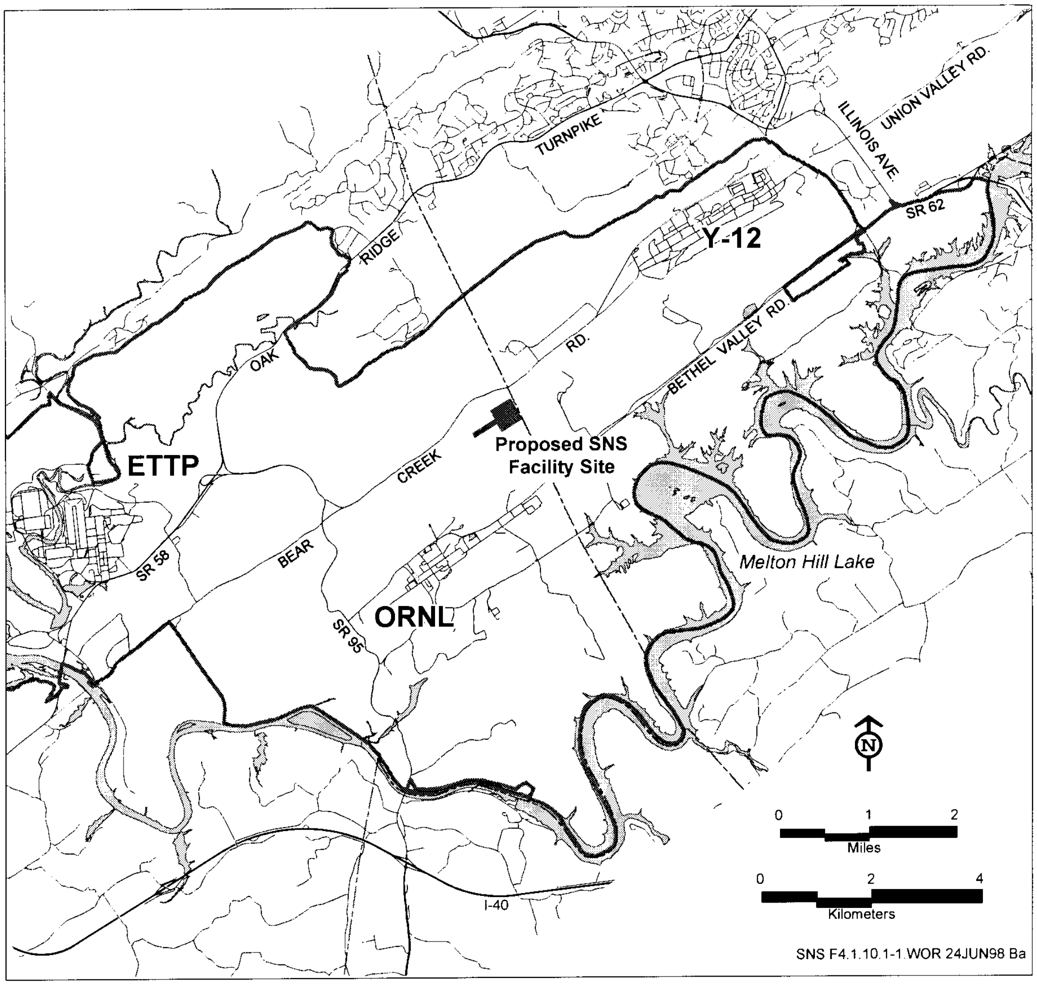


Figure 4.1.10.1-1. Transportation routes at the ORR and surrounding areas.

Table 4.1.10.1-1. Existing average daily traffic flows (vehicles/day) and LOS at ORR.

Road Segment	Average Daily Flow
Bethel Valley Road (east) (from Melton Valley Rd. eastward to SR-62)	7,400
Bethel Valley Road (west) (from Melton Valley Rd. westward to SR-95)	4,200
State Route 95 (north) (from Bethel Valley Rd. northward to SR-58)	6,600
State Route 95 (south) (from Bethel Valley Rd. southward to I-40)	6,600
State Route 62 (south) (from Bethel Valley Rd. southward to the Pellissippi Parkway toward Knoxville)	29,940

Source: Blasing et al. 1992.

process steam. ORNL's maximum steam consumption is approximately 70,000 lb/hr in the summer. Currently, there are no steam lines or facilities onsite.

4.1.10.2.3 Natural Gas

East Tennessee Natural Gas Company (ETNG) supplies natural gas to ORR. A 22-in. main enters ORR from Knox County, crosses the Clinch River, and proceeds to a valve station located along Bethel Valley Road. Smaller pipelines [6 to 14 in. (15.2 to 35.6 cm)] supply gas to various facilities around the laboratory. ETNG mainline pressures range from 450 to 600 psi but are reduced to 65 and 125 psig for distribution to ETTP and the Y-12 Plant, respectively, and 100 psig for distribution to ORNL. The annual natural gas demand for ORNL ranges from 110,000 to 150,000 million ft^3/yr (33,528 to 45,720 million m^3/yr). Currently, there are no natural gas lines or facilities onsite. The distribution header is located approximately 1 mi (1.6 km) from the proposed SNS site.

4.1.10.2.4 Water Service

DOE withdraws water from the Clinch River at a point south of the eastern end of the Y-12 Plant. The water is filtered and chlorinated at a water treatment plant located north of the Y-12 Plant and distributed to the City of Oak Ridge, the Y-12 Plant, and ORNL. This treatment facility provides potable water through two storage reservoirs with a combined capacity of 7 million gal (26.5 million L). Water is distributed from the treatment facility to ORNL via a 24-in. (61-cm) water main. An existing 24-in. (61-cm) line currently exists adjacent to the southern and eastern edge of the proposed SNS facility. At ORNL, two 3-million-gal (11.4-million-L) storage reservoirs hold the water before it is distributed through ORNL's water distribution system.

4.1.10.2.5 Sanitary Waste Treatment

ETTP and ORNL operate and maintain individual sanitary wastewater treatment plants (SWTPs), while the Y-12 Plant uses sewage treatment services at the City of Oak Ridge. The SWTP at ORNL is located on the western end of the laboratory. The SWTP's current capacity is 300,000 gpd (1.1 million lpd), while the average daily flow to the SWTP is less than 200,000 gpd (757,080 lpd). Within the last four years, the SWTP received upgrades including new chlorination and ozone systems and a relining of all major underground sewer lines to eliminate groundwater infiltration. The closest sewer line to the proposed SNS facility is approximately 1 mi (1.6 km) south of the site.

4.2 LOS ALAMOS NATIONAL LABORATORY

The proposed site for the SNS facility is located on the Pajarito Plateau on the east-central edge of the Jemez Mountains. The plateau is formed by an apron of volcanic sedimentary rocks and is dissected into a number of narrow mesas by southeast-trending canyons. Most of these canyons support intermittently flowing streams. The stream drainages ultimately descend into White Rock Canyon and converge with the Rio Grande near the eastern boundary of Los Alamos National Laboratory (LANL). The Rio Grande is the only permanently flowing river near the project area.

The proposed site is within a portion of the LANL reservation called Technical Area 70 (TA-70) (Figure 4.2-1), which is located on a mesa flanked by Ancho Canyon 0.27 mi (0.47 km) to the southwest and a small unnamed canyon an equal distance to the northeast. To the southeast, the Rio Grande flows through nearby White Rock Canyon, at a distance of approximately 1.2 mi (1.9 km) from the proposed facility site. The proposed site is located 0.22 mi (0.35 km) to the east of State Road 4, a two-lane paved road (Figure 4.2-1). Elevations within the area evaluated range from 6,410 ft (1,954 m) to 6,490 ft (1,978 m).

4.2.1 GEOLOGY AND SOILS

LANL is located in north central New Mexico on the Pajarito Plateau between the Jemez Mountains on the west and the Rio Grande on the east. The topography of the area is characterized by mesas and bluffs with deeply incised canyons. The major geologic feature of the area is the Rio Grande rift that extends from northern Mexico across central New Mexico and terminates in south central Colorado. The Rio Grande rift is a series of grabens or down-thrown blocks resulting from tensional tectonics some 32 million years ago. The present-day form of the rift is displayed by a series of basins filled with sediments eroded from adjacent highlands interspersed with lava flows. The rift basin in the vicinity of Los Alamos and Santa Fe is referred to as the Española Basin.

The Valles Caldera is the dominant physical feature adjoining the Los Alamos area. The caldera formed when the center of the volcanic uplift collapsed after a large volume of magma ejected along a series of ring-shaped fractures that now defines the present-day structure. Faulting associated with the rifting provided conduits for volcanic activity, such as the basaltic lavas that are interbedded with the basin-filling sediments (Figure 4.2.1-1). The deep faulting helped localize the expression of some major trends in volcanic activity. The volcanic vents in and near the Jemez Mountains lie at the intersection of a northeast trend of volcanic centers and the western edge of the Española Basin. Deposits from the Jemez Mountain vents covered the basin-filling sediments and the adjacent uplands over an area of more than 800 mi^2 (2,100 km^2). Pyroclastic eruptions occurring about 1.5 to 1.0 million years ago resulted in significant accumulations of ash fall that is called the Bandelier Tuff.

4.2.1.1 Stratigraphy

The tuffs accumulated on the Pajarito Plateau include a mixture of ash falls, ash fall pumice, and rhyolite tuff and range from welded to nonwelded tuffs. On the Pajarito Plateau the Bandelier Tuff is divided into the Otowi and Tshirege members (Figure 4.2.1.1-1). This tuff is more than 300 m (1,000 ft) thick in the western part of the plateau near the Jemez Mountains and thins to about 80 m (260 ft) at the eastern edge of the plateau above the Rio Grande.

Surface geology at the site proposed for the SNS facility is characteristic of the lower elevation mesa tops on the Pajarito Plateau. The site slopes less than 20° from the northwest to the southeast towards White Rock Canyon and the Rio Grande. The surface of the mesa top is composed of bare tuff bedrock with scattered areas of soil. Surface bedrock at this site is on the Tshirege member, but its thickness at TA-70 has not been determined.

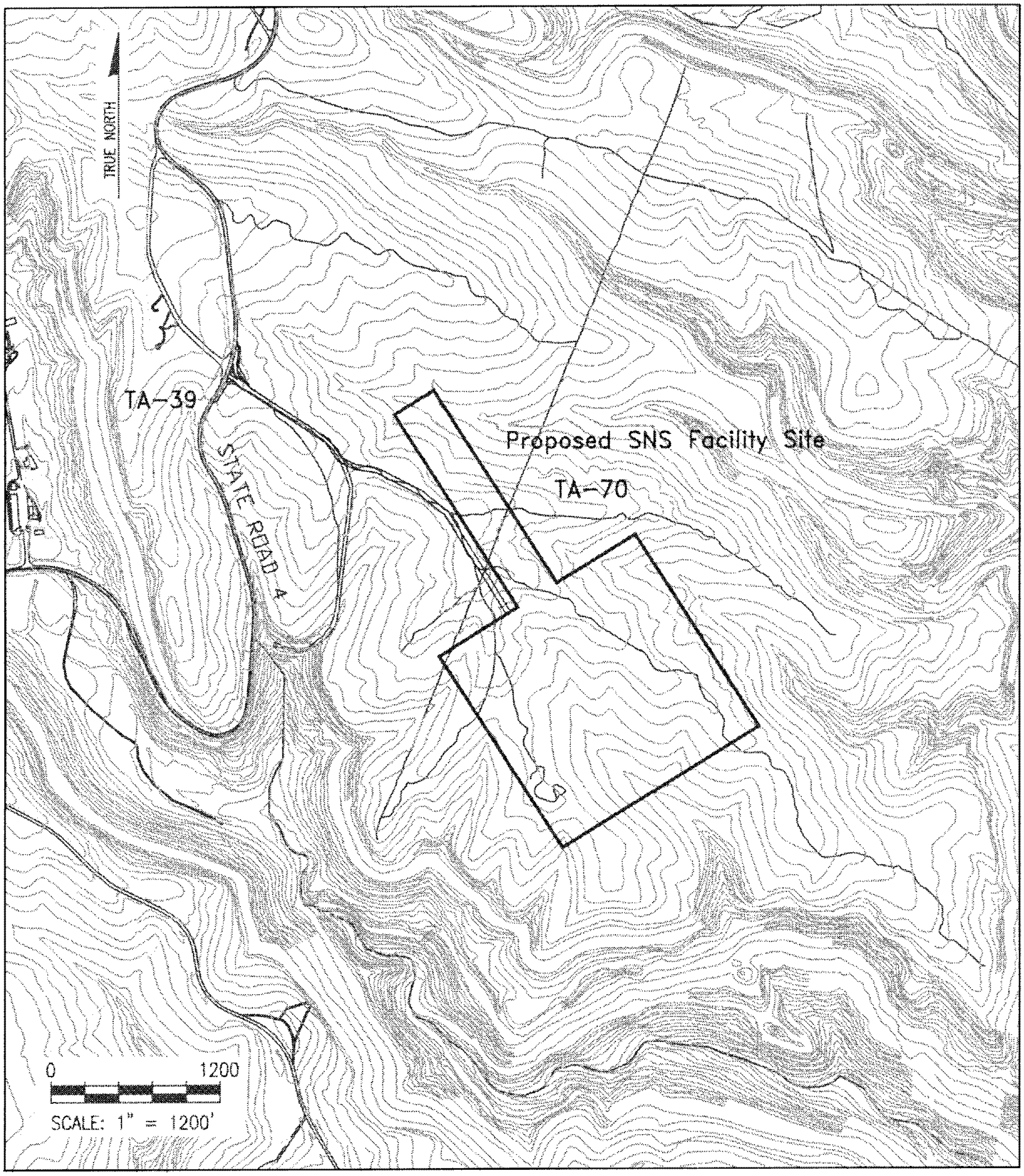


Figure 4.2-1. Proposed SNS site at LANL.

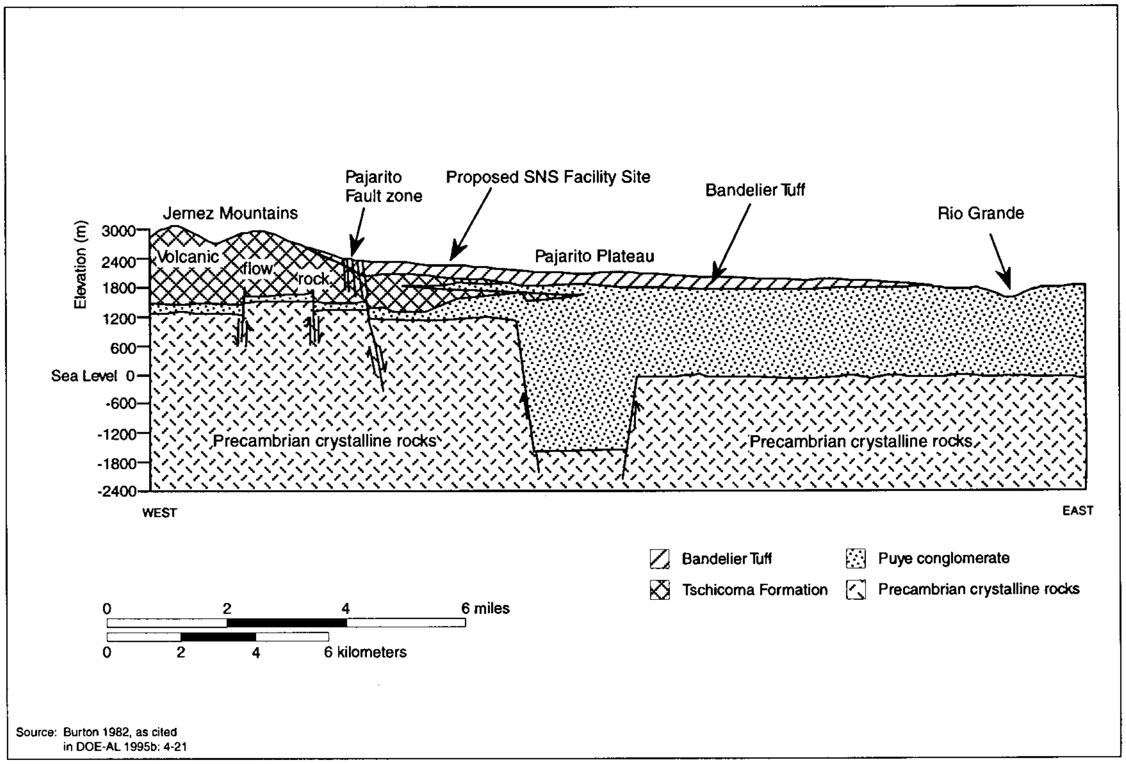


Figure 4.2.1-1. Geologic cross section of the LANL region.

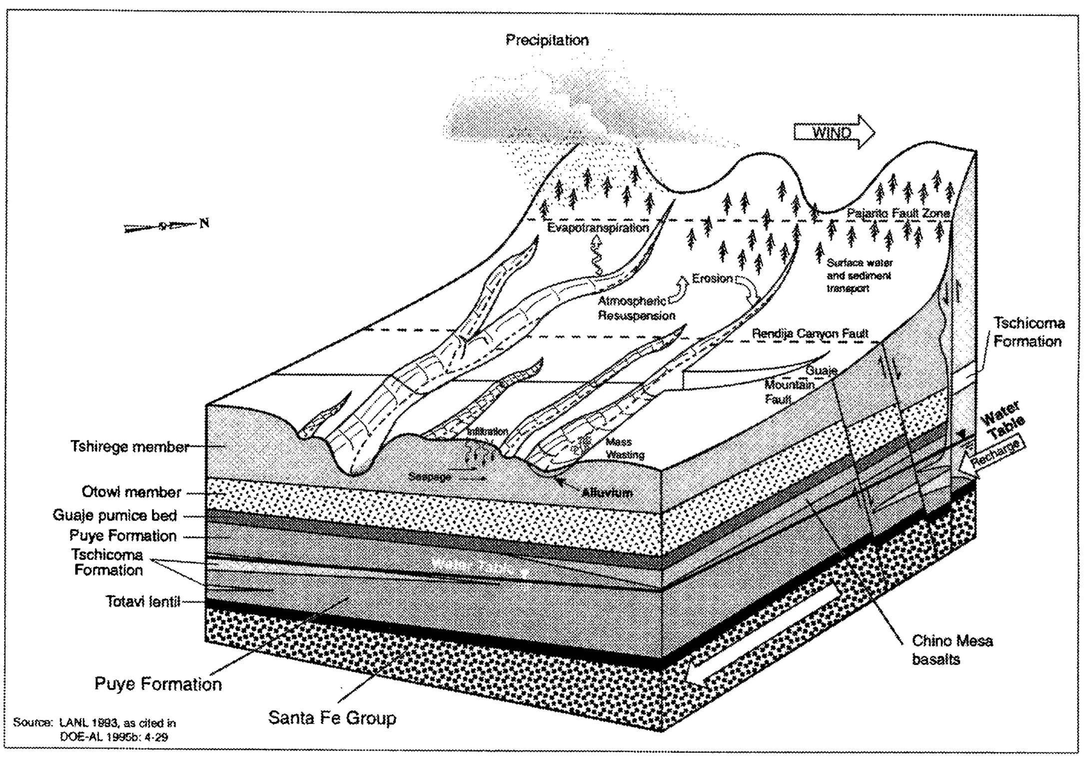


Figure 4.2.1.1-1. Conceptual model of the LANL area showing the relationships of major geologic features on the Pajarito Plateau.

4.2.1.2 Structure

The geologic structure of LANL is dominated by three fault zones—the Pajarito, Rendija Canyon, and Guaje Mountain faults. These faults are clearly expressed by surface offsets at some locations and are inferred from geologic evidence at others. Figure 4.2.1.2-1 shows the results of recent mapping of faults, including the young faulting that is significant to LANL in general (Wong et al. 1995). The Pajarito fault is thought to mark the currently active western boundary of the Española Basin. Prior to the Jemez Mountains volcanism, the basin boundary may have been farther west and under the present Valles Caldera. The Rendija Canyon and Guaje Mountain faults are geologically young and are capable of producing future earthquakes.

There are no known faults within a 2.8-mi (4.5-km) radius of the TA-70 site. The primary fault zones mapped within the LANL reservation occur well to the west of the TA-70 site, and no faults have been identified along the eastern boundary of LANL (although LANL is currently updating a prior study to better define the extent and paleomovements of regional faults). Using the current knowledge base, the three faults listed in Table 4.2.1.2-1 are the primary controls on the estimates of seismic hazards at the proposed SNS location because of their size, proximity, and evidence of geologically young movement.

4.2.1.3 Soils

Several distinct soil types have developed on the Pajarito Plateau as the result of interaction among the bedrock, surface morphology, and local climate. Alluvium derived from the plateau, the Jemez Mountains, and windblown deposits contributes to soils in the canyons and also on some of the mesa tops. Layers of pumice from past eruptions in the Jemez Mountains and windblown sediment from beyond the Pajarito Plateau are also significant components of many soils on the plateau.

Soils on the mesas can vary widely in thickness and are typically thinnest near the edges of the mesas where bedrock is often exposed. Large areas of soil are not common at the proposed SNS site. The majority of the site consists of exposed bedrock with soils accumulated in low spots or along bedrock outcrops. Surface deposits on the mesa top include locally derived soils and in places a thin cover of fine-grained eolian sediment. The soil that does occur on the proposed site has been identified as a Hackroy sandy loam. The Hackroy is typically a light brownish, sandy loam over tuffaceous bedrock greater than 15.7 in. (40 cm) deep. The canyon slopes and bottoms adjacent to the site contain a variety of loose soils, cobble, and large boulders from mass wasting of the canyon edges. There are no agricultural activities present at LANL, nor are there any prime farmlands (DOE 1996d).

Samples to assess the soil quality were collected from 12 onsite and 10 perimeter areas around the laboratory, analyzed for radiological and nonradiological constituents, and compared to regional site locations. Radionuclides in soils collected from regional background areas are due to natural and/or to worldwide fallout. In general, most radionuclide concentrations in onsite and perimeter areas were within regional statistical reference levels (i.e., the upper limit background concentration from data averaged from 1974 to 1994) and were far below LANL screening action levels. Trend analyses show that most radionuclides in soils from onsite and perimeter areas have been decreasing over time.

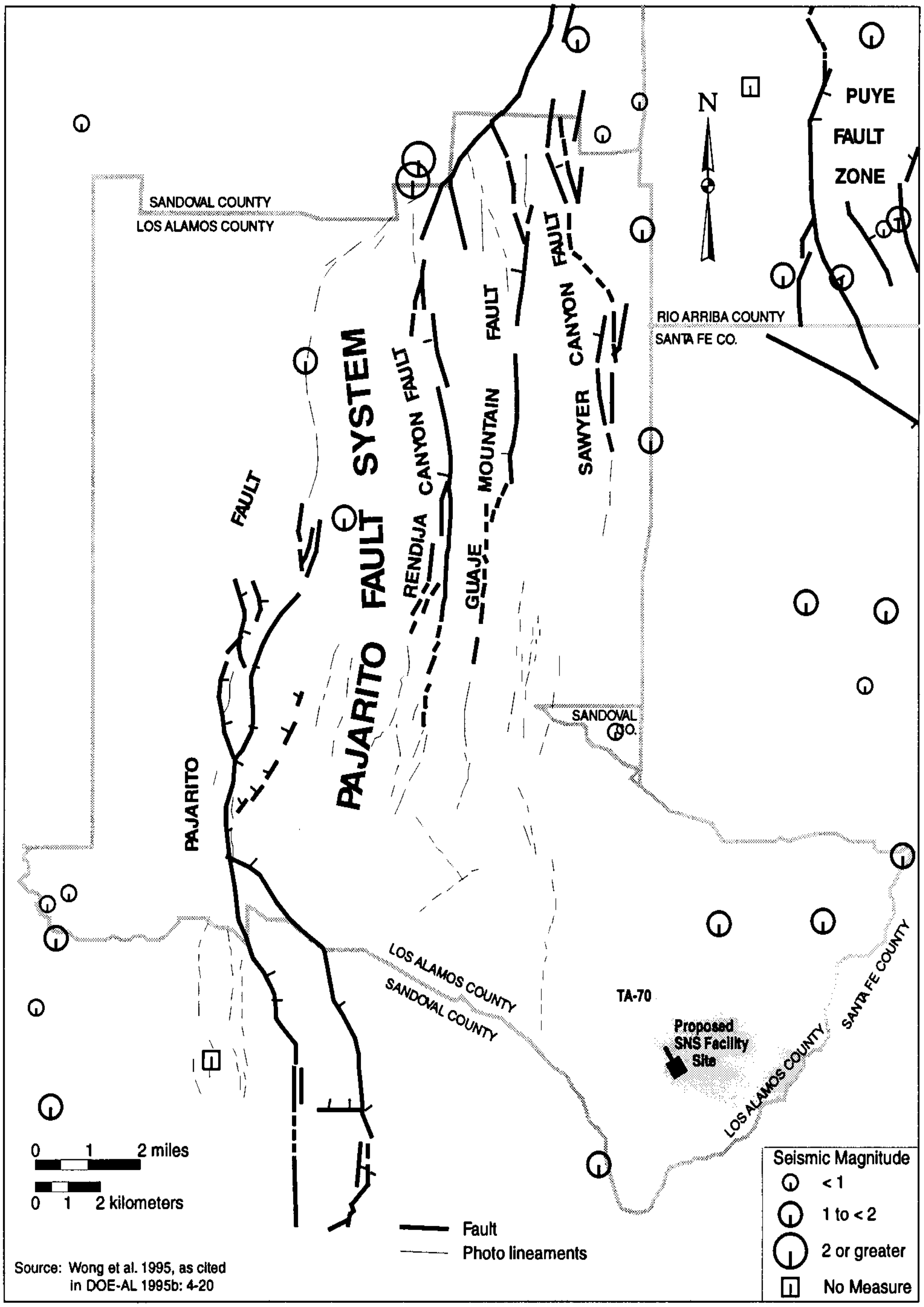


Figure 4.2.1.2-1. Recent geologic mapping of faults, lineaments, and earthquakes at LANL.

Table 4.2.1.2-1 Major faults at LANL.[a]

Name	Approximate Length [mi/(km)]	Type[b]	Most Recent Movement	Maximum Earthquake (Mw)[c]
Pajarito	29 (47.0 km)	Normal, East Side Down	multiple in past 100,000 to 200,000 years	7
Rendija Canyon	6 (9.7 km)	Normal, West Side Down	8,000 to 9,000 years ago	6.5
Guaje Mountain	8 (12.9.0 km)	Normal, West Side Down	4,000 to 6,000 years ago	6.5

[a] Source: Wong et al. 1995.
[b] Normal Fault - steep to moderately steep fault for which the movement is downward for the rock above the fault zone.
[c] Mw denotes the moment magnitude scale, which is physically based and calibrated to the Richter local magnitude scale at the lower values.

These trends were especially apparent for tritium and uranium in soils from onsite areas. Soils were also analyzed for trace and heavy metals, and most metals were within regional statistical reference levels and were well below LANL screening action levels.

4.2.1.4 Stability

The ground is stable at the TA-70 site, and liquefaction and mass movement are not considered to be an issue. Subsidence is unlikely due to the presence of firm rock beneath LANL. The potential for liquefaction is also minimal. Liquefaction occurs when saturated and unconsolidated sediments lose their cohesive nature and become fluid due to vibratory motions of seismic events. Conditions favorable to liquefaction do not exist at LANL. Site stability could be affected by erosional retreat of cliffs forming the mesa rims and shaking from seismic ground motions. However, geologic studies of the stability of rocks near the rim of nearby Pajarito Mesa conclude that placing a facility similar to the proposed SNS more than 200 ft (60 m) from the mesa rim would be adequate to ensure the integrity of such facilities for periods exceeding 10,000 years (DOE-AL 1995b).

The occurrence of volcanism is relatively recent on Pajarito Plateau. The youngest volcano deposit is the El Cajete Pumice derived from the El Cajete crater in the southern part of the Valles caldera. Age-dating techniques have suggested a wide range of possible ages; however, it is thought to have occurred between 45,000 and 73,000 years ago, probably around 60,000 before present (Wong et al. 1995). While this is relatively recent in geologic time, volcanism is not considered likely within the 10,000-year standard for this type of facility.

Earthquakes in the region are not always well correlated with faults that are expressed at the surface. Refer to Figure 4.2.1.2-1, which shows the epicenter for reported earthquakes near LANL from 1873 through 1992 (Wong et al. 1995). A few of these epicenters are situated near the Pajarito and Rendija Canyon faults. While the exact epicenter locations have a degree of uncertainty, geologic and seismic evidence indicates that faulting in the region is an ongoing process.

Maximum earthquake amplitudes could cause damage to structures not designed to resist such force, but it is important to note that the maximum earthquake on any fault is predicted to be a rare event. A historical catalog has been compiled of earthquakes of estimated Richter magnitude that have occurred in the LANL area from 1873 to 1991 (Wong et al. 1995). A review of the catalog indicates that only six earthquakes having an estimated magnitude of five or greater have taken place in the LANL region. The seismic hazard results indicate that the Pajarito Fault system represents the greatest potential seismic risk, and, although large uncertainties exist, an earthquake with a magnitude greater than six is estimated to occur once every 4,000 years. An earthquake with a magnitude of seven is estimated to occur once every 10,000 years.

It is possible to relate Richter magnitudes to ground acceleration values, but the relationships should be considered approximate because of numerous factors affecting the correlation (distance to epicenter, orientation in relation to fault strike, depth to solid rock, etc.). The seismic hazards study estimated ground acceleration and return period for each of eight TAs (TA-2, TA-3, TA-16, TA-18, TA-21, TA-41, TA-46, TA-55) throughout the LANL reservation. Ground acceleration values for the various TAs ranged as follows (Table 4.2.1.4-1).

4.2.2 WATER RESOURCES

The following section discusses the water resources, surface water, flood potential, and groundwater at LANL.

4.2.2.1 Surface Water

The Rio Grande is the major source of surface water in north-central New Mexico. All surface water drainage and groundwater discharge from the Pajarito Plateau ultimately arrives at the Rio Grande. The Rio Grande drainage basin at Otowi has an area of 14,300 mi^2 (37,037 km^2) in southern Colorado and northern New Mexico. The flow at Otowi has ranged from a recorded low of 60 ft^3/s (1.7 m^3/s) in 1902 to a high of 24,400 ft^3/s (69 m^3/s) in 1920. The river transports about one million tons of suspended sediments past Otowi annually (LANL 1993a, as cited in DOE-AL 1995a).

There are no permanent surface water resources within 0.25 mi (0.44 km) of the proposed SNS facility site. The TA-70 site lies on a mesa bordered by Ancho Canyon to the south, an unnamed canyon to the north, and the White Rock Canyon and the Rio Grande to the east. The drainage in Ancho Canyon and the unnamed canyon are classified as intermittent riverine wetlands by the USFWS National Wetlands Inventory. Major canyons (Figure 4.2.2.1-1) that contain localized reaches of perennial streams inside LANL include Pajarito, Water,

Table 4.2.1.4-1. Predicted peak ground acceleration (PGA) and recurrence period.

Return Period (yrs)	500	1,000	2,000	10,000
PGA	0.14 - 0.15	0.21 - 0.22	0.29 - 0.31	0.55 - 0.57

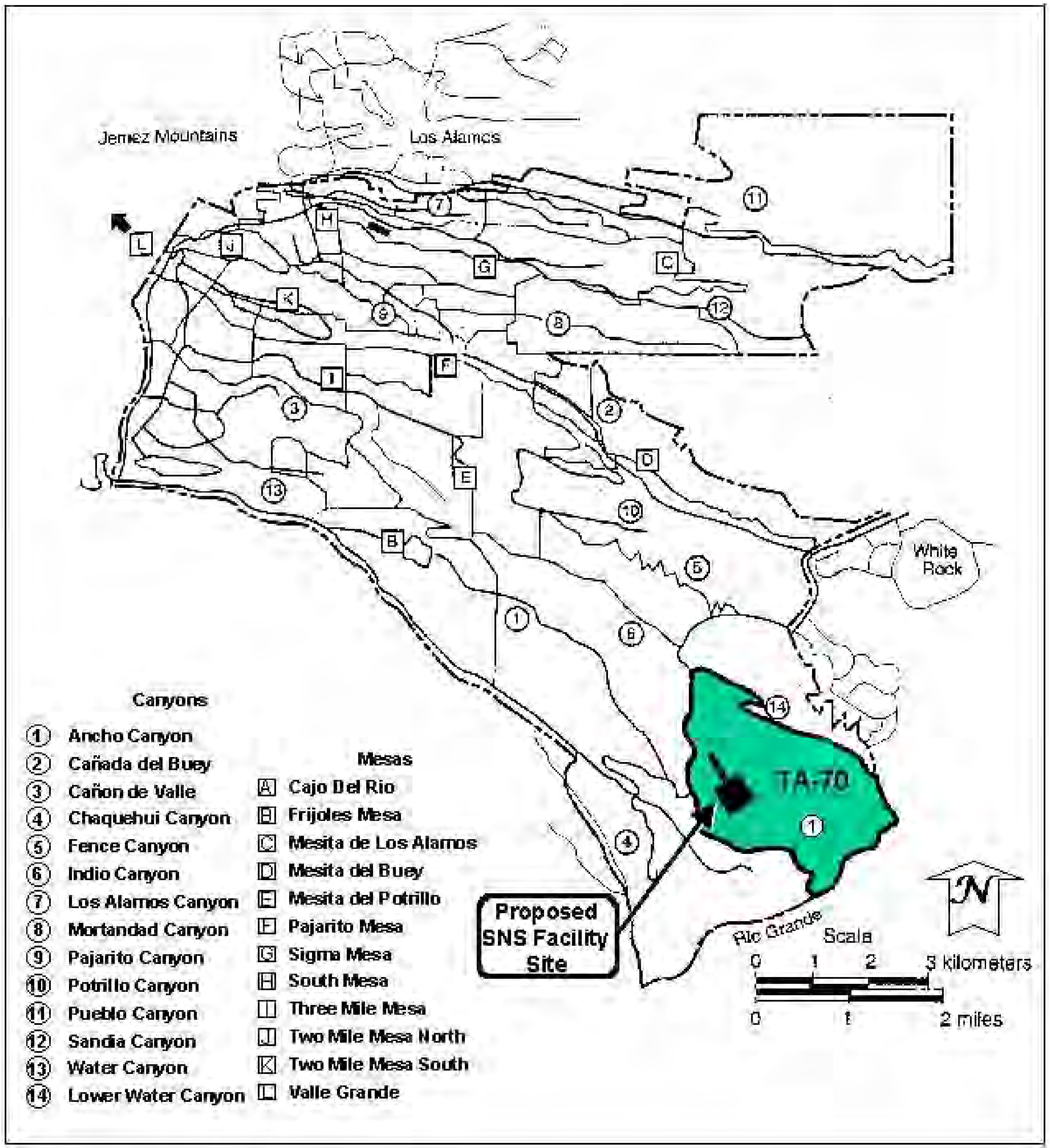


Figure 4.2.2.1-1. Major canyons and mesas at LANL.

Ancho, and Chaquehui canyons. Los Alamos, Water, and Pajarito canyons/streams originate upstream of LANL facilities. Perennial streams in the lower portions of Ancho and Chaquehui Canyons extend to the Rio Grande without being depleted by recharge to the ground. In lower Water Canyon, the perennial stream is very short and does not extend to the Rio Grande. In Pajarito Canyon, Homestead Spring feeds a perennial stream only a few hundred yards long, followed by intermittent flows for varying distances, depending upon climatic conditions. Springs between 7,900- and 8,900-ft (2,408- and 2,713-m) elevations on the eastern slope of the Jemez Mountains supply base flow throughout the year to the upper reaches of Cañon de Valle, Los Alamos, Pajarito, and Water Canyons. These springs discharge water perched in the Bandelier Tuff at rates from 0.0045 to 0.30 ft^3/s (0.0001 to 0.0085 m^3/s). The volume of flow from the springs is insufficient to maintain surface flow within more than the western third of the canyons before total evaporation, transpiration, and/or infiltration into the underlying alluvium.

Surface waters from regional and Pajarito Plateau stations are monitored to evaluate the environmental effects of LANL operations (no surface water is present at the proposed SNS site). The current network of annual sampling stations for surface water (both runoff and perennial flow) includes a set of regional (or background) stations and a group of stations near or within the LANL boundary. The regional stations are used to evaluate the background quantities of radionuclides derived from natural rock-forming minerals and from fallout affecting the region. The LANL stations monitor overall water quality effects of past or potential contaminant sources such as industrial or NPDES.

Concentrations of radionuclides in surface water samples may be compared to the DOE-Derived Concentration Guides (DCGs) for public dose, which are in general two orders of magnitude more conservative (lower) than similar New Mexico Water Quality Control Commission (NMWQCC) stream standards. The results of radiochemical analyses for surface water samples for 1996 are all below DCGs for public dose, and the majority are near or below the detection limits of the analytical method. Two stations sampled in 1996 were in proximity to TA-70, which allowed water quality to be characterized adjacent to or downstream from the site. Table 4.2.2.1-1 shows the results for the runoff station at Ancho Canyon near Bandelier National Monument and the surface water station Ancho Canyon at Rio Grande. None of the analyses exceeded or approached the DCG level or National Primary Drinking Water Standards (used in the absence of DCGs).

4.2.2.2 Flood Potential

Runoff from heavy thunderstorms and rapid snowmelt reaches the Rio Grande several times a year from some drainages that transect LANL. Water Canyon to the north of the TA-70 site has a drainage area greater than 10 mi^2 (26 km^2), while Ancho Canyon to the south has an area of less than 5 mi^2 (13 km^2). Theoretical maximum flood peaks range from 24 ft^3/s (0.7 m^3/s) for a two-year recurrence to 686 ft^3/s (19 m^3/s) for a 50-year recurrence. The overall flood risk to LANL and facilities at TA-70 is small because of the position of this site on a mesa top.

4.2.2.3 Groundwater

Groundwater within the LANL reservation occurs in three modes: (1) within the alluvium deposited on the canyon floors, (2) perched

Table 4.2.2.1-1. Radiochemical analyses for runoff and surface water sampling stations within the LANL area of influence of TA-70.

Station	Tritium (pCi/L)	Sr-90 (pCi/L)	Cs-137 (pCi/L)	Total Uranium (g/L)	Pu-238 (pCi/L)
Ancho at Rio Grande	-122	1.0	-0.1	0.3	0.010
	±134	±0.4	±0.3	±0.0	±0.010
Ancho near Bandelier	-41	1.2	1.0	1.53	0.002
	±73	±0.4	±0.9	±0.15	±0.005
Water Quality Criteria	20,000[a]	8[a]	120[b]	30[b]	1.6[b]

Station	Pu-239,249 (pCi/L)	Am-241 (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
Ancho at Rio Grande	-0.007	-0.017	-0.4	2.9	-148
	±-0.007	±-0.017	±-0.0.1	±0.4	±50
Ancho near Bandelier	0.039	-0.014	1.4	14.7	-118
	±0.013	±0.020	±0.3	±1.8	±50
Water Quality Criteria	1.2[b]	1.2[b]	15[a]	NA	NA

±0.4 Measurement uncertainty associated with instrument quantification. If the uncertainty approaches the measurement value, then the more likely that the value is not a positive detection. Negative values represent measurements below the detection limit, which are useful for incorporation into long-term averages.

[a] Maximum Contaminant Level National Primary Drinking Water Regulations [40 CFR 141].

[b] U.S. DOE DCGs for drinking water (DOE Order 5400.5).

NA – Not available.

water within the unsaturated zone, and (3) within the main saturated regional aquifer. The main aquifer in the LANL area is the only aquifer in the area capable of serving as a municipal water supply. It is currently designated as a Class 2 aquifer but meets all the criteria for classification as a sole-source aquifer. LANL, the nearby communities of Los Alamos and White Rock, and Bandelier National Monument are entirely dependent on groundwater for their water supply, which is primarily obtained from well fields. About 4 mgpd (15.1 million lpd) are used by these communities.

The potentiometric surface of the main aquifer rises westward from its point of discharge into the Rio Grande. Here, the main aquifer surface lies within the Santa Fe Group but rises stratigraphically into the Puye Formation beneath the central and western part of the Pajarito Plateau. Figure 4.2.2.3-1 shows the elevation of the main aquifer across the LANL reservation. Depth to groundwater, 840 ft (256 m), at TA-70 is inferred from a monitoring well adjacent to the site. The depth to groundwater at the bottom of Ancho Canyon along the southern edge of TA-70 is 600 ft (183 m).

The long-term trend of water levels in the water supply wells and test wells in the main aquifer indicate that there is no major depletion of the resource as a result of pumping of the Los Alamos water supply (LANL 1997d).

Groundwater quality monitoring at LANL is divided into three principal modes cited above.

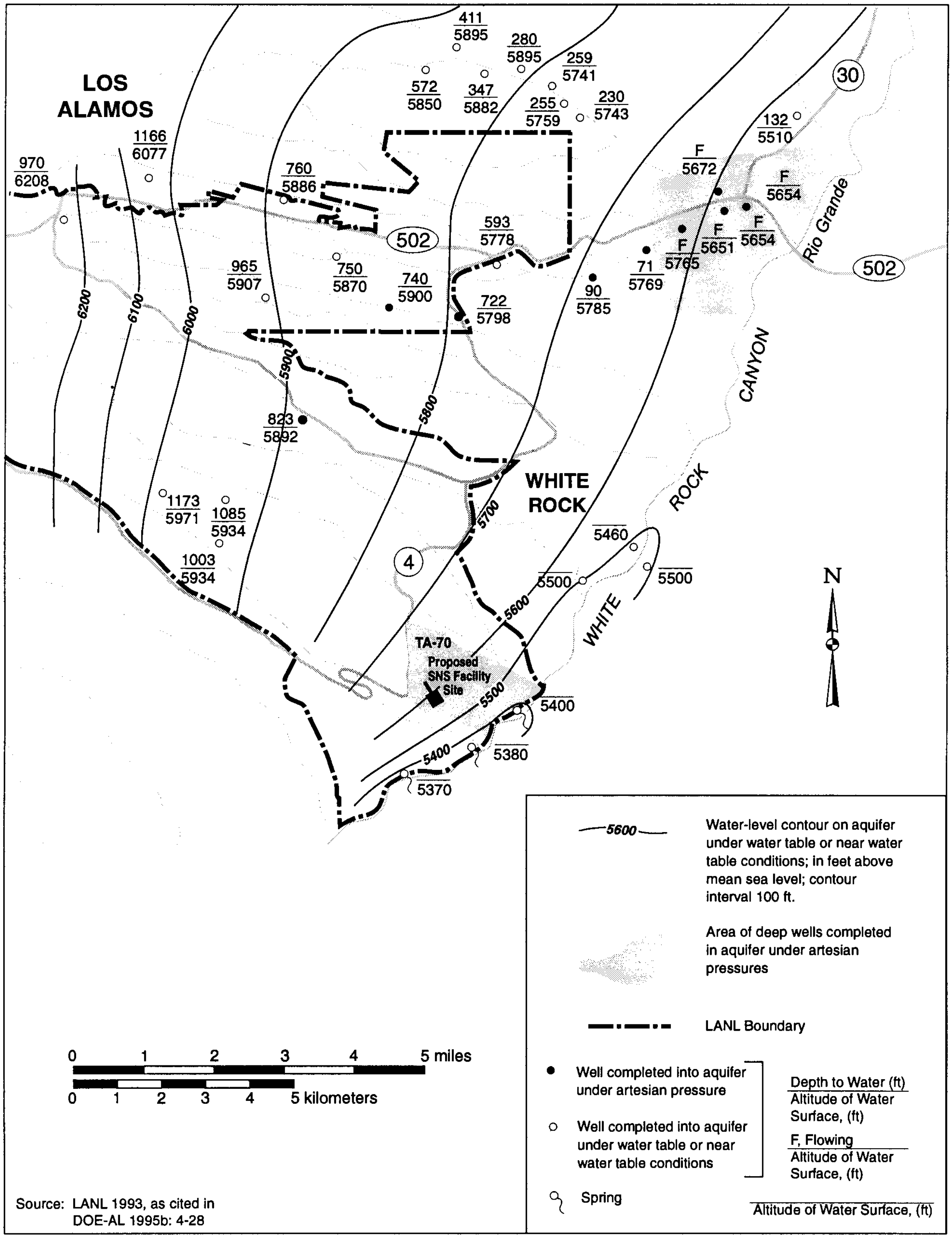


Figure 4.2.2.3-1. Groundwater surface of the main aquifer in the LANL area.

Groundwater quality data are limited for the proposed SNS site at TA-70. Neither observation wells nor springs are available for monitoring of the shallow or intermediate groundwater systems in this area of the reservation. The nearest deep well to penetrate the main aquifer is located over 3.1 mi (5 km) from the site and would not be representative of the area. Ancho Spring in Ancho Canyon is sourced by the main aquifer and is adjacent to the proposed SNS site (Table 4.2.2.3-1). Background concentrations of radionuclides and trace metals are shown in the Ancho Spring results. No organic compounds were detected in the samples. As compared to drinking water criteria and DOE-DCGs, groundwater in the vicinity of TA-70 is not affected by LANL.

The long-term trends of the water quality in the main aquifer beneath LANL have shown little impact resulting from operations (LANL 1997d). For 1996, radiochemical results for most water samples from wells or springs in the main aquifer were near or below the analytical detection limits. The few detects of radionuclides were not reproducible and were considered analytical anomalies (with the exception of dissolved uranium that is a common constituent of groundwater in the area). With just a few exceptions, values for chemical parameters measured in the water supply wells were within drinking water standards. The exceptions were not considered significant given the large number of samples, diversity of sample types, and varied well construction materials incorporated into the sampling program.

4.2.3 CLIMATE AND AIR QUALITY

The following is a brief description of Los Alamos climatology provided by LANL. For a more detailed discussion, Bowen (as cited in LANL 1997g) published a comprehensive climatology of the Los Alamos area based on observations at several meteorological observation stations within the LANL boundary

Table 4.2.2.3-1. Main aquifer water quality near the SNS site at LANL.

Radiochemical (pCi/L)	**H-3**	**Sr-90**	**Cs-137**	**U_{total} (µg/L)**	**Gross Alpha**	**Gross Beta**	**Gross Gamma**
Ancho Spring	-119 (134)	0.8 (0.3)	0.48 (2.5)	0.29 (0.03)	-0.34 (.08)	2.15 (0.3)	-137 (50)
DCG-DW[a]	80,000	40	120	30	1.2	40	—
EPA-DW[b]	20,000	8	—	20	15	—	—

Chemical Quality (mg/L)	**SO_4**	**F**	**NO_3-N**	**TDS[c]**	**Conductive (µS/cm)**
Ancho Spring	4.4	0.35	0.43	120	133
EPA-DW	500	4	10	—	—

Recoverable Trace Metals (µg/L)	**As**	**Ba**	**Be**	**Cd**	**Cr**	**Hg**	**Ni**	**Pb**	**Sb**	**Se**	**Tl**
Ancho Spring	2	26	<3	<2	3	<.2	<10	<3	<3	3	<3
EPA-DW	50	2000	4	5	100	2	100	15	6	50	2

[a]DCG-DW - Derived Concentration Guide Drinking Water
[b]EPA-DW - EPA Drinking Water
[c]TDS - total dissolved solids

and a summary document with more recent observations. The climate description presented here summarizes some of the Bowen analyses and discusses some recent observations of wind patterns in Los Alamos Canyon.

Los Alamos has a temperate mountain climate with four distinct seasons. Spring tends to be windy and dry. Summer begins with warm, often dry conditions in June, followed by a two-month rainy season. Summer is the rainy season (accounting for 37 percent of the annual precipitation) with afternoon convective-type thunderstorms and associated hail and lightning (Figure 4.2.3-1). In the autumn there is a return to drier, cooler, and calmer weather. Winters are generally mild, but occasional winter storms dump large snows and cause frigid temperatures.

The climate of Los Alamos is strongly influenced by the range of elevations, which creates large temperature and precipitation differences (Figure 4.2.3-2). In July, the warmest month of the year, the temperature ranges from an average daily high of 81 °F (27.2 °C) to an average daily low of 55 °F (12.8 °C). The extreme daily high temperature in the record is 95 °F (35 °C). In January, the coldest month, the temperature ranges from an average daily high of 40 °F (4.2 °C) to a low of 17 °F (-8.3 °C). The extreme daily low temperature in the record is -18 °F (-27.8 °C). The large daily range in temperature is exaggerated by the site's relatively dry, clear atmosphere, which allows strong solar heating during the daytime and rapid radiant cooling at night.

The average annual precipitation (rainfall plus the water-equivalent of frozen precipitation) is 18.7 in. (47.6 cm). However, the annual total fluctuates considerably from year to year; the standard deviation of these fluctuations is 4.9 in. (12.2 cm). The lowest recorded annual precipitation is 6.8 in. (17.3 cm), and the highest is 30.3 in. (77.1 cm). The maximum precipitation recorded for a 24-hr period is 3.5 in. (8.8 cm). The maximum 15-min precipitation in the record is 0.9 in. (2.3 cm). Over the entire year, it appears that evapotranspiration totals approximately 90 percent of the annual precipitation.

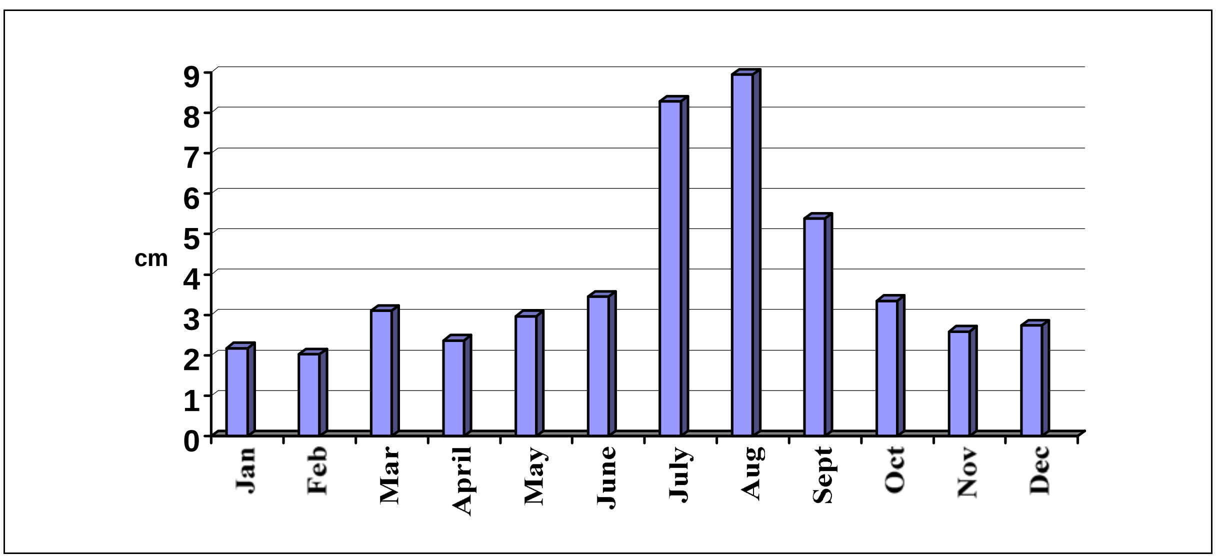


Figure 4.2.3-1. Average monthly precipitation at LANL.

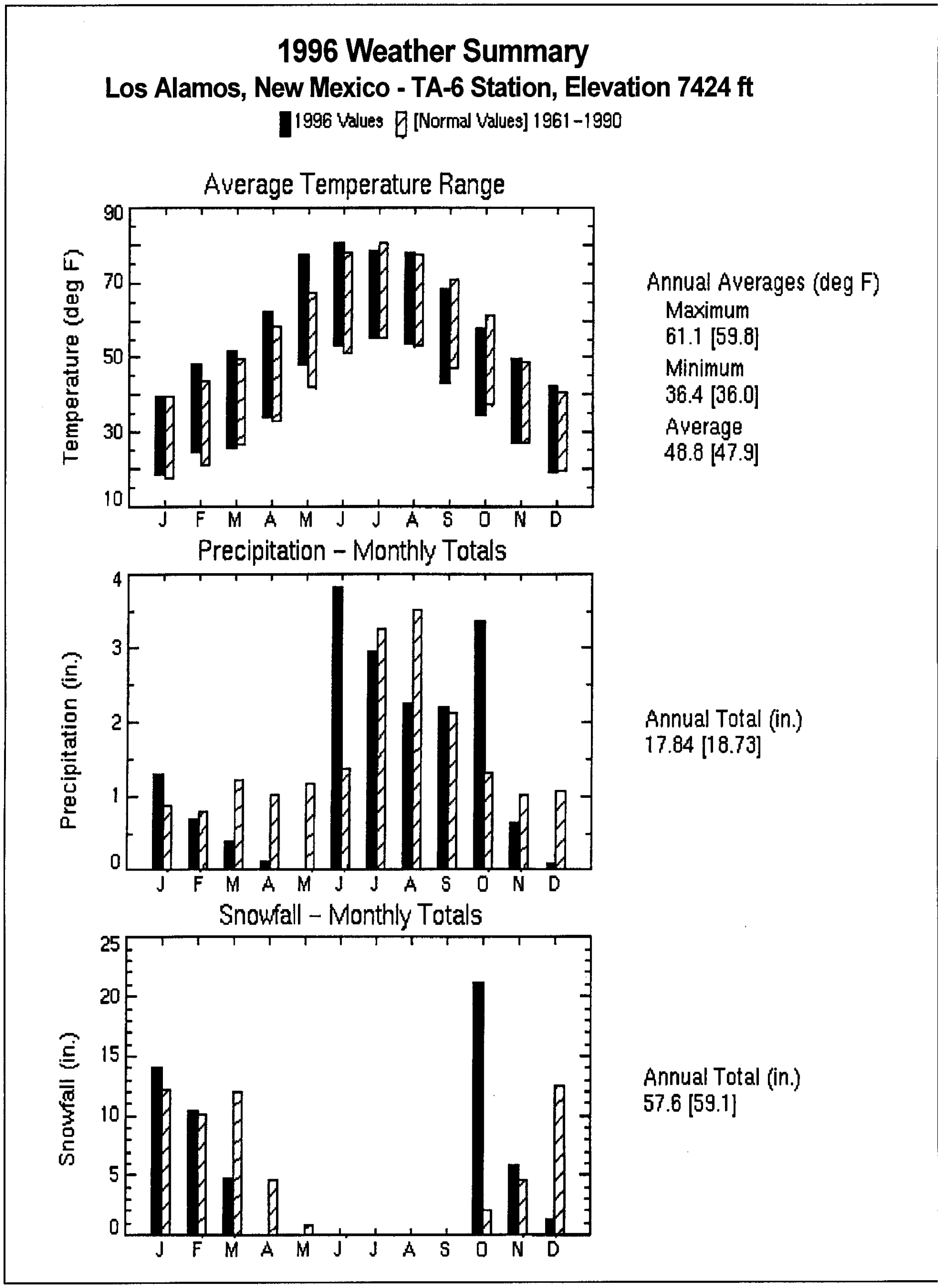


Figure 4.2.3-2. LANL 1996 weather summary chart.

Because of the eastward slope of the terrain, there is a large east-to-west gradient in precipitation across the plateau. White Rock often receives 5.1 in. (13 cm) less annual precipitation than the official observing station, and the eastern flanks of the Jemez often receive 5.1 in. (13 cm) more.

This summertime precipitation is often referred to as the “monsoon” season, but “rainy season” is probably a more accurate characterization of the July-August period. Winter precipitation occurs mostly as snow; freezing rain is rare. The snow is generally dry. On average, 20 units of snow is equivalent to one unit of water. Annual snowfall averages 59 in. (150 cm) but is quite variable. The standard deviation of fluctuations in the annual value is 28 in. (71 cm). The highest recorded snowfall for one season (1986-87) is 153 in. (389 cm), and the highest recorded snowfall for a 24-hour period (January 15, 1987) is 22 in. (56 cm). In a typical winter season, snowfalls equal to or exceeding 1 in. (2.5 cm) occur on 14 days, while snowfalls equal to or exceeding 4 in. (10.2 cm) occur on four days. The extreme single-storm snowfall in the record is 4 ft (122 cm).

4.2.3.1 Severe Weather

About 36 percent of the annual precipitation falls from convective storms during July and August. Most of these convective storms are of the single-cell type; local conditions do not support the development of supercells and the severe weather associated with them. Consequently, tornadoes are a very rare occurrence in New Mexico (refer to Figure 4.1.3.1-1), and no tornadoes are known to have touched ground in the Los Alamos area. However, funnel clouds have been observed in Los Alamos and Santa Fe counties. High winds are associated with frontal passages, thunderstorms, and mid-latitude storm systems. The highest wind gust on record is 77 mph (124 km/h).

Large-scale flooding is not common in New Mexico. However, flash floods in areas such as arroyos, canyons, and low spots do occur. Severe widespread flooding has never been observed in Los Alamos, but heavy downpour combined with saturated soil conditions caused flash flooding in Los Alamos on August 4, 1991.

Lightning is very frequent in Los Alamos. In an average year, Los Alamos experiences 61 thunderstorm days, about twice the national average. Only in the southeastern part of the U.S. is this frequency exceeded. In addition to lightning, hail often accompanies these summertime convective storms. Hailstones of 0.25 in. (0.6 cm) are common, but stones of 1 in. (2.54 cm) have been reported. Hail has caused significant damage to property and vegetation, and localized accumulations of 3 in. (7.6 cm) have been observed.

Fog in the Los Alamos area is a very rare occurrence. On average it occurs less than five times a year.

4.2.3.2 Atmospheric Dispersion

Los Alamos winds are generally light, having an annual average (at the TA-6 station) of 5.5 mph (9 km/h). However, the period from mid-March to early June is apt to be windy. During this windy period, sustained wind speeds exceeding 8.8 mph (14 km/h) occur 20 percent of the time during the daytime, and the daily maximum wind gust exceeds 31 mph (50 km/h) about 20 percent of the time.

Winds over the plateau show considerable spatial structure and temporal variability. The relatively dry climate promotes strong solar heating during the daytime and radiant cooling by night. Because the topography is very complex, the heating and cooling rates are uneven over the area. When the large-scale pressure gradient is weak, thermally generated local flows develop and respond to the heating/cooling cycle. During sunny, light-wind days, an up-slope flow often develops over the plateau in the morning hours. This flow is more pronounced along the western edge of the plateau, where it is 650 to 1,650 ft (200 to 500 m) deep. By noon, southerly flow usually prevails over the entire plateau. Daytime wind roses are presented in Figure 4.2.3.2-1.

The prevailing nighttime flow over the western portion of the site is west-southwesterly to northwesterly. These nighttime westerlies result from cold air drainage off the Jemez Mountains and the Pajarito Plateau; the drainage layer is typically 165 ft (50 m) deep in the vicinity of TA-6. At stations farther from the mountains, the nighttime direction is more variable but usually has a relatively strong westerly component. Just above the drainage layer, the prevailing nighttime flow is southwesterly. A nighttime wind rose is presented in Figure 4.2.3.2-2.

Observations made at TA-41 in Los Alamos canyon show that atmospheric flow in canyons is quite different from flow over the plateau. During the nighttime, cold air drainage flow is observed about 75 percent of the time. This gravity flow is steady and continues for an hour or two after sunrise when it abruptly ceases and is followed by an unsteady up-canyon flow for a couple of hours. The up-canyon flow usually gives way to the development of what appears to be a rotor that fills the canyon when the wind over the plateau has a strong cross-canyon component. When the rotor occurs, southwesterly (or southeasterly) flow over the plateau results in northwesterly (or northeasterly) flow at the canyon bottom. Down-canyon flow begins again around sunset, but the onset time appears to be more variable than cessation time in the morning. Rotors have been observed at night, but they are very rare.

Although the dry atmosphere promotes rapid nighttime cooling near the ground, this cooling is somewhat counterbalanced by the flux of heat from above, generated by turbulence in the drainage flow. Therefore, the strong surface-based temperature inversions often observed in valleys are not observed on the Pajarito Plateau. Inversions of 5.4 °F (3 °C) over 328 ft (100 m) are typical, and these are generally destroyed in less than two hours after sunrise.

Turbulence intensity, when expressed as the standard deviation of fluctuations in the horizontal wind direction, has a median value of 22° during the day. Other conditions being equal, this value is larger than would be observed over flatter, smoother sites. At night, when the atmosphere is stable, the median value of the standard deviation of wind direction fluctuations drops to 15°.

Atmospheric dispersion potential is often related to a stability parameter that ranges from A to F (good to poor mixing potential). When this parameter is based on sigma phi measured at the TA-6 station, the frequency of occurrence of different stability parameter values is A: 10.6 percent, B: 8.0 percent, C: 15.9 percent, D: 38.6 percent, E: 13.9, and F: 13.1 percent. Statistics vary from station to station.

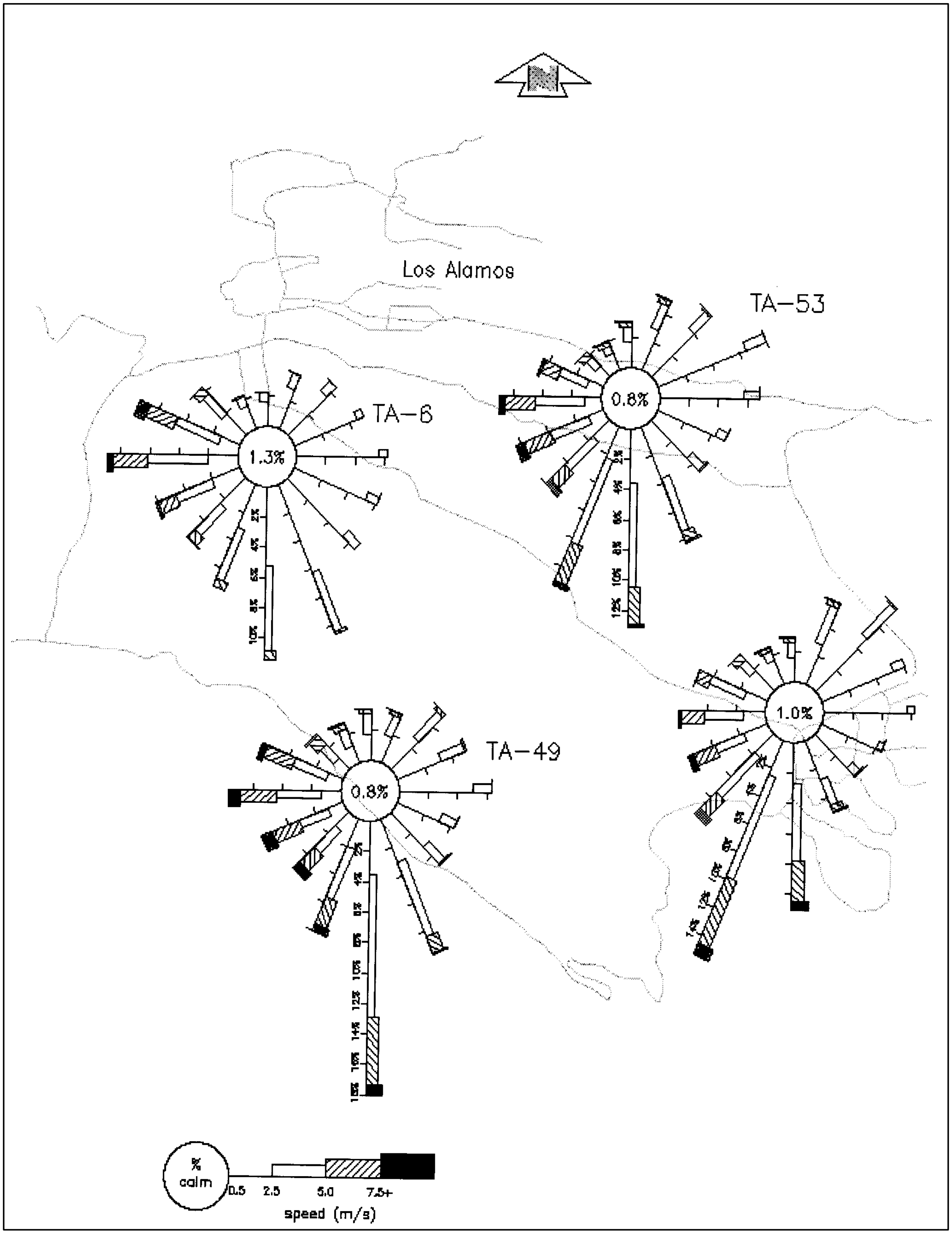


Figure 4.2.3.2-1. Daytime wind direction and speed at LANL.

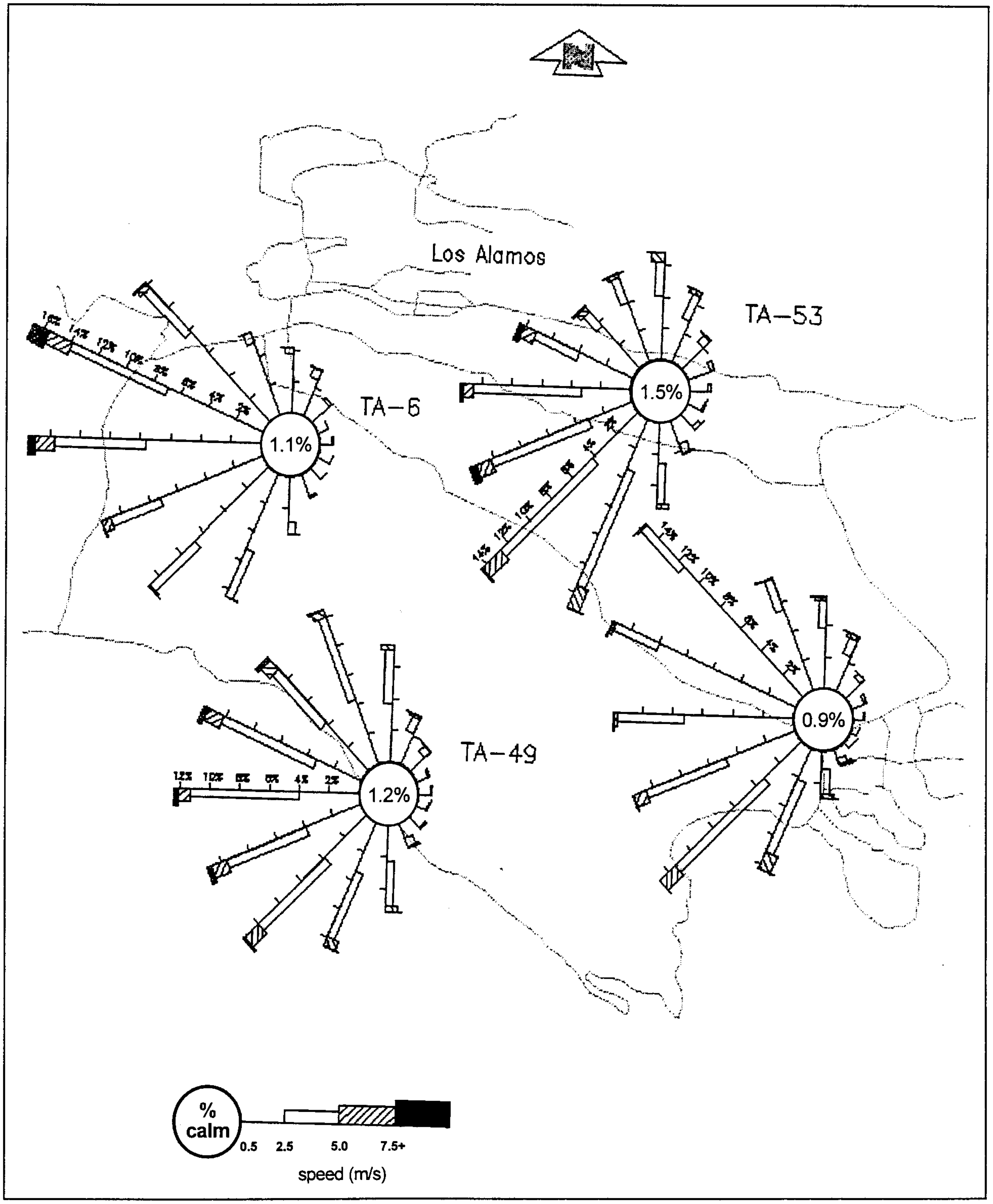


Figure 4.2.3.2-2. Nighttime wind direction and speed at LANL.

4.2.3.3 Air Quality

LANL is subject to a number of federal and state air quality programs: NESHAP, NAAQS, New Source Performance Standards, Stratospheric Ozone Protection, and Operating Permit Program. While no nonattainment areas under the Federal Clean Air Act are designated near LANL, the Bandelier National Monument and associated wilderness areas are categorized as Class I PSD areas.

Existing ambient air quality in the vicinity of LANL is best quantified in terms of recent ambient monitoring data collected by the New Mexico Environment Department Air Quality Bureau (NMEDAQB) at nearby locations. Table 4.2.3.3-1 summarizes these data and is taken from *New Mexico Air Quality 1994-1996* (NMEDAQB 1997).

Criteria pollutants released from LANL operations are primarily from combustion sources such as boilers, emergency generators, and motor vehicles. Toxic air pollutants from LANL are released primarily from laboratory, maintenance, and waste management operations. Emissions from industrial sources are calculated annually because these sources are responsible for over 90 percent of all the nonradiological air pollutant emissions at the laboratory. Unlike a production facility with well-defined processes and schedules, LANL is a research and development facility with great fluctuations in both types of chemicals emitted and their emission rates. Because past reviews demonstrate that LANL's toxic air pollutant emissions are below the state's permitting threshold limits, LANL is not required to monitor toxic air pollutant emissions. As such, these emissions are not calculated annually; instead, each new or modified research source is addressed in the new source review process. Ambient monitoring for nonradioactive air pollutants was limited to particulate matter sampling as discussed herein.

Table 4.2.3.3-1. Summary of 1996 monitoring data in the vicinity of LANL.

Pollutant Averaging Time	Nearest Monitor Location	Maximum 1st	Maximum 2nd	NAAQS NMAAQS	Number of Exceedances
PM-10	Bandelier (1994)				
24-hour		29.0	19.0	150.0 μg/m^3	0
Annual		9.0		50.0 μg/m^3	0
Ozone	Bandelier (1994)				
1-hour		0.090	0.074	0.12 ppm	0
NO_x	Bandelier (1994)				
Annual		0.003		0.05 ppm	0
24-hour		0.006	0.004	0.10 ppm	0
SO_2	Bloomfield				
3-hour		0.041	0.027	0.5 ppm	0
24-hour		0.010	0.010	0.10 ppm	0
Annual		0.0028	-	0.02 ppm	0
CO	Santa Fe				
1-hour		7.2	6.1	13.1 ppm	0
8-hour		2.3	2.2	8.7 ppm	0

Source: NMEDAQB 1997. NMAAQ – New Mexico Air Quality Standards.

The 1996 estimated emissions are shown in Table 4.2.3.3-2. These are typical industrial-type sources. LANL nonradiological emissions from research operations are small when compared with the listed sources. The three power plants, the largest sources of nonradioactive emissions, are used to supply steam for heating. The steam plant at TA-3 also produces electricity when sufficient power from outside sources is not available; approximately one-third of the emissions from this steam plant results from electricity production. The plants are primarily operated on natural gas but can use fuel oil as a backup.

PM_{10} samples (particles less than 10 µm in aerodynamic diameter) were collected for two events during 1996: the Dome Fire from April 26 through May 2 and a controlled burn on laboratory property in November. The Dome Fire samples were collected at the TA-49 air monitoring compound near the entrance to Bandelier National Monument. The controlled burn samples were collected downwind from the fire in the northwest part of Pajarito Acres. During the Dome Fire, the PM_{10} concentrations averaged 17 $\mu g/m^3$, with the highest one-day concentration of 32 $\mu g/m^3$, both of which are well below the federal standard of 150 $\mu g/m^3$. These concentrations are typical values for the dry windy conditions present during the Dome Fire.

The laboratory conducts explosive testing by detonating explosives at firing sites operated by the Dynamic Testing Division. The laboratory maintains monthly shot records that include the type of explosives used as well as other material expended at each mound. The explosives detonations conducted at the laboratory during 1996 released quantities of beryllium, aluminum, tantalum, copper, and molybdenum. The laboratory also burns scrap and waste explosives because of treatment requirements and safety concerns. In 1996, the laboratory burned 3,482 lb of high explosives.

4.2.4 NOISE

The SNS site is proposed for an isolated area of the LANL reservation 0.6 to 1.2 mi (1 to 2 km) from the nearest public-use highway (State Road 4) and roughly 3 mi (5 km) from the nearest community of White Rock. A site-specific survey has not been conducted, but ambient noise levels in a rural setting such as this are typically in the 35- to 45-dB range. Because of its remote location, the proposed site would be protected from distant sources of noise and would be removed from any sensitive populations. The proposed site is situated about 10 mi (16 km) from the primary residential population of the City of Los Alamos.

Table 4.2.3.3-2. Emissions by source, 1996 (tons).

Source	PM	CO	NOx	SOx	VOC
TA-3 Power Plant	1.5	11.7	47.5	0.17	0.40
TA-16 Power Plant	1.9	5.5	22.6	0.08	0.19
TA-21 Power Plant	.47	1.2	4.7	0.02	0.10
Asphalt Plant	.14	.07	.05	0.001	0.03
Total	3.01	18.47	74.85	0.271	0.73

4.2.5 ECOLOGICAL RESOURCES

This section provides a general description of the ecological resources for the proposed SNS site and the surrounding area. The discussions are based on information readily available from other sources. Site-specific surveys were done for protected species and wetlands. All other information was obtained from existing publications. For the most part, the impacts from construction and operation of the proposed SNS would be minor. Therefore, much of the information presented here is summary in nature. Greater detail can be obtained from the references compiled.

4.2.5.1 Terrestrial Resources

Three major vegetative community types have been identified within the boundaries of LANL: juniper savannas at the lowest elevations in White Rock Canyon, piñon-juniper woodlands at intermediate elevations on the mesas, and ponderosa pine forests at higher elevations on the mesas.

The juniper savanna community is found along the Rio Grande on the eastern border of the Pajarito plateau and extends upward on the south-facing sides of the canyons at 5,600 to 6,200 ft (1,700 to 1,900 m). Principal species in this community include one-seeded juniper (*Juniperus monosperma*), skunk bush sumac (*Rhus trilobata*), and sagebrush (*Artemisia spp*). The piñon-juniper community, generally found in the 6,200- to 6,900-ft (1,900- to 2,100-m) elevation range, includes large portions of the mesa tops and north-facing slopes at the lower elevations. This woodland consists of stands of piñon pine (*Pinus edulis*) and one-seeded juniper, both dominant, and includes grasses such as blue grama (*Bouteloua gracilis*) and galleta (*Hilaria jamesii*) (Travis 1992, as cited in DOE-AL 1995b).

The ponderosa pine community is found in the western portion of the plateau and on mesa tops in the 6,900- to 7,500-ft (2,100- to 2,300-m) elevation range. This community is characterized by ponderosa pine (*Pinus Ponderosa*) as the primary overstory vegetation. It also contains Douglas fir (*Pseudotsuga menziesii*), Gambel oak (*Quercus gambelii*), mountain muhly (*Muhlenbergia montana*), and little bluestem grass (*Andropogon scoparius*) (Travis 1992, as cited in DOE-AL 1995b).

Mixed-conifer forests also occur on the north-facing slopes of some canyons. Riparian zones occur in many of the drainages and along the Rio Grande.

The vegetation in the proposed SNS facility area is dominated by piñon-juniper woodlands with scattered juniper savannas. Additionally, much of the land in and bordering the adjacent canyons is bare rock. Overstory plant species include piñon and one-seed juniper. Scattered grasses, primarily blue grama, shrubs, and forbs are found in the understories. In areas where bedrock is near the soil surface, the most common shrubs include wavy-leaf oak (*Quercus undulata*), hedgehog prickly pear (*Opuntia erinacea*), and sticky rabbitbrush (*Chrysothamnus viscidiflorus*). In areas with deeper soils, big sagebrush (*Artemisia tridentata*) is common. Forbs on both deep and shallow soils include greenthread (*Thelesperma trifidum*), golden aster (*Chrysopsis villosa*), thelypody (*Thelypodium wrightii*), and trailing fleabane (*Erigeron flagellaris*).

Complete lists of species found to be occurring in the proposed SNS facility area are located in

Foxx 1996. Rocky Mountain elk (*Cervus elaphus nelsoni*) use piñon-juniper woodlands for wintering habitat and some year-round use. Mule deer (*Odocoileus hemionus*), coyote *(Canis latrans*), grey fox (*Urocyon cinereoargenteus*), rock squirrel (*Spermophilus variegatus*), and desert cottontail (*Sylvilagus auduboni*) are common mammals. Common bird species include common raven (*Corvus corax*), scrub jay (*Aphelocoma coerulescens*), piñon jay *(Gymnorhinus cyanocephalus*), plain titmouse (*Parus inornatus*), and ash-throated flycatcher *(Myiarchus cinerascens*).

4.2.5.2 Wetlands

A 1996 field survey by LANL personnel identified an estimated 50 acres (20 ha) of wetlands, based on the presence of wetland vegetation (hydrophytes), within the LANL boundaries. More than 95 percent of the wetlands are located in the Sandia, Mortandad, Pajarito, and Water Canyon watersheds.

There are no wetlands in TA-70. In the vicinity of the proposed SNS site, the drainages in Ancho Canyon, 0.27 mi (0.47 km) to the southwest, and in an unnamed canyon, 0.27 mi (0.47 km) to the northeast, are classified as intermittent riverine wetlands by the USFWS National Wetlands Inventory. These are dry and sandy drainages (arroyos) that occasionally contain water after snow melt or heavy rainstorm events. Riparian vegetation is supported in some portions of these arroyos (Foxx 1996).

4.2.5.3 Aquatic Resources

Aquatic habitats in LANL are limited to the Rio Grande and several springs and intermittent streams in the canyons. These habitats currently receive NPDES-permitted wastewater discharges from LANL. The streams and springs at LANL do not support fish; however, many other aquatic species thrive in these waters (Foxx 1996).

4.2.5.4 Threatened and Endangered Species

DOE is in the process of consulting with the USFWS regarding whether or not construction and operation of the proposed SNS at LANL would jeopardize the habitat of any threatened and endangered species and regarding appropriate mitigation measures. USFWS responded with a list of federally endangered, threatened, and candidate species and species of concern potentially occurring in Los Alamos County, New Mexico. Appendix C presents the letters of consultation.

DOE has not begun consultation with the New Mexico Department of Game and Fish. DOE recently completed the Site Draft EIS for continued operation of LANL (DOE-AL 1998). Included in Appendix C is a listing from the site-wide draft EIS of federal- and state-protected species occurring in the region of LANL.

Potential threatened or endangered species at LANL are listed in Table 4.2.5.4-1. The habitat within the proposed SNS facility site is not suitable for Mexican spotted owl *(Strix occidentalis lucida*), black-footed ferret (*Mustela nigripes*), and southwestern willow flycatcher *(Empidonax traillii extimus*). Therefore, these species were dismissed from consideration. The proposed SNS facility site area includes foraging habitat for American peregrine falcon (*Falco peregrinus anatum*) and foraging and roosting habitat for bald eagle (*Haliaeetus leucocephalus*). The American

Table 4.2.5.4-1. Threatened or endangered species potentially occurring on LANL.

Species	Scientific Name	Habitat Associations
American peregrine falcon (federally endangered)	*Falco peregrinus anatum*	Nests on cliff faces. Forages in all habitat types within LANL.
Whooping crane (federally endangered)	*Grus americana*	Migrates along Rio Grande in White Rock Canyon.
Southwestern willow flycatcher (federally endangered)	*Empidonax traillii extimus*	Inhabits riparian areas with established willow stands.
Black-footed ferret (federally endangered)	*Mustela nigripes*	Inhabits established prairie dog towns.
Arctic peregrine falcon (federally endangered)	*Falco peregrinus tundrius*	Potentially migrates along the Rio Grande in White Rock Canyon.
Bald eagle (federally threatened)	*Haliaeetus leucocephalus*	Inhabits riparian areas along permanent water ways such as lakes and rivers.
Mexican spotted owl (federally threatened)	*Strix occidentalis lucida*	Inhabits multistoried mixed conifer and ponderosa pine forests.

peregrine falcon is a summer resident and migrant on the Pajarito Plateau. Peregrines do not nest with LANL boundaries but do nest on surrounding land in the Jemez Mountains. Both adult and immature birds have been observed foraging on LANL. The preferred prey of perergrine falcons includes doves, pigeons, and waterfowl, all captured in flight (DOE-AL 1998). The nearest identified peregrine falcon nesting habitat is in White Rock Canyon, approximately 1.2 mi (1.9 km) from the site. Wintering bald eagles forage and roost within White Rock Canyon and connecting canyons, including Ancho Canyon. Additionally, bald eagles, whooping cranes (*Grus americana*), American peregrine falcon (*Falco peregrinus anatum*), and Arctic peregrine falcon (*Falco peregrinus tundrius*) may use White Rock Canyon as a migration route. Additional information on protected species at LANL is located in Appendix D.

4.2.6 SOCIOECONOMIC AND DEMOGRAPHIC ENVIRONMENT

The ROI for the SNS at the proposed LANL site includes Los Alamos, Rio Arriba, and Santa Fe Counties, as shown in Figure 4.2.6-1. Approximately 90 percent of LANL employees reside in this region. The region includes the cities of Santa Fe and Española, the incorporated communities of Los Alamos and White Rock, and several small villages and unincorporated communities. The Native American Pueblos of San Ildefonso, Santa Clara, San Juan, Nambe, Pojoaque, Tesuque, and part of the Jicarilla Apache Indian Reservation are included in this tri-county region.

This section provides a description of the following socioeconomic and demographic characteristics:

- Demographics
- Housing
- Infrastructure
- Local economy
- Environmental justice

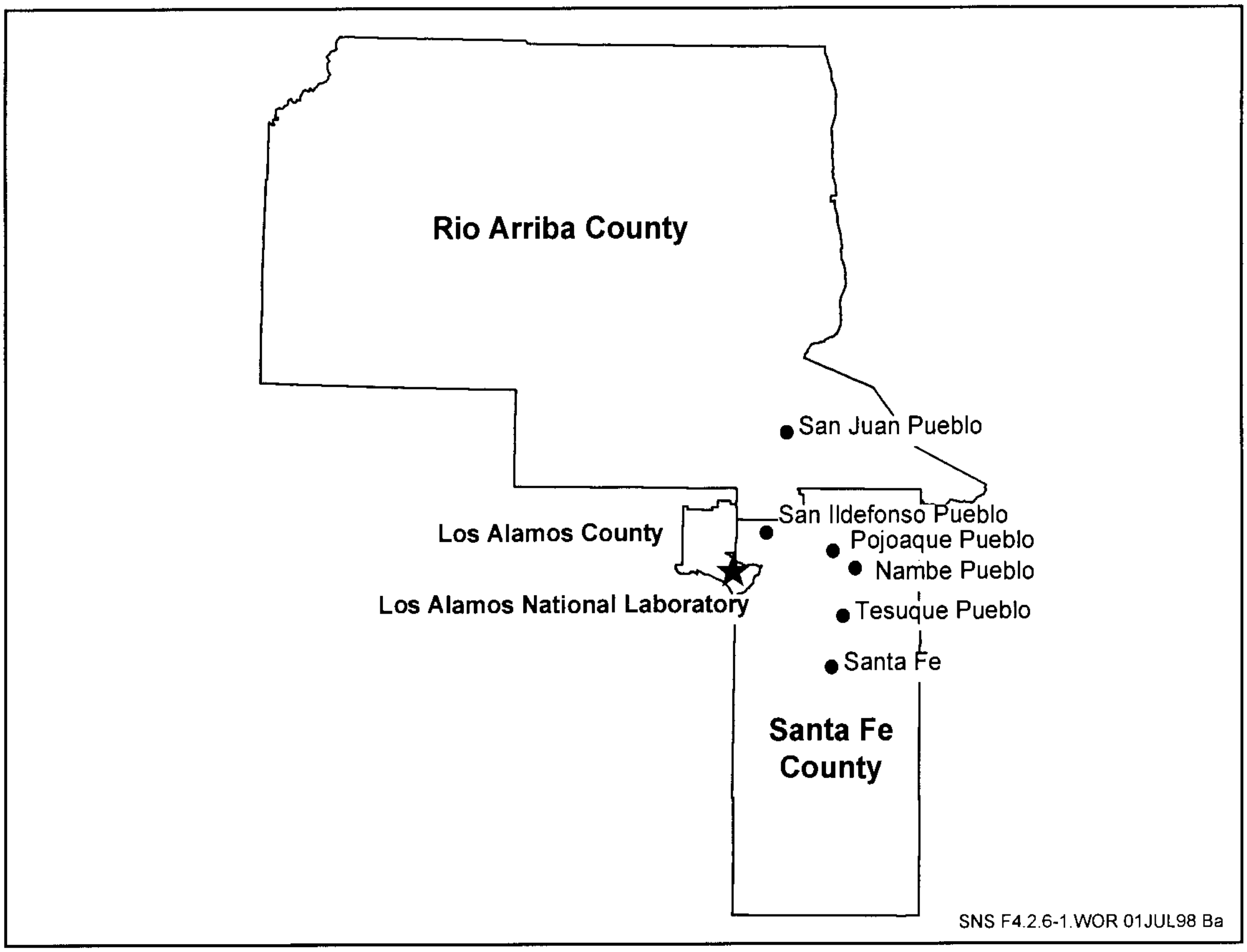


Figure 4.2.6-1. Map of socioeconomic region-of-influence for LANL.

4.2.6.1 Demographic Characteristics

Population trends and projections for each of the counties in the ROI are presented in Table 4.2.6.1-1. Of the three counties, Santa Fe has the largest population, with 68 percent of the 1995 regional population of 171,977. Rio Arriba County accounted for 21 percent of the regional population, and Los Alamos County accounted for the remaining 11 percent. Population projections prepared by the New Mexico Bureau of Business and Economic Research anticipate that the combined population of the three counties will increase by 47,000 between 1995 and 2010 (about two percent per year).

Population data for the cities, communities, and pueblos in the tri-county region are presented in Table 4.2.6.1-2. Population trends in the region reflect the development of LANL as well as the growth of the tourist economy in the Santa Fe area.

Table 4.2.6.1-1. Regional population trends and projections.

County	1980	1990	1995	2000	2005	2010
Los Alamos	17,599	18,115	18,604	19,317	19,729	20,123
Rio Arriba	29,282	34,365	36,959	38,531	39,765	41,201
Santa Fe	75,519	98,928	116,414	128,985	142,792	157,925
Region	122,400	151,408	171,977	186,833	202,486	219,249
State	1,302,894	1,515,069	1,686,299	1,821,078	1,956,725	2,090,678

Sources: DOE-AL 1998; U.S. Bureau of the Census 1990; New Mexico BBER 1997.

Table 4.2.6.1-2. Population for incorporated and unincorporated areas within the LANL tri-county region.

Communities	1990	Most Recent
Santa Fe	56,537	66,522 (1996)
Española	8,389	9,008 (1996)
Los Alamos[a]	11,420	18,365 (1994)
Pueblos		
San Ildefonso[b]	424	580 (1998)
San Juan[b]	1,200	1,500 (1998)
Nambe[b]	NA	623 (1998)
Pojaque[b]	1,037	NA
Tesuque[b]	500	450 (1998)

[a] Includes the community of White Rock.
[b] Personal communication with tribal spokesperson, April 9, 1998.
NA - Not available.
Source: U.S. Bureau of Census 1990; U.S. Bureau of Census 1996.

Population by race and ethnicity for the tri-county region is presented in Table 4.2.6.1-3. Census data from 1990 reflect different racial and ethnic compositions in three counties. Los Alamos County is predominantly Caucasian (85 percent); Rio Arriba County is predominantly Hispanic of any race (73 percent); and Santa Fe County is predominantly Hispanic of any race (50 percent). Native Americans compose 14 percent of the population in Rio Arriba County, 2 percent in Santa Fe County, and 0.6 percent in Los Alamos County.

4.2.6.2 Housing

Regional housing characteristics are presented in Table 4.2.6.2-1. In 1990, vacancy rates in the region ranged between a low of five percent in Los Alamos County to a high of 20 percent in Rio Arriba County. Approximately 70 percent of all occupied units were “owner occupied,” and 30 percent were rented.

4.2.6.3 Infrastructure

The Infrastructure section characterizes the region’s community services with indicators such as education, healthcare, and public safety.

4.2.6.3.1 Education

New Mexico is divided into 89 school districts, four of which are predominantly within the tri-county ROI. Information regarding school

Table 4.2.6.1-3. 1990 LANL population by race and ethnicity for the region.[a]

All Persons, Race/ Ethnicity	Los Alamos County		Rio Arriba County		Santa Fe County		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
All Persons	18,115	100.0	34,365	100.0	98,928	100.0	151,408	100.0
Caucasian	15,467	85.0	4,375	13.0	46,450	47.0	66,292	44.0
African-American	88	0.5	117	0.3	505	0.5	710	0.5
American Indian[b]	112	0.6	4,830	14.0	2,284	2.0	7,226	5.0
Asian/ Pacific Islander	421	2.0	40	0.1	439	0.4	900	0.6
Hispanic of any race[c]	2,008	11.0	24,955	73.0	48,939	50.0	75,902	50.0
Other races	19	0.1	48	0.1	311	0.3	378	0.3

[a] Percentages may not total to 100 due to rounding.
[b] Numbers for Aleuts and Eskimos were placed in the "other" category, given their small number.
[c] In the 1990 Census, Hispanics classified themselves as White, Black, Asian/Pacific Islander, American Indian, Eskimo, or Aleut. To avoid double counting, the number of Hispanics was subtracted from each of the race categories.
Sources: DOE-AL 1998; U.S. Bureau of Census 1990; U.S. Bureau of Census 1996.

Table 4.2.6.2-1. Housing summary for the LANL region, 1990.[a]

	Los Alamos County		Rio Arriba County		Santa Fe County	
	Number	Percent	Number	Percent	Number	Percent
Total Housing Units	7,565	100	14,357	100	41,464	100
Occupied	7,213	95	11,461	80	37,840	91
Vacant	352	5	2,896	20	3,624	9
Median Home Value	$125,100	N/A	$57,900	N/A	$103,300	N/A
Median Contract Rent	$403	N/A	$189	N/A	$422	N/A

N/A - Not applicable.
[a] May not total 100 due to rounding.
Sources: DOE-AL 1998; U.S. Bureau of Census 1990.

districts within the tri-county region is presented in Table 4.2.6.3.1-1.

The Los Alamos School District receives 36 percent of its funding from the federal government, over 56 percent from the state, and 6.5 percent from local sources such as the property tax levy and surplus school space rental. The total school budget for FY 1997 is projected to be $24.5 million. Capacities differ at each school now in use, but as a whole, schools currently in use could accommodate approximately 1,560 more students in the coming years.

4.2.6.3.2 Health Care

The three hospitals serving the tri-county region are Los Alamos Medical Center, Española Hospital, and St. Vincent Hospital in Santa Fe. St. Vincent Hospital is the second-busiest in the state and houses the only trauma center in the area. Table 4.2.6.3.2-1 presents data on hospital capacity and usage. The percentage of annual bed-days used indicates sufficient capacity to accommodate additional patients.

4.2.6.3.3 Police and Fire Protection

The Los Alamos County Police Department has 39 officers and 4 detention staff, with an approved FY 1997 budget of $3.7 million. The police department responds to approximately 1,700 service calls monthly and is involved in various community programs. The ratio of commissioned police officers in Los Alamos County was 2.14 officers per 1,000 of population in January 1997. This ratio is a higher level of police manpower than in Santa Fe. In addition to serving Los Alamos and White Rock, the police department investigates criminal activity at LANL.

The Los Alamos County Fire Department is owned by DOE and is operated through contract by Los Alamos County (fire department personnel are county employees). The Fire Department provides fire suppression, medical/rescue, wildland fire suppression, and fire prevention services to both LANL and the Los Alamos County community.

Table 4.2.6.3.1-1. Public school statistics in the LANL region, 1996-97 school year.

District	Student Enrollment[a]	Teachers[b]	Teacher/Student Ratio	Per-Student Operational Expenditures[c]
Los Alamos	3,879	264	1:15	$6,640
Santa Fe	16,490	917	1:18	$3,665
Española	6,445	369	1:17	$3,986
Pojoaque	2,140	116	1:18	$4,011
State Average	330,522	21,066	1:17	$4,009

[a] Includes public, nonpublic, and home-school students.
[b] Full-time equivalent figures.
[c] 1995-1996 data.
Sources: DOE-AL 1998; New Mexico Department of Education 1997.

Table 4.2.6.3.2-1. Hospital capacity and usage in the LANL tri-county region.

Hospital	Number of Beds	Annual Bed-Days Used[a] (%)
Los Alamos Medical Center	53	26
Española Hospital	81	32
St. Vincent Hospital	268	51

[a] Based on the number of people discharged and the average length of stay divided by total beds available annually.
Source: DOE-AL 1998.

4.2.6.4 Local Economy

This subsection provides information on the economy of the region, including employment, education, income, and fiscal characteristics.

4.2.6.4.1 Employment

Regional employment data for 1996 are summarized in Table 4.2.6.4.1-1. Both Los Alamos and Santa Fe counties had unemployment rates below the state average of 8.1 percent and the 5.6 percent average for the U.S. By contrast, the unemployment rate in Rio Arriba County was 15.2 percent.

Almost two-thirds of regional 1995 employment was in the "government" and "services" sectors. Employment in those two sectors totaled more than 64,000 persons. Also significant was employment in "retail trade" (19,200), which accounted for 19 percent of the total.

Table 4.2.6.4.1-2 presents employment by industry for the ROI. Government and services are the principal economic sectors in the region. There were approximately 6,000 business establishments, government agencies, and government enterprises in the tri-county region in 1994. Nearly 29 percent of these were service businesses that employed less than 33 percent of the employed workforce in the area and paid 30 percent of the earnings reported in 1993. Approximately 21 percent were farms or ranches, which employed less than two percent of the employed workforce and provided 0.3 percent of the 1993 earnings. Retail trade establishments composed another 21 percent of the business, and government operations employed slightly more that 17 percent of the employed workforce and paid 12 percent of the 1993 reported earnings. Government agencies and enterprises, including federal, state, county, city, school district, and tribal governments, composed 36 percent of these establishments, employed nearly 29 percent of the employed workforce, and paid nearly 40 percent of the total earnings reported in 1993.

4.2.6.4.2 Income

In 1995, total regional income was approximately $3.78 billion, and 13 percent of this ($473 million) was paid to the LANL workforce residing in the tri-county region. Wages and salaries in the region increased 47 percent between 1989 and 1994. Income data for the tri-county region are presented in Table 4.2.6.4.2-1. Median family incomes in the region vary considerably, from $21,144 in Rio Arriba County to $60,798 in Los Alamos County. In 1989, Los Alamos County had the highest family and per capita incomes in New Mexico and the highest median family income of all U.S. counties. The percentage of persons below the poverty level was approximately

Table 4.2.6.4.1-1. LANL regional employment data, 1996.

County	Civilian Labor Force	Employed	Unemployed	Unemployment Rate (%)
Los Alamos	10,544	10,229	315	3.0
Rio Arriba	18,099	15,352	2,747	15.2
Santa Fe	61,181	58,301	3,880	4.7
Tri-county region	89,824	83,882	5,942	6.6
State of New Mexico	799,807	735,363	64,444	8.1

Source: New Mexico BBER 1997.

Table 4.2.6.4.1-2. Employment by industry for the Los Alamos region-of-influence, by county, and for the State of New Mexico, 1995.

Economic Characteristic	Los Alamos County	Rio Arriba County	Santa Fe County	Region of Influence	State of New Mexico
Employment by Industry (1995)					
Farm	0	993	352	1,345	20,465
Agriculture Services	53	(D)	713	766	12,203
Mining	34	(D)	414	478	21,539
Construction	314	743	5,211	6,268	59,763
Manufacturing	166	547	3,009	3,722	52,058
Transportation and Public	78	456	1,443	1,977	36,269
Wholesale Trade	120	168	1,581	1,869	31,468
Retail Trade	1,449	1,904	15,852	19,205	163,452
Finance, Insurance, and Real Estate	589	438	5,718	6,745	53,915
Services	6,136	4,120	25,597	35,853	263,654
Government	9,860	2,933	15,549	28,342	188,626

(D) - Data withheld to avoid disclosure when there are less than four businesses in an industry classification.
Source: Regional Economic Information for Los Alamos, Rio Arriba, Santa Fe Counties and State of New Mexico (U.S. Bureau of Census 1990).

Table 4.2.6.4.2-1. Measures of LANL regional income.

Area	Median Family Income 1989 ($)	Per Capita Income 1989 ($)	Per Capita Income 1994 ($)
Los Alamos County	60,798	24,473	29,762
Rio Arriba County	21,144	8,590	11,731
Santa Fe County	34,073	16,679	22,531
State of New Mexico	27,623	11,246	16,346

Source: DOE-AL 1998; New Mexico BBER 1997.

two percent in Los Alamos County, 13 percent in Santa Fe County, and 28 percent in Rio Arriba County (Santa Fe Planning Department 1998).

4.2.6.4.3 Fiscal Characteristics

Municipal and county general fund revenues in the tri-county ROI are presented in Table 4.2.6.4.3-1. The general funds support the ongoing operations of local governments as well as community services such as police protection and parks and recreation. In Los Alamos County, the fire department is funded through a separate fund derived from DOE contract payments.

New Mexico communities are heavily dependent on gross receipts tax revenues, which are sensitive to changes in employment, income, procurement and construction contracting. In recent years, gross receipts tax revenues from retail and services have either declined or increased modestly in the region. Property taxes, another source of general fund revenues, are limited by New Mexico statute to a 5 percent annual increase on any single property.

4.2.6.5 Environmental Justice

Figures 4.2.6.5-1 and 4.2.6.5-2 illustrate distributions for minority and low-income populations residing within 50 mi (80 km) of LANL. The definitions of minority and low-income populations and the methodology for assessing potential environmental justice effects are given in Section 5.3.6.5.

Approximately 270,000 people live within a 50-mi (80-km) radius of the proposed LANL site. Minorities comprise 48.1 percent of this population. In 1990, minorities composed 24.4 percent of the national population and 24 percent of the population in New Mexico. There are several federally recognized Native American groups within 50 mi (80 km) of the site. The percent of persons below the poverty level is 13 percent, which compares with the 1990 national average of 13.1 percent and a statewide figure of 31 percent (U.S. Census 1990).

4.2.7 CULTURAL RESOURCES

The cultural resources in the Los Alamos area and on LANL land have been extensively studied and documented. Approximately 75 percent of LANL has been surveyed for cultural resources, although the coverage of some individual surveys has been less than 100 percent. However, about 60 percent of LANL has received 100 percent survey coverage (DOE 1993, as cited in DOE-AL 1998: 4-157). The cumulative results of these surveys and site excavations are recorded on the LANL Cultural Resources Database.

The LANL Cultural Resources Database indicates that 1,295 prehistoric sites have been identified on laboratory land. These prehistoric sites include archaeological sites such as simple pueblos, complex pueblos, small cave pueblos, highly eroded pueblos, rock shelters, artifact scatters, lithic scatters, and rock rings. Other sites in the database include trails and steps, rock art, water control features, and game traps. Of the total number of prehistoric sites in the database, 1,192 have been assessed for NRHP eligibility. Out of this number, 770 are eligible for listing on the NRHP, 322 are potentially eligible, and 100 sites are ineligible. The other 103 prehistoric sites have not been assessed for

Table 4.2.6.4.3-1. Municipal and county general fund revenues in the LANL tri-county region, FY 1995.[a]

Revenue by Source	Los Alamos County		Rio Arriba County		City of Española		Santa Fe County		City of Santa Fe	
	($)	Percent	($)	Percent	($)	Percent	($)	Percent	($)	Percent
Property Tax	3,001,910	14	2,504,037	22	262,707	5	9,819,861	34	964,507	2
Gross Receipts Tax	10,361,829	50	663,626	6	3,930,810	72	4,233,441	15	46,986,752	79
Lodgers Tax	921,854	4	205,451	2	671,746	13	1,325,943	4	3,244,930	5
Others	921,854	4	205,451	2	671,746	13	1,325,943	4	3,244,930	5
Fees, Fines, Charges, Forfeits, Licenses, and Permits	2,427,527	12	132,857	1	373,620	7	1,458,675	5	3,853,266	7
Oil and Gas Taxes	NA	NA	3,319,900	30	NA	NA	NA	NA	NA	NA
Miscellaneous Income	4,033,998	19	1,306,555	12	153,686	3	1,428,134	5	1,185,088	2
Restricted Funds	NA	NA	3,091,129	28	NA	NA	10,822,381	37	NA	NA
Total Revenues	20,919,195	100	11,223,555	100	5,450,354	100	29,088,435	100	59,870,838	100

NA - Not available.

[a] Percentages may not total 100 due to rounding.

Source: DOE-AL 1998.

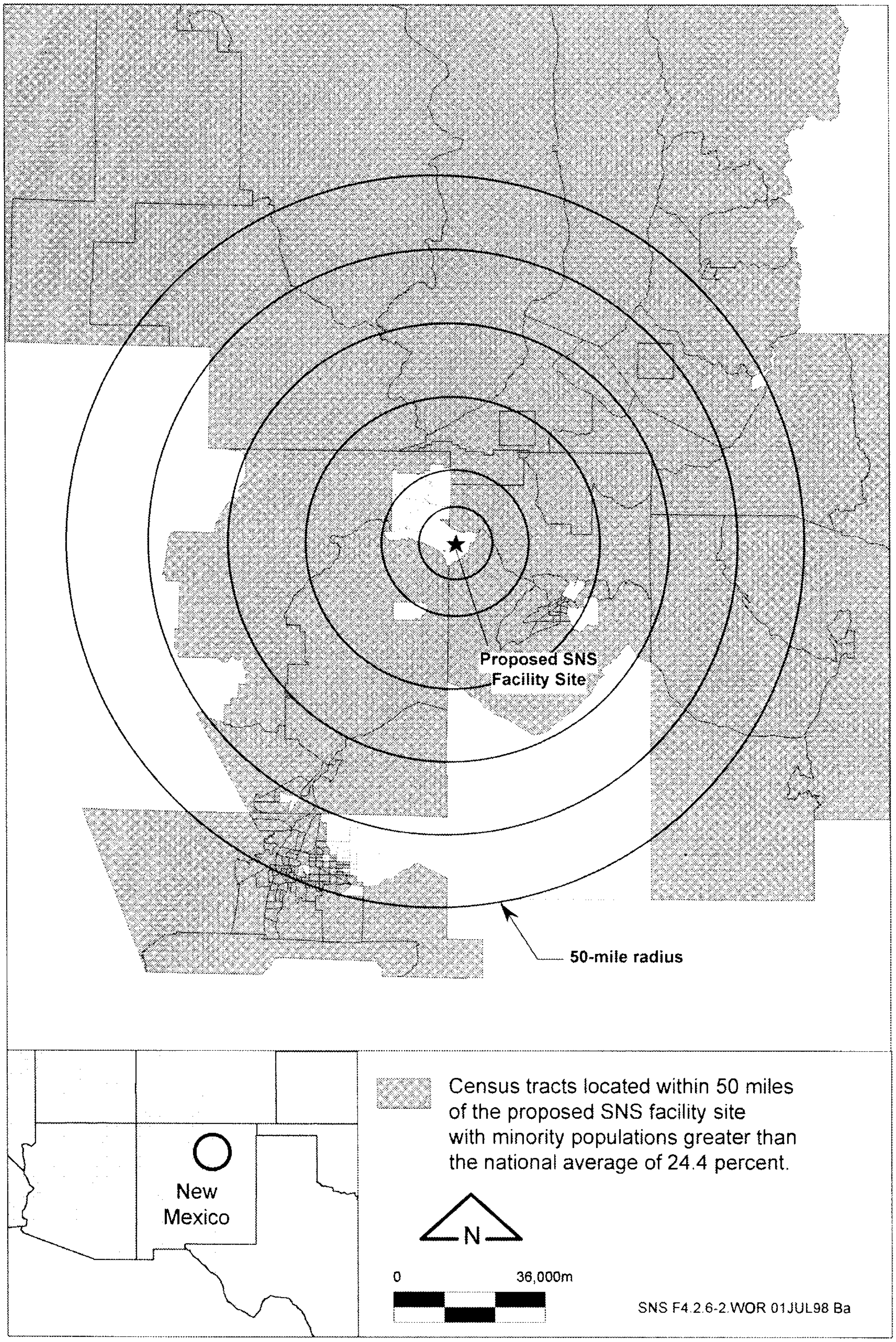


Figure 4.2.6.5-1. Distribution of minority populations at LANL.

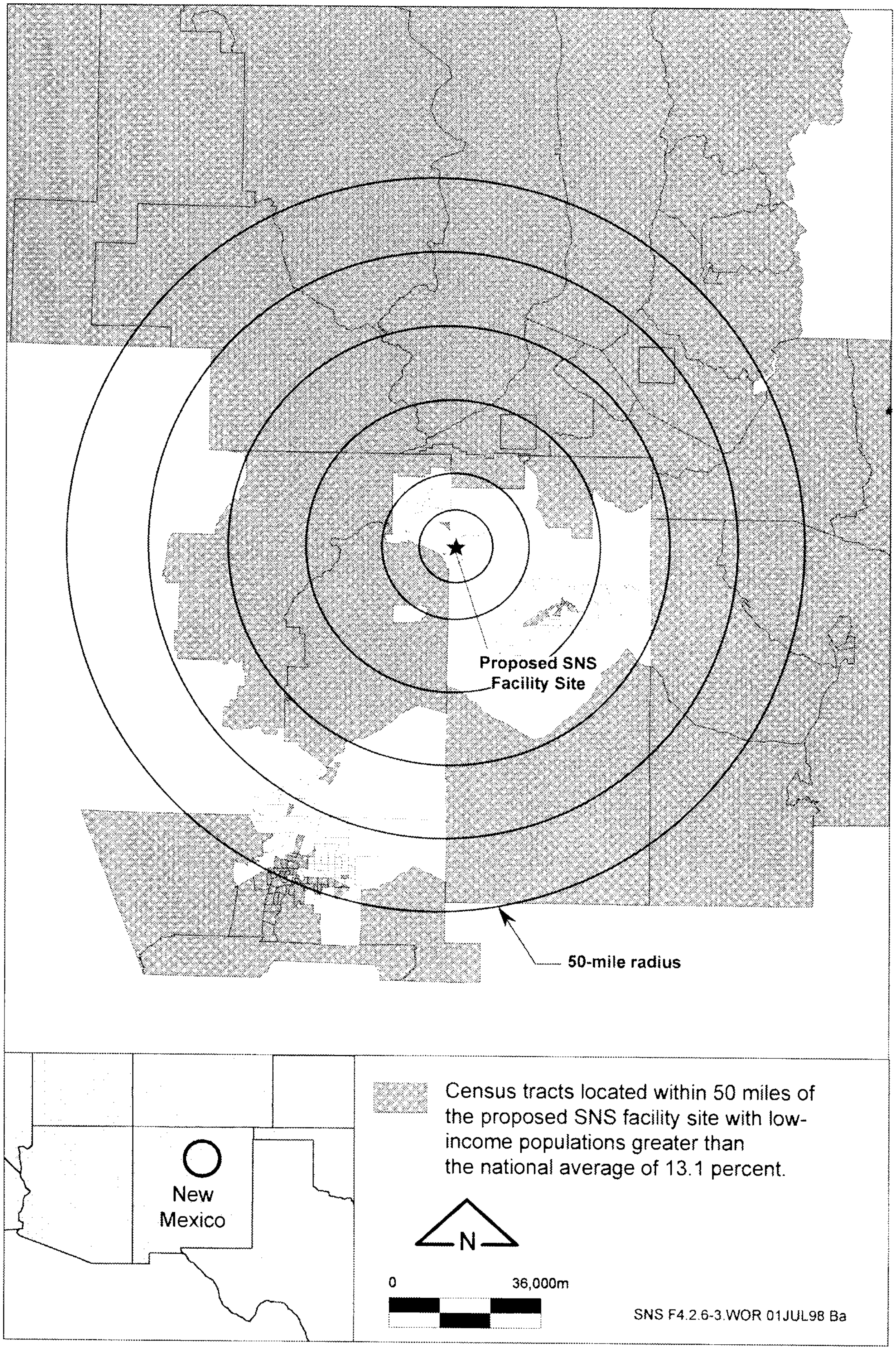


Figure 4.2.6.5-2. Distribution of low-income populations at LANL.

NRHP eligibility, but they are assumed to be potentially eligible until such assessments can be made (DOE-AL 1998: 4-158).

The Laboratory has not been systematically and comprehensively surveyed for historic cultural resources. However, the surveys performed to date have identified 214 historic sites. Approximately 2,105 more historic sites have been identified through a combination of archival research and field observations. Sites identified include historic archaeological sites, homesteads, commercial ranches, and guest ranches established prior to 1943. In addition, they include the original Los Alamos town site and numerous other buildings and facilities associated with the early development of nuclear weapons [World War II–Early Nuclear Weapons Development Period (A.D. 1943–1948)]. Most of the historic sites at LANL are buildings and facilities associated with Cold War Period (A.D.1946–1989) activities. Ninety-nine of the historic sites at LANL are eligible for listing on the NRHP, and two sites are listed on the State Register of Cultural Properties (DOE-AL 1998: 4-158 to 4-159).

A number of TCPs have been identified within the LANL boundaries and at nearby locations outside the laboratory boundaries. These TCPs include substance features, ceremonial and archaeological sites, natural features, plant gathering sites, and sites where artisans obtain raw materials.

A cultural resources survey of the proposed SNS site and an associated buffer zone was procured by LANL in 1997 to support preparation of this EIS. However, only about 65 percent of this area was surveyed (LANL 1998); five prehistoric cultural resources were identified (refer to Section 4.2.7.1). Furthermore, the density of prehistoric sites per unit area of LANL land as a whole is high, and most of these sites are eligible for listing on the NRHP. Considering these factors, the chances of finding additional cultural resources within the unsurveyed 35 percent of the proposed SNS site and buffer zone would be reasonably high. If the proposed site at LANL is eventually chosen for construction of the SNS, the remaining 35 percent of the area of potential impact would be surveyed for cultural resources prior to the initiation of construction activities.

The SNS design team has not established the areas where construction or improvement of utility corridors and roads would be necessary to support the proposed SNS at LANL. In addition, the locations of ancillary structures such as a retention basin, switchyard, and sanitary waste treatment systems have not been determined. As a result, such areas could not be surveyed for cultural resources. However, the eventual establishment of these areas would proceed in such a manner as to avoid known cultural resource locations. If the proposed SNS site at LANL were chosen for construction, these areas would be surveyed for cultural resources prior to the initiation of construction-related activities within them.

The locations of archaeological sites, historic sites, and TCPs are not provided as part of the cultural resource descriptions in this section of the EIS. These omissions are consistent with DOE and the University of California efforts to protect cultural resources from vandalism by not revealing these locations in documents available to the general public. Because several of the original reports cited in this section show the locations of cultural resources at LANL, copies of them are not available in the DOE public reading rooms established as part of the SNS EIS process.

4.2.7.1 Prehistoric Resources

Five prehistoric archaeological sites have been identified on and adjacent to the proposed SNS site at LANL. All of these sites are located within the 65 percent of the proposed SNS site and an adjacent buffer zone that have been surveyed for cultural resources. Three of these sites date to the Coalition Period, and two sites date to the Classic Period (LANL 1998).

Most of the prehistoric sites within the LANL boundaries date to the Coalition Period (A.D. 1100 to 1325). The peoples of the Coalition Period in the LANL area were maize horticulturists. Their early sites are characterized by adobe and masonry rectangular structures, and the later sites have large, masonry-enclosed plaza room blocks with over 100 rooms. Some researchers attribute the increase in numbers of sites during this period to migration of peoples into the area, while others believe that the increase was a function of *in situ* population growth.

The Classic Period (A.D. 1325 to 1600) immediately followed the Coalition Period in the LANL area. The people of this period practiced intensive maize horticulture. The settlements on the Pajarito Plateau were aggregated into three population clusters with outlying one- to two-room field houses. The central cluster consisted of four temporally overlapping sites: Navawi, Otowi, Tsankawi, and Tsirege. The Otowi and Tsirege sites are on DOE land at LANL. The ruins on these sites are ancestral to the current Tewa speakers living at the nearby Pueblo of San Ildefonso.

Descriptive data covering the prehistoric archaeological sites identified on and adjacent to the proposed SNS site are provided in Table 4.2.7.1-1. These descriptions include the official site designation, the site type defined by function, the period when the site was occupied, the time range of the period, the size of the major remains at the sites, and the NRHP eligibility of the sites.

4.2.7.2 Historic Resources

No Historic Period cultural resources have been identified within the 65 percent survey area at the proposed SNS site.

4.2.7.3 Traditional Cultural Properties

A number of TCPs are known to be present on LANL land as a result of a study conducted in support of the recent site-wide EIS covering laboratory operations. Twenty-three American Indian tribes and two Hispanic communities were contacted during the study. The Hispanic communities and 19 tribes agreed to consult with DOE on the identification of TCPs in the LANL region. All groups indicated the presence of TCPs on or near LANL land. These resources can be broadly categorized as artisan material sites, natural features, ethnobotanical sites, subsistence features, ceremonial sites, and archaeological sites (DOE-AL 1998: 4-160 to 4-161). Generally, the consulted groups consider all archaeological sites, rivers and water resources, human burials, shrines, trails, plants, animals, and minerals to be TCPs (DOE-AL 1998: 5-71). Although such resources are located throughout LANL and adjacent lands, the consulting groups did not identify specific TCP features or locations (DOE-AL 1998: 4-161).

Table 4.2.7.1-1. Prehistoric cultural resources on the proposed SNS site at LANL.

Designation	Type	Period (Components)	Dates	Size	NRHP Eligibility[3]
LA12676-B[1]	Field house	Coalition	A.D. 1100–1325	1–2 Rooms	E
LA12676-C[1]	Pueblo	Early Coalition	A.D. 1100–1213	8–10 Rooms	E
L-154[2]	Pueblo	Classic	A.D. 1325–1600	2–4 Rooms	E
LA6786[1]	Pueblo	Early Coalition		6–8 Rooms	E
LL-155[2]	Field house	Classic	A.D. 1325–1600	1 Room	E

[1]New Mexico Laboratory of Anthropology number.
[2]LANL field numbers.
[3]E - Eligible for listing on the NRHP under Criterion D. This criterion applies to sites that are significant because of their potential to contribute to archeological and historical research.
Source: LANL 1998.

The five prehistoric archaeological sites identified within the 65 percent survey area on the SNS site would be considered to be TCPs (see Section 4.2.7.1). The specific identities and locations of any other TCPs on and adjacent to the proposed SNS site are not known and cannot be reasonably estimated.

4.2.7.4 Consultation with the State Historic Preservation Officer

DOE-AL is in the process of performing the required consultations under Section 106 of NHPA. This section will be written when the consultations have been completed and documented. A copy of the consultation letter from the SHPO will be included in Appendix C.

4.2.8 LAND USE

Descriptions of land use in the vicinity of LANL, within the boundaries of LANL, and on the proposed SNS site are provided in this section. The descriptions cover past, current, and future uses of the land in these areas. In addition, they include descriptions of environmentally sensitive land areas that have been set aside for public use, environmental protection, or research. These areas include parks, natural areas, environmental education centers, and public recreation areas. The section concludes with a discussion of visual resources.

4.2.8.1 Past Land Use

LANL has been surrounded by large tracts of federal, county, and Native American tribal lands for many years. Generally, the federal and tribal lands have remained in their natural state and may be largely categorized as open space. However, some areas within these lands have been devoted to residential and limited commercial/industrial use. Historically, a very small percentage of the land in the vicinity of LANL has been under local government or private ownership. This small percentage includes the urban lands in Los Alamos and White Rock. Most of the privately owned land has been developed for residential, commercial, and industrial use (DOE-AL 1995b: 4-4; LANL 1998).

The land within the boundaries of LANL was largely open space wilderness prior to its use by the Manhattan Project in 1943. Over the next 55 years, the current pattern of land use at LANL gradually evolved. This evolution involved the increasing use of laboratory land for industrial purposes related to scientific research and the development of nuclear weapons. During this period, large portions of LANL remained as open space in its natural state.

The proposed SNS site, located in TA-70 at LANL, has always been largely an open space wilderness area covered with piñon-juniper woodlands. Piñon-juniper woodlands cover 12,770 acres (5,108 ha) of land at LANL (DOE-AL 1998: 4-103). The proposed SNS site and TA-70 have not been a focus of past industrial development, and no contamination of soil from past activities is known to be present at the site. In addition to TA-70 and the proposed SNS site, TA-69 and TA-71 are also undeveloped, as is most of TA-6 (DOE-AL 1998: 2-19 to 2-22). The total area of land in TA-70 is about 1,825 acres (739 ha). The total land area in the other three TAs is approximately 1,684 acres (682 ha). On a lab-wide basis, it is estimated that approximately 16,000 acres (6,478 ha) of land have never been developed, but about 14,000 acres (5,668 ha) are unsuitable for development because they consist of canyon bottoms and land with slopes in excess of 20 percent (Anderson 1998: 1-2).

4.2.8.2 Current Land Use

The land use pattern in the vicinity of LANL stems from predominant ownership and management of the land by governmental entities and Native American tribal authorities. A general depiction of land use areas in the vicinity of LANL is provided in Figure 4.2.8.2-1.

A portion of the northern laboratory boundary is adjoined by the community of Los Alamos, which is characterized by a combination of residential, commercial, public/quasi public, and open space land use. The rest of the northern boundary is adjacent to the Santa Fe National Forest. The national forest is managed by the U.S. Department of Agriculture (USDA) and contains a total land area of 1,567,181 acres (634,238 ha). This area consists primarily of open space in its natural state and specific natural areas preserved for research purposes by the USDA (DOE-AL 1995b: 4-4). Land use within the national forest is further categorized according to eight discrete forest management areas. These forest management areas are delineated and described in the *Santa Fe National Forest Plan* (USFS 1987, as cited in DOE-AL 1998).

The Tsankawi area of Bandelier National Monument, lands of the Pueblo of San Ildefonso, and the community of White Rock lie along the eastern boundary of LANL. The Tsankawi area, managed by the Department of the Interior (DOI), is nonwilderness open space covering 826 acres (334 ha) and characterized by the presence of prehistoric Native American ruins. With the exception of a few small commercial, industrial, residential, and agricultural use areas, the Native American pueblo lands are largely open space. The urban land use pattern in the community of White Rock is similar to the one in Los Alamos (DOI 1995, as cited in DOE-AL 1998; DOE-AL 1995b: 4-4).

The southern and eastern boundaries of LANL are adjacent to an area of the Santa Fe National Forest and the primary area of Bandelier National Monument, respectively. The national forest tract is open space. The primary unit of the national monument is wilderness and nonwilderness open space containing prehistoric ruins (DOE-AL 1995b: 4-4). A small portion of this area is developed to meet the needs of

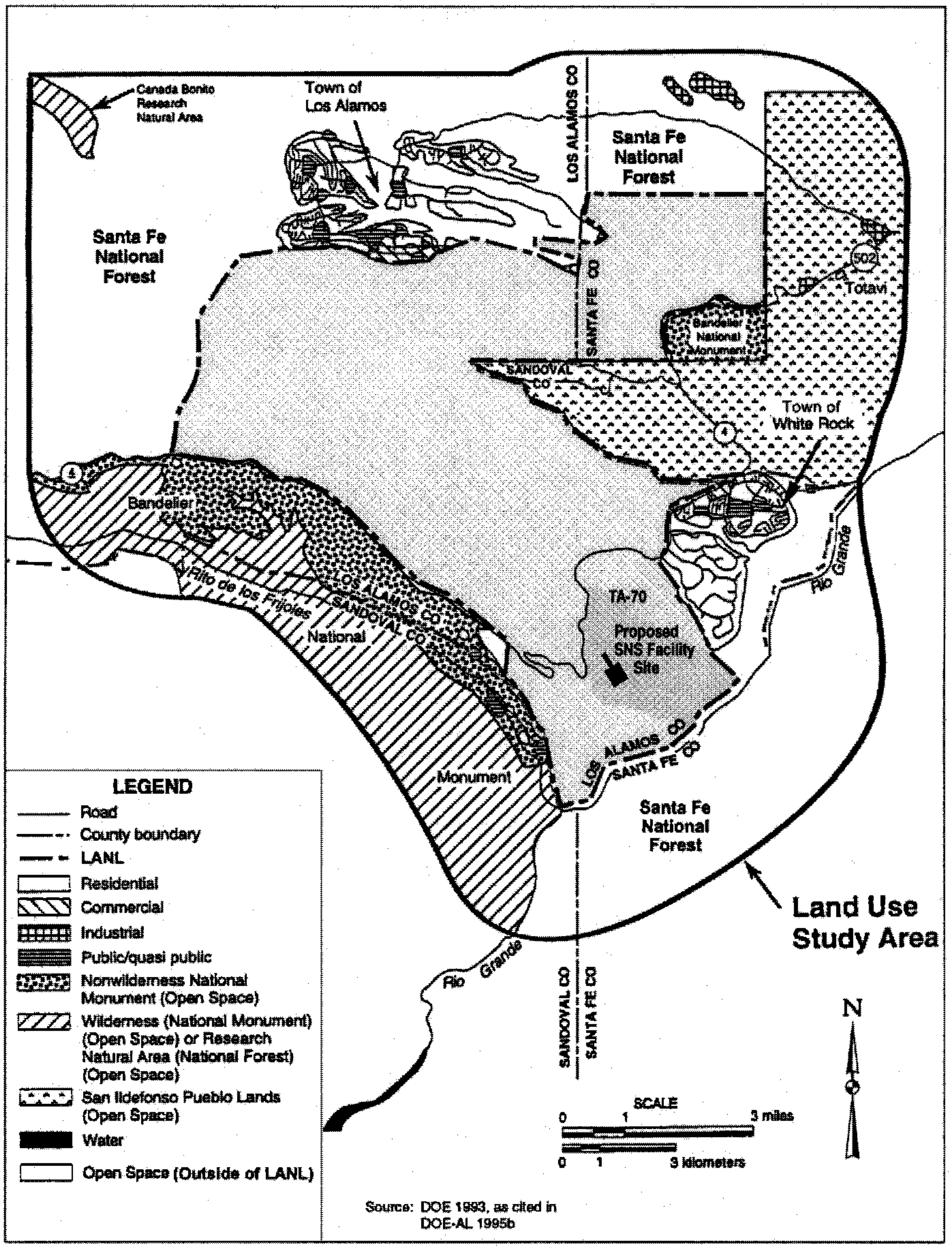


Figure 4.2.8.2-1. Map of current land use in the vicinity of LANL.

visitors (DOI 1995, as cited in DOE-AL 1998: 4-13).

The laboratory occupies approximately 27,832 acres (11,268 ha) of land in Los Alamos and Santa Fe Counties. It is subdivided into 49 distinct technical areas, but only 30 of these are active (DOE 1996c: 4-246).

The laboratory uses a current land use characterization system consisting of 11 major categories: Environmental Research/Buffer, Physical Support and Infrastructure, Experimental Science, High Explosives Research & Development and Testing, Special Nuclear Materials Research & Development, Public and Corporate Interface, Administrative and Technical Services, Waste Management, Theoretical and Computational Science, Non-DOE Land: Potentially Physical Support and Infrastructure, and High Explosives Administrative and Technical Support Area (LANL 1995: 11). The areas of laboratory land within each category are shown in Figure 4.2.8.2-2.

The proposed SNS site is located within TA-70 at the southeast end of LANL (refer to Figure 4.2.8.2-2). All of TA-70 is in the Environmental Research/Buffer land use category (LANL 1995: 11). This area has remained largely undeveloped and could be classified as open space in more conventional land use terminology. It is surrounded on the north, east, and west by land in the same use category. The Rio Grande River and the Santa Fe National Forest are along its southern boundary.

The entire laboratory has been designated as a NERP, and all of the land on and adjacent to the proposed site is in the Environmental Research/Buffer land use category. The land on and in the vicinity of the proposed SNS site is not being used for environmental research projects that would be potentially sensitive to SNS activities. (Withers 1998: 2).

4.2.8.3 Future Land Use

Future land use in the area surrounding LANL is managed according to comprehensive land use and development plans prepared for Los Alamos County, Santa Fe National Forest, and Bandelier National Monument. A formal land use plan has not been adopted for the Pueblo of San Ildefonso.

Fifty-four percent of the land in Los Alamos County, which includes the communities of Los Alamos and White Rock, has slopes of 20 percent or greater. Land with such slopes is not conducive to building. As a result, future urban development is expected to occur in compact, contiguous areas with less slope, where public services can be most efficiently provided and where environmental impacts can be minimized. Much of this development would occur as infill or reuse of land. An outlying development is planned along the northern edge of the community of Los Alamos on land that will be transferred to the county by the U.S. General Services Administration. In cooperation with the Pueblo of San Ildefonso, another outlying development is planned on pueblo land north of the community of White Rock (Los Alamos County 1987, as cited in LANL 1997b).

Most of the land surrounding LANL is expected to remain as federal and tribal land. The use of the federal lands for a national forest and a national monument will continue for the foreseeable future, although specific land uses within each area may change with agency

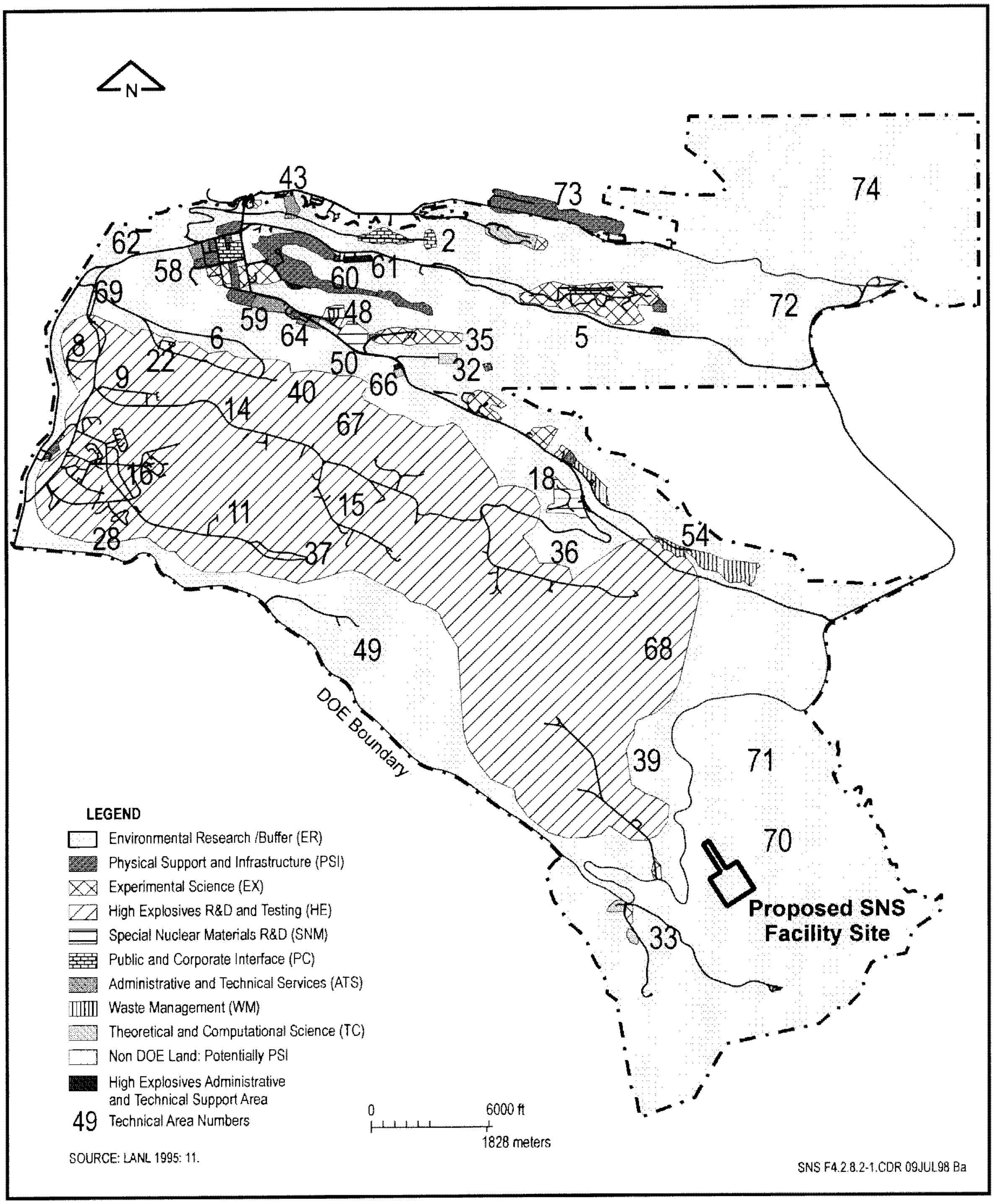


Figure 4.2.8.2-2. Map of current land use at LANL.

priorities. In the absence of a land use plan, projected land use on the Pueblo of San Ildefonso remains unknown.

The zoning of LANL land for future use involves the expansion of many current land uses into areas now used for other purposes. For example, large portions of the current Environmental Research/Buffer category are zoned for future use in Experimental Science and High Explosives Research & Development and Testing. Portions of the current Environmental Research/Buffer areas and High Explosives Research & Development and Testing areas are zoned as Waste Management in anticipation of expanding future laboratory waste management activities into these areas. The zoning of LANL land for future use is shown in Figure 4.2.8.3-1 (LANL 1995: 12).

A large portion of the current Environmental Research/Buffer land in TA-70 is zoned as Experimental Science for future use. The SNS is an experimental science facility, and the proposed SNS site is located within this zone. No environmental research that would be potentially sensitive to SNS activities is planned for the proposed site or areas in its vicinity (Withers 1998: 2). The Future Site Use Planning Integration Team was established in the mid-1990s at LANL. Its purpose was to integrate the planning of land use, facility development, environmental restoration, laboratory strategic planning, and stakeholder involvement in the current and future planning processes of the laboratory (LANL 1995: 10). However, this process has not resulted in independent stakeholder recommendations to DOE on future land use at the laboratory (Withers 1998: 1-2).

4.2.8.4 Parks, Preserves, and Recreational Resources

Several parks, natural areas, and recreation areas are located on the land surrounding LANL. Bandelier National Monument is a popular public attraction that offers natural beauty, prehistoric ruins, historic structures, abundant wildlife, picnic areas, playgrounds, campgrounds, and concession facilities. In addition, it contains 65 mi (105 km) of maintained hiking trails, ranging from easy to strenuous. In addition to timber growth and logging, the Santa Fe National Forest offers public recreation opportunities such as sightseeing, hiking, fishing, hunting, camping, and skiing. The Jemez Division of the national forest includes the Jemez Mountains and the Dome Wilderness Area, a designated habitat for federal and state protected species such as the Mexican spotted owl. Research natural areas, additional habitat for threatened and endangered species, and cultural resources are present in other areas of the national forest (USDA 1987, as cited in LANL 1997b; DOE-AL 1995b: 4-6).

The public is provided with limited access to certain areas of LANL for recreational purposes. An area north of Ancho Canyon between the Rio Grande River and State Road 4 is open to the public for activities such as hunting and hiking. In addition, portions of Mortandad and Pueblo Canyons are open to the public. An archaeological site (Otawi Tract) is located north of State Road 502 and is open to the public, subject to cultural resource management restrictions (DOE-AL 1995b: 4-6).

The U.S. Energy Research and Development Administration, the predecessor agency to DOE, designated all laboratory land as a NERP in

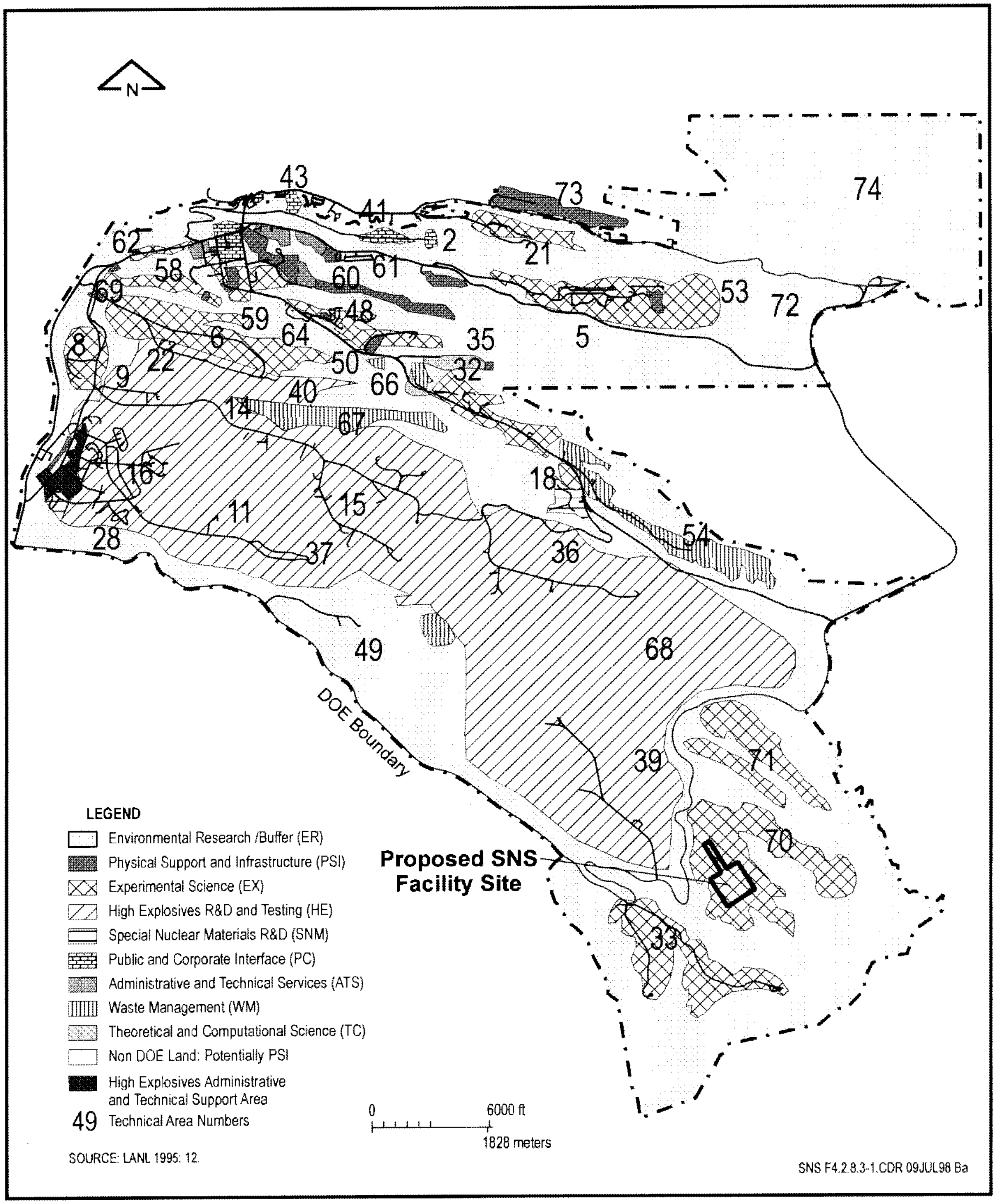


Figure 4.2.8.3-1. Land use zoning map of LANL.

1977. This park is used by the national scientific community as an outdoor laboratory to study the effects of DOE activities on southwest woodland ecosystems (DOE 1985a: 3, 21, as cited in DOE 1996c: 4-246.)

The proposed SNS site is currently open for use by the general public. Several unpaved hiking trails are present in the site area (LANL 1998).

4.2.8.5 Visual Resources

The LANL region is well known for its spectacular views. The orientation and geographical features on the Pajarito Plateau provide dramatic views of landscapes ranging from arid grasslands to alpine and subalpine mountains (LANL 1998).

The mountains of the region are clearly visible from LANL. Looking southward from most locations at LANL, the Sandia Mountains near Albuquerque can be seen. Looking to the north and east, one can see the Upper Rio Grande Valley and the Sangre de Cristo Mountains. The Jemez Mountains are visible west of the Pajarito Plateau. The elevation of the mountains, along with the finger-like mesas and deep canyons that separate them, create a fascinating combination of landscape features at LANL (LANL 1998).

The proposed SNS site is located in a remote, undisturbed piñon-juniper woodland. Traveling from Bandelier National Monument to the community of White Rock, the site is visible from State Route 4. It is not visible from White Rock or popular use areas in Bandelier National Monument (LANL 1998).

4.2.9 RADIOLOGICAL AND CHEMICAL ENVIRONMENT

This section describes the radiological and chemical environment at LANL.

4.2.9.1 Radiological Environment

Currently LANL's largest contributors of radiation and radioactive materials to the environment are the Los Alamos Neutron Science Center (LANSCE), tritium operations, the Criticality Facility at TA-18, the Pulsed High Energy Radiation Machine Emitting X-rays Facility at TA-15, the dynamic testing facility at TA-36, and the low-level radioactive waste disposal at Material Disposal Area G.

4.2.9.1.1 Air

LANL air monitoring is designed to measure environmental levels of airborne radionuclides that may be released from laboratory operations. Radionuclide emissions from LANL point and nonpoint sources include several isotopes such as tritium, uranium, ^{90}Sr, and plutonium. During 1996, LANL conducted ambient air sampling for airborne radioactivity at more than 50 stations (called AIRNET) including onsite, regional, pueblo, and perimeter [within 2.5 mi (4 km) from the site] locations. Collected samples were analyzed for uranium, plutonium, americium, and tritium. Natural atmospheric and fallout radioactivity levels fluctuate and affect measurements made by the laboratory's air sampling program. Regional airborne radioactivity is largely composed of fallout from past atmospheric weapons tests, natural radioactive constituents from the radioactive decay of thorium and uranium attached to dust particles, and from cosmic radiation. Regional levels of radioactivity in the atmosphere are useful for comparison against onsite measurements made at LANL (Table 4.2.9.1.1-1). Note that the measurements taken in Santa Fe (by EPA) are similar to those taken (by LANL) surrounding the LANL reservation.

More than 1,000 air samples were analyzed for gross alpha and beta contamination. Results indicate that gross alpha and beta concentrations were well below the National Council on Radiation Protection and Measurement's estimated national averages of 2 femtocuries (fCi)/m³ and 20 fCi/m³, respectively. In 1996, laboratory operations released 680 Ci of tritium. The perimeter sampling stations exhibited average tritium concentrations of 1.3 pCi/m³ that were higher than the regional and pueblo tritium concentrations. Elevated tritium concentrations were observed at a number of onsite locations. The highest maximum and annual mean concentrations were measured at TA-54 (waste disposal site), near shafts where tritium-contaminated waste is disposed.

The 1996 EDE for the maximally exposed offsite individual was 1.93 mrem/yr, primarily from the LANSCE operations. The collective EDE attributable to laboratory operations to persons living within 50 mi (80 km) of the LANL was calculated to be 1.2 person-rem.

Gross alpha and gross beta analyses are used to evaluate general radiological air quality and identify potential trends. If gross activity is inconsistent with past observations, then analysis of specific radionuclides is performed. When pre-established investigation levels are exceeded, then a process is undertaken to validate the results and identify the source of the radioactivity. During 1996 further investigation was initiated by anomalous levels at TA-54, Area G; TA-16; TA-21; firing sites at TA-15; and Station #30. For a detailed discussion of those investigations, reference the annual report, *Environmental Surveillance and Compliance at Los Alamos during 1996* (LANL 1997d). None of the onsite or regional sampling and analyses suggested air quality impacts to TA-70.

Table 4.2.9.1.1-1. Average regional background comparison against LANL radioactivity levels.[a]

Radionuclide	Units	Santa Fe 1990–1995	LANL 1996	EPA Limits[b]
Gross Alpha	fCi/m³ (10^{-15}Ci)	NA	0.8	NA
Gross Beta	fCi/m³ (10^{-15}Ci)	10	10.2	NA
U-234	aCi/m³ (10^{-18}Ci)	14	35.6	7,700
U-235	aCi/m³ (10^{-18}Ci)	0.6	2.2	7,100
U-238	aCi/m³ (10^{-18}Ci)	13	24.7	8,300
Pu-238	aCi/m³ (10^{-18}Ci)	0.2	0.1	2,100
Pu-239-240	aCi/m³ (10^{-18}Ci)	0.3	0.7	2,000
H-3	pCi/m³ (10^{-12}Ci)	NA	0.3	1,500
Am-241	aCi/m³ (10^{-18}Ci)	NA	2.1	1,900

[a] Source: LANL 1997d.
[b] Each EPA limit equals 10 mrem/yr.
NA - Not available.

4.2.9.1.2 Water

Surface waters from regional and Pajarito Plateau stations are monitored to evaluate the environmental effects of LANL operations. The current network of annual sampling stations for surface water (both runoff and perennial flow) includes a set of regional (or background) stations and a group of stations near or within the LANL boundary. None of the surface waters of the laboratory are a source of municipal, industrial, or irrigation water. In 1996, the results of radiochemical analyses indicated that all surface water concentrations were below the DOE DCGs for public dose. The majority of values were near or below the detection limits of the analytical methods except for samples from Mortandad Canyon at GS-1 (^{239}Pu, ^{240}Pu, and ^{241}Am). Most of the measurements at or above the detection limits were from locations with previously known contamination (Acid/Pueblo Canyon, DP/Los Alamos Canyon, and Mortandad Canyon). Surface and runoff water results from Ancho Canyon (TA-70) indicate all radionuclides well below the DOE DCGs for public dose, with many reported values below analytical detection limits (Table 4.2.9.1.2-1).

Groundwater surveillance efforts at LANL are focused on the main aquifer underlying the region, the perched alluvial groundwater in the canyons, and the localized intermediate-depth perched groundwater systems. Sample results from the main aquifer indicate that most levels of ^{3}H, ^{90}Sr, uranium, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Am, and gross beta were below the DOE DCGs. Some test wells exhibited slightly elevated values from ^{3}H, ^{90}Sr, and uranium. The long-term trends of the water quality in the main aquifer have shown little impact resulting from LANL operations (LANL 1997d).

Sample results from the alluvial groundwaters indicate that except for ^{90}Sr in Mortandad and Los Alamos Canyon, none of the radionuclide activities exceed the DOE DCGs applicable to drinking water.

4.2.9.1.3 Soil

The soil sampling program at LANL evaluates radionuclide, radioactivity, and heavy metals in soils collected onsite (12 sites), around the LANL perimeter (10 sites), and regional (background) locations (six sites). In order to assess radioactive contamination from air stack emissions and fugitive dust, the onsite locations are located close to or downwind from major facilities or operations at LANL. In 1996, most radionuclide concentrations in soils were within background concentrations as compared to data collected over the last 21 years. Some total uranium, ^{239}Pu, and ^{240}Pu values in some perimeter and onsite stations were higher than background but well within LANL screening levels.

4.2.9.1.4 Ambient Gamma Radiation

The laboratory’s largest contributor to the ambient gamma radiation in the environment is the Criticality Facility at TA-18. Criticality experiments produce neutrons and photons; contribute to the external penetrating radiation dose. During experiments that have the potential to produce a dose in excess of 1 mrem per operation, public access is restricted by closing Pajarito Road from White Rock to TA-51. The other potentially significant contributor to penetrating radiation exposures is the LANSCE at TA-53. During experimentation at LANSCE, short-lived positron emitters are released from the stacks and diffuse from the buildings. These

Table 4.2.9.1.2-1. Radiochemical analyses for runoff and surface water sampling stations within the LANL area of influence of TA-70.

Station	Tritium (pCi/L)	Sr-90 (pCi/L)	Cs-137 (pCi/L)	Total Uranium (µg/L)	Pu-238 (pCi/L)
Ancho at Rio Grande	-122 ± 134	1.0 ± 0.4	-0.1 ± 0.3	0.3 ± 0.0	0.010 ± 0.010
Ancho near Bandelier	-41 ± 73	1.2 ± 0.4	1.0 ± 0.9	1.53 ± 0.15	0.002 ± 0.005
Water Quality Criteria	20,000[a]	8[a]	120[b]	30[b]	1.6[b]

Station	Pu-239–249 (pCi/L)	Am-241 (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)
Ancho at Rio Grande	-0.007 ± -0.007	-0.017 ± -0.017	-0.4 ± - 0.01	2.9 ± 0.4	-148 ± 50
Ancho near Bandelier	0.039 ± 0.013	-0.014 ± 0.020	1.4 ± 0.3	14.7 ± 1.8	-118 ± 50
Water Quality Criteria	1.2[b]	1.2[b]	15[a]	NA	NA

Note: ± 0.4 Measurement uncertainty associated with instrument quantification. If the uncertainty approaches the measurement value, then the more likely the value is not a positive detection. Negative values represent measurements below the detection limit which are useful for incorporation into long-term averages.

[a] Maximum Contaminant Level National Primary Drinking Water Regulations (40 CFR 141).

[b] DOE DCGs for drinking water (DOE Order 5400.5).

NA – Not available.

emitters release photon radiation as they decay, producing a potential external radiation dose. Most of the emitters decay very quickly, and within a few hundred meters from LANSCE the dose is negligible. However, the dose at East Gate (the laboratory boundary north-northeast of LANSCE) is elevated by these laboratory emissions. The laboratory's contribution to the penetrating radiation dose at East Gate is derived by modeling and environmental measurements. The EDE as measured at the East Gate in 1996 was approximately 168 mrem, while the background measurements at TA-49 were approximately 164 mrem.

4.2.9.2 Chemical Environment

This section describes nonradiological contaminants in air, water, and soil at LANL.

4.2.9.2.1 Air

Levels of particulates with aerodynamic diameters less than 10 µm (PM_{10}) were measured during two events in 1996: the Dome Fire from April 26 through May 2 and a controlled burn on LANL property in November. PM_{10} levels at TA-49 air monitoring compound downwind of the Dome Fire averaged 17 µg/m³, and the highest 1-day level was 32 µg/m³. PM_{10} levels before and after the controlled burn in November were 12 µg/m³ and 30 µg/m³ during the burn. These levels are well below the federal 24-hour standard of 150 µg/m³.

4.2.9.2.2 Water

Surface water samples from stations on the Rio Grande and Jemez Rivers are monitored as background locations, and samples from the Pajaroito plateau surrounding the site are monitored as indicator locations. Major chemical constituents in these samples from 1996 show some variability but are generally consistent with results from previous years. With the exception of some pH values of 8.5, monitored parameters were within applicable standards. Trace metals (lead, barium, silver, and mercury) were found in a number of surface water samples.

Groundwaters in the main aquifer, canyon alluvial aquifers, and the intermediate perched groundwater system are monitored for nonradiological contaminants. Most parameters in samples from drinking water supply wells were below applicable standards in 1996. The pH standard of 8.5 was exceeded at three locations (G-1, G-1A, and Otowi-1). At G-1, a silver concentration of 52 µg/L exceeded applicable state standards, and a thallium level of 6.0 µg/L exceeded the EPA action level. Samples from the alluvial canyon aquifers show elevated nitrate levels attributable to LANL operations. Trace metal concentrations were lower than in previous years. Levels of iron, lead, manganese, and zinc approached or exceeded the water quality standard in samples from the perched aquifer.

4.2.9.2.3 Soil

Soil samples from 1996 were analyzed for trace and heavy metals and were within background concentrations for the Los Alamos area. In fact, they were within the range of metal concentrations normally encountered in the continental U.S. (LANL 1997d).

4.2.10 SUPPORT FACILITIES AND INFRASTRUCTURE

The Support Facilities and Infrastructure section characterizes the local vehicular transportation routes around the proposed SNS site. The existing utilities that are available to provide needed services to support the operation of the proposed SNS are also described.

4.2.10.1 Transportation

The regional highway system and major roads in the LANL area are illustrated in Figure 4.2.10.1-1. Regional transportation routes connecting LANL with Albuquerque and Santa Fe are I-25 to US 84/285 to NM 502. Connection with Española is via NM 30 to NM 502. The route connecting LANL with western communities (including Jemez Springs) is NM 4.

Only two major roads, NM 502 and NM 4, access Los Alamos County. Traffic volume on these two highway segments is primarily associated with LANL activities. Approximately 11,000 DOE and DOE contractor personnel support LANL operations. Approximately 63 percent of commuter traffic originates from Los Alamos County, while roughly 35 percent originates from east of Los Alamos County (the Rio Grande Valley and Santa Fe). Only one percent of LANL

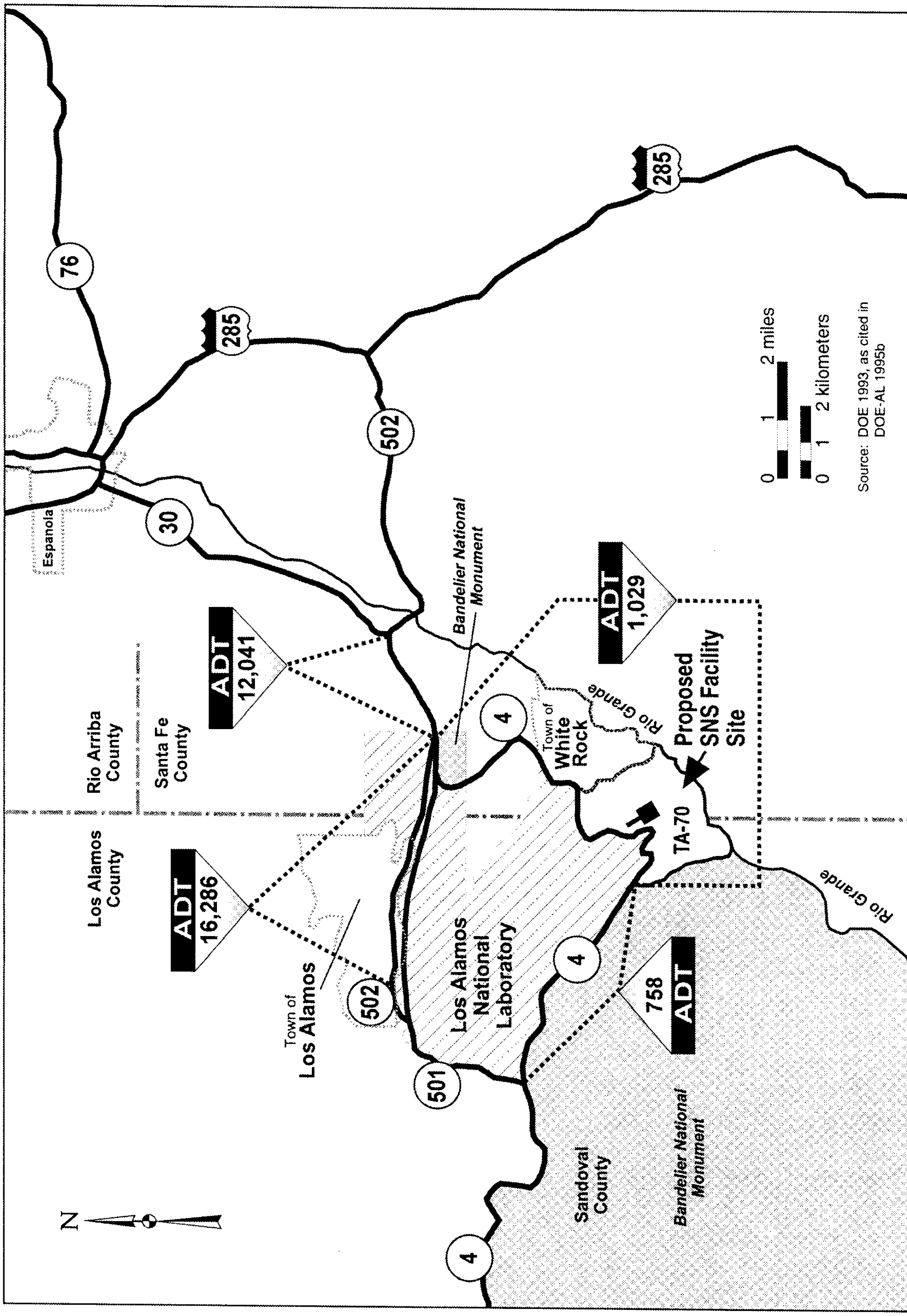


Figure 4.2.10.1-1. Transportation routes at LANL and surrounding areas

employees commute to LANL from the west along NM 4 (DOE-AL 1998).

NM 4 is a two-lane state highway that would be the primary access road for the proposed SNS at TA-70. Access to NM 4 from both Los Alamos County and counties from the east is via NM 502. From Los Alamos County to NM 4, NM 502 is a two- to four-lane state highway, while NM 502 from NM 30 to the intersection of NM 4 is a four-lane divided state highway with an uphill truck lane.

Traffic counts in 1994 indicated that the average daily traffic on these two segments was 16,286 and 12,041, respectively. The same 1994 traffic counts indicate that the average daily traffic on NM 4 between the intersection of NM 501 and NM 4 and the entrance to Bandelier National Monument [4 mi (6.4 km)] is 758 vehicles. The average daily traffic between the entrance to Bandelier National Monument and NM 502 [9 mi (14.5 km)] is 1,029 vehicles. The latter is the section of NM 4 that would access the proposed SNS site.

4.2.10.2 Utilities

Ownership and distribution of utility services are split between the DOE and Los Alamos County. DOE owns and distributes utility services to LANL facilities, and the county provides these services to the neighboring communities of White Rock and Los Alamos. DOE also owns and maintains several main lines for electrical, natural gas, and water distribution located throughout the town's residential areas. The County's Department of Public Utilities utilizes these lines at a number of locations while maintaining the final distribution systems.

4.2.10.2.1 Electrical Service

In 1985, DOE and Los Alamos County combined their generating and transmission resources to form the Electric Resource Pool (Pool). Pool resources currently provide 72 to 94 MW from a number of hydroelectric, coal, and natural gas power generators throughout the western U.S. The Pool receives power from two 115-kV electric power transmission lines originating from near Albuquerque and near White Rock. These lines distribute electricity to LANL as well as White Rock, Los Alamos, and Bandelier National Monument. Onsite electrical generation comes from the TA-3 steam/power plant, which is capable of producing up to 14 MW. The TA-3 plant is used as a peaking facility when peak load demands exceed the capacity of the two 115-kV lines. The Pool peak electrical demand in 1995 was approximately 80 MW. LANL consumed roughly 66 MW (83 percent) of the total demand.

The majority of LANL's 120-mi (193-km) electrical distribution system is past or nearing the end of its useful design life. Most of LANL's 480/277-V and 208/120-V systems would fall below industry reliability standards if used to supply additional power. Roughly 19 mi (30.6 km) of 40-year-old underground cables and 13.8-kV switchgear will require replacement in the next 10 years.

4.2.10.2.2 Natural Gas

LANL purchases natural gas from the Natural Gas Clearing House through a DOE–Department of Defense Federal Defense Fuels Procurement. The majority of the onsite gas supply lines are located in the northern portion of the site. The southern portion of the site and the TA-70 area are devoid of any existing natural gas lines or distribution lines. In 1995, LANL consumed approximately 2.7 billion ft^3 of natural gas. Approximately 80 percent of the gas is used for heating (steam and hot air). The remainder is used for electrical generation. The electrical generation was used to fill the difference between peak loads and the electric distribution system capacity. Natural gas capacity is considered adequate in the region with reserves available to meet existing system needs and commitments (Withers 1998).

4.2.10.2.3 Water Service

DOE has rights to withdraw 5,541.3 acre-feet or about 1,806 million gal (6.8 billion L) of water per year from the main aquifer. In addition, DOE obtained the right to purchase 1,200 acre-feet [391 million gal (1.5 billion L)] of water per year from the San Juan–Chama Transmountain Diversion Project in 1976. Although the San Juan–Chama water rights exist, DOE has no delivery system in place and has no plans at this time to exercise this right. DOE's potable water production system consists of 14 deep wells, 153 mi (244.8 km) of main distribution lines, pump stations, storage tanks, and nine chlorination stations.

During FY 1994, of the 1,450 million gal (5.5 billion L) that DOE withdrew from the aquifer, LANL operations used approximately 487 million gal (1.8 billion L) or roughly 34 percent of the water drawn. Los Alamos County used approximately 958 million gal (3.6 billion L) [66 percent], and the National Park Service used approximately 5 million gal (19 million L).

4.2.10.2.4 Sanitary Waste Treatment

Sanitary liquid wastes are delivered by dedicated pipelines to the Sanitary Waste System Consolidation plant at TA-46, which processes sanitary waste streams from various site buildings. The plant has a design capacity of 600,000 gpd (2.3 million lpd) and in 1995 processed a maximum of about 400,000 gpd (1.5 million lpd). Some septic tank pumpings are delivered periodically to the plant for treatment.

4.3 ARGONNE NATIONAL LABORATORY

Argonne National Laboratory (ANL) occupies 1,500 acres (610 ha) of gently rolling land in the Des Plaines River Valley of DuPage County, Illinois, about 27 mi (43 km) southwest of downtown Chicago and 24 mi (39 km) west of Lake Michigan. Surrounding the ANL site is the Waterfall Glen Forest Preserve, a 2,040-acre (826-ha) greenbelt forest preserve of the DuPage County Forest Preserve District. This land was deeded to the DuPage County Forest Preserve District in 1973 for use as a public recreation area, nature preserve, and demonstration forest. Nearby highways are Interstate 55 to the north and Illinois Highway 83 to the east. About 1 mi (1.6 km) south of ANL are the Des Plaines River, the Chicago Sanitary and Ship Canal, and the Illinois Waterway (Illinois and Michigan Canal) (Figure 4.3-1).

The terrain of ANL is gently rolling, partially wooded, former prairie and farmland. The principal stream on ANL is Sawmill Creek, running through the eastern portion of ANL,

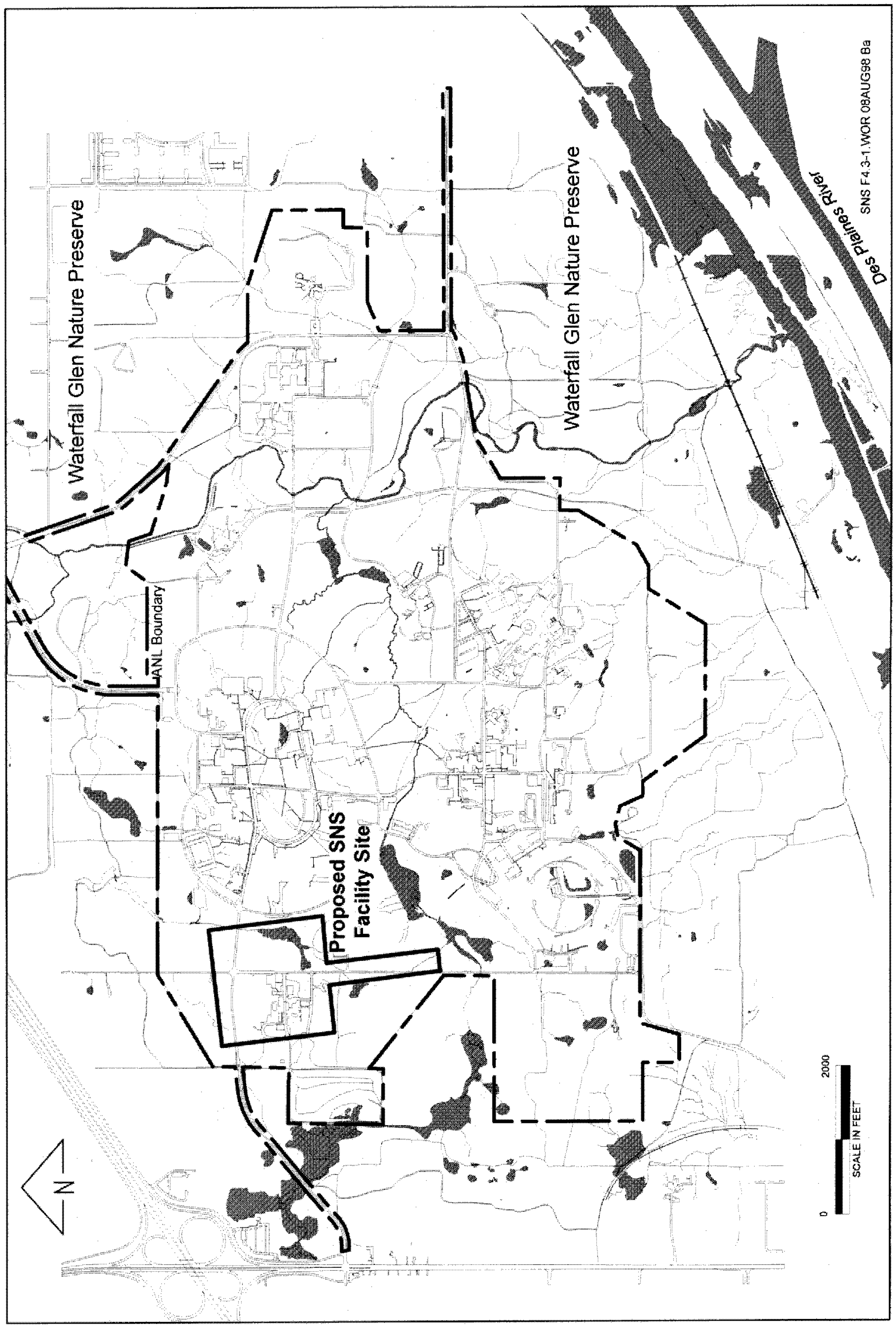


Figure 4.3-1. Proposed SNS site at ANL.

draining southward to the Des Plaines River, located approximately 1.3 mi (2.1 km) southeast of the center of the property. The forest preserve and the area between the river and ANL are undeveloped, whereas urban developments predominate other surrounding areas.

4.3.1 GEOLOGY AND SOILS

ANL sits on a slightly tilted plain that is lower to the east. Some relief exists as a result of stream erosion. Steep slopes are found only adjacent to the floodplain areas and near the southeastern edge of the reservation where the fall into the Des Plaines River Valley begins. The Des Plaines River Valley was carved by waters flowing out of the glacial Lake Michigan about 11,000 years ago.

4.3.1.1 Stratigraphy

The area surrounding ANL is located on a glacial till plateau that forms a complex arrangement of hills and depressions comprising the Valpariso Moraine (which has a northwest-southeast trend). The moraine consists of a prominent bedrock high that is covered by surficial deposits and two Pleistocene glacial units that are designated as the Wadsworth Till and the underlying Lemont Drift (Figure 4.3.1.1-1). The surficial deposits are wind-blown silts generally less than 5 feet (1.5 m) thick. The composition of the Till and Drift is

Quarternary	Pleistocene	Surficial Deposits Wadsworth Till Lemont Drift	
Silurian	Niagaran	Racine Formation (dolomite) Sugar Run Formation (dolomite and shale) Joliet Formation (dolomite and shale)	
	Alexandrian	Kankakee Formation Elwood Formation Wilhelmit Formation (dolomitic)	
Ordovician	Cincinnatian	Maquoketa Shale Group	
	Champlainian	Galena and Platteville Groups (dolomitic)	
		Ancell Group	Glennwood Sandstone St. Peter Sandstone
Cambrian	Canadian	Knox Dolomite Megagroup	
		Ironton and Galesville Sandstones	
		Eau Claire Formation (shales and siltstones)	
		Elmhurst-Mt Simon Sandstone	
Precambrian		Precambrian Basement (granites, granodiorites, rhyolites)	

Figure 4.3.1.1-1. Stratigraphy for Northeast Illinois and ANL.

highly variable both horizontally and vertically over short distances. The Till is dominated by a thick silty clay to clayey silt. Thin discontinuous granular zones, usually less than 5 to 10 ft (1.5 m to 3 m) thick, may occur within the Till. The Drift consists of sandy silt, silty sand, and clayey silt of various origins but also includes large volumes of glaciolacustrine and glaciofluvial materials. A rubble zone of dolomite fragments less than 3 feet (1 meter) to more than 10 ft (3 m) thick is present at the base of the Lemont at several locations penetrated by bedrock monitoring wells. The total thickness of deposits overlying the bedrock ranges from about 40 to 160 ft (12 to 49 m).

The bedrock surfaces underlying ANL are the Silurian-age Niagaran and Alexandrian Series dolomites. The dolomites are thin to massive bedded, fine-to-medium grained, and calcareous with some chert, and have fractures, joints, and bedding planes that are enlarged by solutioning.

It is divided into several formations and is 200 to 225 ft (60 to 70 m) thick at the ANL site. Older units from the Ordovician and Cambrian systems underlie the Silurian dolomites. The relatively impermeable Maquoketa Shale Group consists of about 165 ft (50 m) of compact, soft shale. Below these units is a sequence containing sandstone strata that have been used as regional aquifers. The Maquoketa Shale separates the upper dolomite aquifer from the underlying sandstone and dolomite aquifers and retards the hydraulic connection between them. The underlying Precambrian basement is composed of granites or granitic rocks.

4.3.1.2 Structure

Structurally, ANL is located on the Kankakee Arch, which defines the northern limits to the Illinois Basin. Strata in the area lay nearly horizontal. No tectonic features within 62 mi (100 km) of ANL are known to be seismically active within recent geologic time, and only two major structural features occur within the region occupied by ANL. The longest of these features is the Sandwich Fault, which extends some 80 mi (128 km) along a northwest-southeast strike roughly 20 mi (32 km) southwest of ANL (William et al. 1975). This fault displays several hundred meters of displacement with the down-thrown side to the north. Smaller structural features include inactive faults of Cambrian age, insignificant faults in the Chicago area, and the Des Plaines Disturbance. The Des Plaines Disturbance is a crypto-explosion structure now believed to be an astrobleme or meteorite impact formed in the Ordovician Period. This feature is situated about 20 mi (32 km) north of ANL and is covered by younger rocks and sediments.

4.3.1.3 Soils

The soils on the ANL property have derived from glacial till over the past 12,000 years. The predominant soils are of the Morley series, which are moderately well drained upland soils with slopes ranging from 2 percent to 20 percent. The surface layer is a dark grayish-brown silt loam, the subsoil is a brown silty clay, and the underlying material is a silty clay loam glacial till. Morley soils have a relatively low organic content in the surface layer, moderately slow subsoil permeability, and a large water capacity. These soils are well suited to growing crops, if good erosion control practices are used. The remaining soils along creeks, intermittent streams, bottom lands, and a few small upland areas are of the Sawmill, Ashkum, Peotone, and Beecher Series, which are generally poorly drained. They have a black to dark gray or brown silty clay loam surface layer, high organic-matter content, and a large water capacity.

The proposed SNS site consists of support-service buildings, open space, and undeveloped ecological plots. The area was prairie and farmland before federal acquisition of the site in 1947. Land use plans designate the area as office, research, and development. This land-use commitment of the site to development precludes the land from being subject to the Farmland Protection Policy Act.

4.3.1.4 Stability

A few minor earthquakes have occurred in northern Illinois, but none have been positively associated with the particular tectonic features mentioned above. Most of the recent local seismic activity is believed to be caused by isostatic adjustments of the crust in response to glacial loading and unloading rather than tectonically induced stress. In general, the area surrounding ANL is seismically quiescent (Figure 4.3.1.4-1).

There are several areas of considerable seismic activity that could influence the proposed SNS site even though they are several hundred kilometers from ANL. These areas include the New Madrid fault zone (southwestern Missouri), the St. Louis area, the Wabash Valley Fault zone along the southern Illinois–Indiana border, and the Anna region of Ohio. According to estimates, ground motions induced by near and distant seismic sources in northern Illinois are expected to be minimal. However, peak accelerations in the ANL area may exceed 10 percent of gravity once in about 600 years (-250 to +450 year error). This amplitude is on the threshold of the major damage range.

4.3.2 WATER RESOURCES

Surface water, flood potential, and groundwater resource characteristics of the area are covered in this section.

4.3.2.1 Surface Water

Surface drainage at ANL is in a southerly direction toward the Des Plaines River approximately 2,000 ft (0.6 km) south. Within ANL, Sawmill Creek flows southerly through the eastern edge of the reservation and discharges into the Des Plaines River channel (Figure 4.3.2.1-1). Two intermittent branches of Freund Brook flow from west to east, draining the interior portion of the reservation and, ultimately, flow into Sawmill Creek. The larger, south branch of the creek originates in a marsh adjacent to the western boundary of the reservation. Also, an unnamed drainage flows from the northwest portion of the reservation northward into the Waterfall Glen Nature Preserve. Along the southern margin of ANL, the terrain slopes abruptly downward, forming forested bluffs. These bluffs are dissected by ravines containing intermittent streams that discharge site drainage into the Des Plaines River channel. Numerous small streams, various ponds, and cattail marshes are present throughout the reservation.

Until 10 years ago, Sawmill Creek carried effluent water from a sewage treatment plant (STP) located approximately 1 mi (1.6 km) north of ANL. Residential and commercial development in the area has resulted in the collection and channeling of runoff water into Sawmill Creek. Treated sanitary and laboratory wastewaters from ANL are combined and discharged into lower Sawmill Creek.

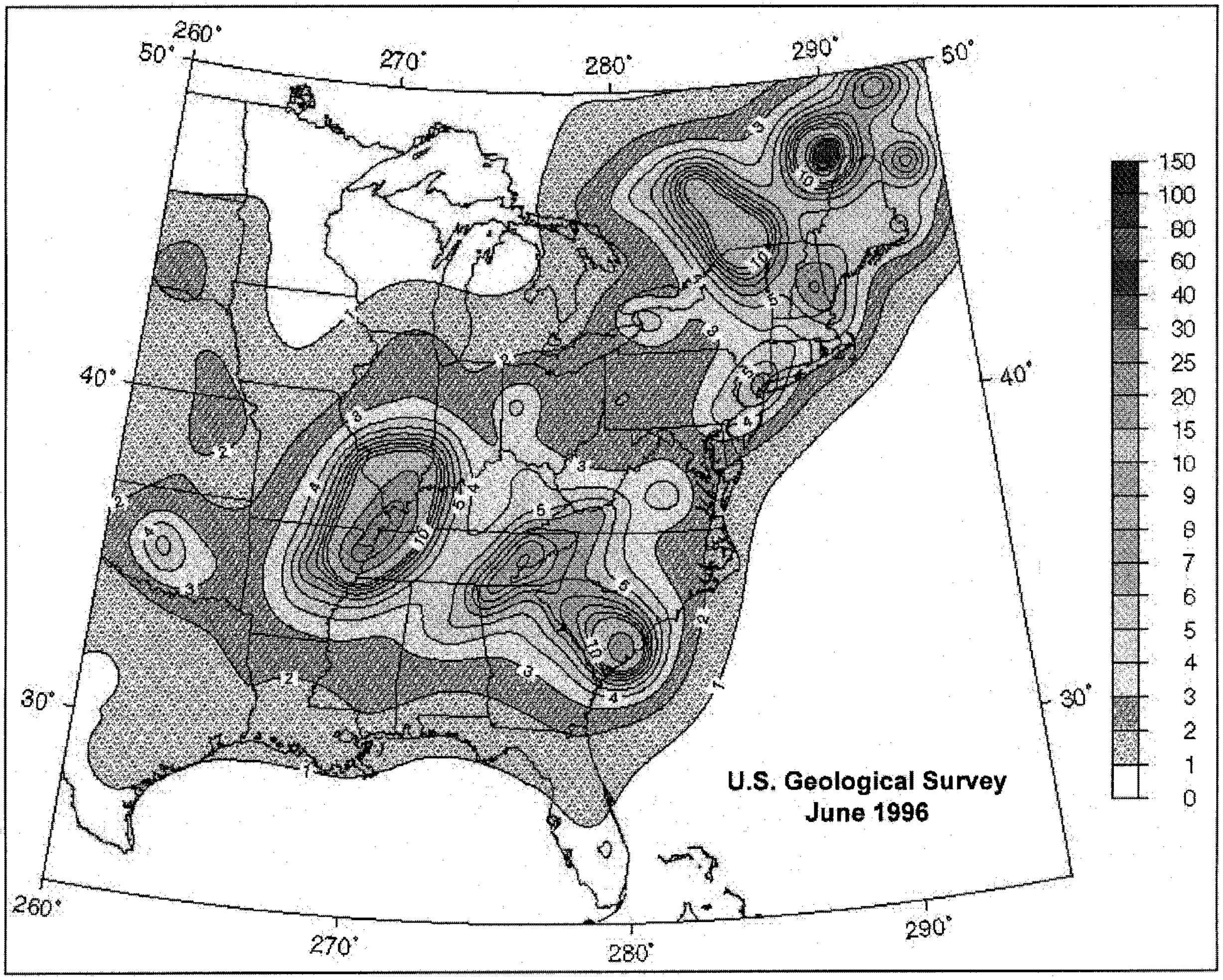


Figure 4.3.1.4-1. Peak acceleration (% gravity) with 10 percent probability of exceedance in 50 years.

Sawmill Creek and the Des Plaines River near ANL receive very little recreational or industrial use. About 290,000 gpd (1.1 million lpd) of water from the Chicago Sanitary and Ship Canal, which runs parallel to the Des Plaines River, was previously used for cooling towers and other industrial purposes. Surface water from the area around ANL is not used as a source of drinking water with the first downstream location [about 150 mi (241 km)] of surface water being used by a community water supply system at Peoria on the Illinois River.

4.3.2.2 Flood Potential

Since the ANL reservation is situated at an elevation about 164 ft (50 m) above the Des Plaines River, it is not subject to major flooding. A number of small areas associated with the Sawmill Creek drainage and other small streams are subject to local flood conditions during heavy precipitation.

The preferred site for the proposed SNS (called the 800 Area) is situated in the northwestern

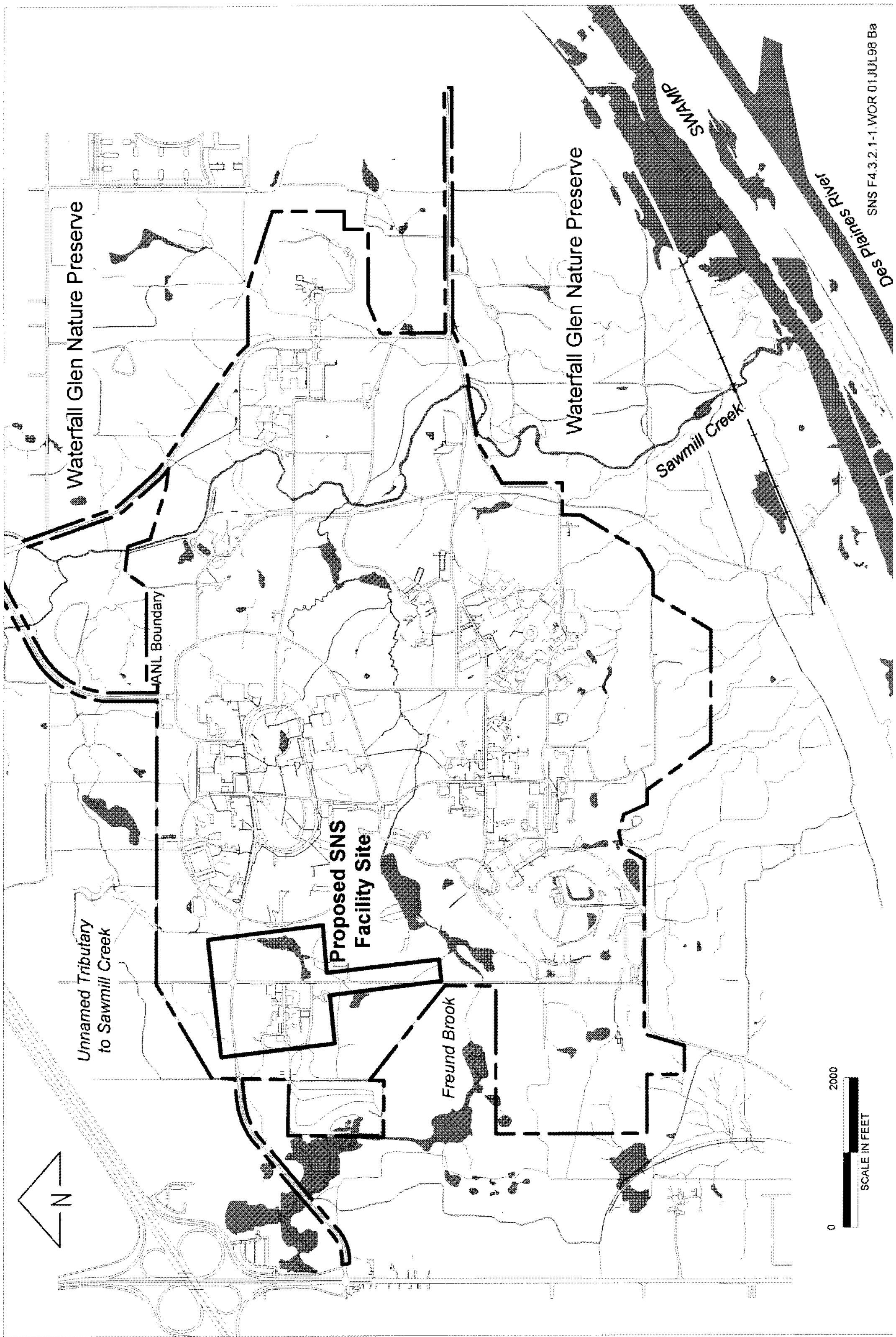


Figure 4.3.2.1- 1. Proposed SNS location and nearby drainages within ANL boundary.

portion of the ANL reservation and will overlie a drainage area within a floodplain and associated wetlands (refer to Figure 4.3.2.1-1). The footprint will also occupy a small portion of the western marsh in the headwaters of Freund Brook. Because of the many streams and marshes within the ANL reservation, alternative sites considered for the proposed SNS would occupy similar or larger floodplains and wetlands areas.

4.3.2.3 Groundwater

Groundwater in the area surrounding ANL is segmented into three hydrogeological groups. From the surface they are (1) the glacial deposits of the Pleistocene age, (2) the shallow bedrock of the Silurian age, and (3) the deeper bedrock aquifers of the Ordovician age. The upper two groups are effectively separated from the deep bedrock system by an aquitard, and the vadose zone occurs within the Pleistocene glacial deposits.

Groundwater in the Wadsworth Till occurs mainly in the silty clay or sandy portions of the unit at a depth of 15 to 30 ft (4.6 to 9.1 m) below ground level in the 800 Area. Data on groundwater levels from 1988 to 1993 show seasonal fluctuations of up to several feet. The water table level and surface elevation are poorly correlated, possibly indicating the absence of significant horizontal groundwater flow. The extremely low permeability (1 x 10^{-7} cm/s) of the Till (SNL 1996) renders this formation unusable as a source of drinking water. The downward rate of water movement or recharge rate through the saturated zone of the Till is approximately 0.1 in./day (0.3 cm/day), or 3 ft/yr (90 cm/yr).

Little information is available on the Lemont Drift to evaluate the hydrogeological characteristics of this unit. The Drift has a clay content approximately one-half of the Wadsworth Till and is probably more permeable than the overlying unit.

The Silurian dolomite aquifer is the uppermost bedrock aquifer lying between the glacial sediments and the Maquoketa Shale. Water levels in this aquifer within the 800 Area lie at a depth of approximately 110 ft (33.5 m). Significant permeability in the dolomite occurs near the top of the unit from secondary structures such as bedding planes, joints, and fractures enhanced by solutioning. Recharge of the dolomite aquifer is primarily by precipitation that percolates downward through fractures and joints. The rate of recharge is about 4 in./yr (10 cm/yr) depending on annual precipitation. An estimated horizontal velocity in the dolomite was calculated using K = 1.3 x 10^{-4} ft/s (4 x 10^{-3} cm/s) with a very low gradient of 0.0005 and estimated fracture void of 10 percent. The velocity is estimated to be 20 ft/yr (1.7 cm/day).

Approximately 300 ft (90 m) below the Maquoketa Shale aquitard is a sandstone aquifer in the Ancell Group. Below the Ancell Group, older rocks contain two water-bearing sandstone units, the Galesville Sandstone and the Elmhurst-Mt. Simon Sandstone. The uppermost of the two sandstone units is the Galesville Sandstone, which is widely utilized as a source of groundwater in northern Illinois. The Elmhurst-Mt. Simon has supplied groundwater to the Chicago region in the past. The sandstone is recharged by precipitation in areas north and west of the Chicago metropolitan area where this aquifer is positioned near the surface.

Groundwater from the Silurian and Ordovician aquifers was used as ANL drinking water supplies until recently. Since 1997, water resources have been obtained from Lake Michigan (Stull 1998). Groundwater flow within the Niagaran dolomite is generally to the southeast; however, historical pumping in the eastern portion of the reservation from four ANL water supply wells has influenced the direction of flow. A large cone of depression in the dolomite potentiometric surface exists as a result of pumping an average 800,000 gpd (3 million lpd) from the supply wells since 1948. This cone extends into the western portions of ANL. Thus, movement of water within this aquifer has been generally toward the wells. The effect of the cessation in pumping will be evaluated as part of a site-wide hydrogeological assessment.

Groundwater quality representative of the 800 Area can be observed from two wells [Illinois Environmental Protection Agency (IEPA) designation G06S and G06D] about 400 ft (122 m) southwest of the proposed SNS location. G06S is screened in the shallow Till aquifer at a depth of 20 to 25 ft below ground surface (BGS) and G06D is screened in the Silurian dolomite aquifer at a depth of 119 to 129 ft (36.3 to 39.3 m) below the ground surface. Each well is sampled quarterly for routine indicator parameters as well as inorganic constituents. The average concentrations from four sampling events in 1997 (ANL 1997) compared against Illinois Class I Groundwater Quality Standards (GWQS) are shown in Table 4.3.2.3-1. From the results, only manganese is elevated in respect to GWQS.

4.3.3 CLIMATE AND AIR QUALITY

The regional climate around ANL is characterized as continental with relatively cold winters and hot summers, and is slightly modified by Lake Michigan. January is the coldest month with an average of 21 °F (-6 °C); July is the warmest month with an average temperature of 70 °F (21 °C). The average annual precipitation at ANL is 31.5 in. (80 cm) and is primarily associated with thunderstorm activity in the spring and summer (Figure 4.3.3-1). Evapotranspiration in the area is estimated at 80 percent of the annual rainfall or about 25 in. (64 cm). The annual average accumulation of snow and sleet is 32.7 in. (83 cm) (DOE-CH 1997). Snow storms resulting in accumulations greater than 5.9 in. (>15 cm) occur only once or twice each year on average, and severe ice storms occur only once every 4 or 5 years (DOE-CH 1997).

Table 4.3.2.3-1. Groundwater quality at ANL 800 Area.

	NH_4 (mg/L)	As (mg/L)	Cd (µg/L)	Cl^- (mg/L)	Fe (µg/L)	Pb (µg/L)	Mn (µg/L)
G06S	<0.1	5.1	<0.1	77	28	<1.0	420
G06D	0.7	4.4	<0.1	186	2,350	<1.0	95
GWQS	10.0	50.0	5.0	200	5,000	7.5	150

	Hg (mg/L)	SO_4 (mg/L)	TDS (mg/L)	Cyanide (mg/L)	Phenol (µg/L)	TOC (mg/L)	TOX (µg/L)
G06S	<0.1	210	1,044	<0.010	<5	3.2	62
G06D	<0.1	89	899	<0.011	5.0	4.7	57
GWQS	2.0	400	1,200	0.2	100.0	-	-

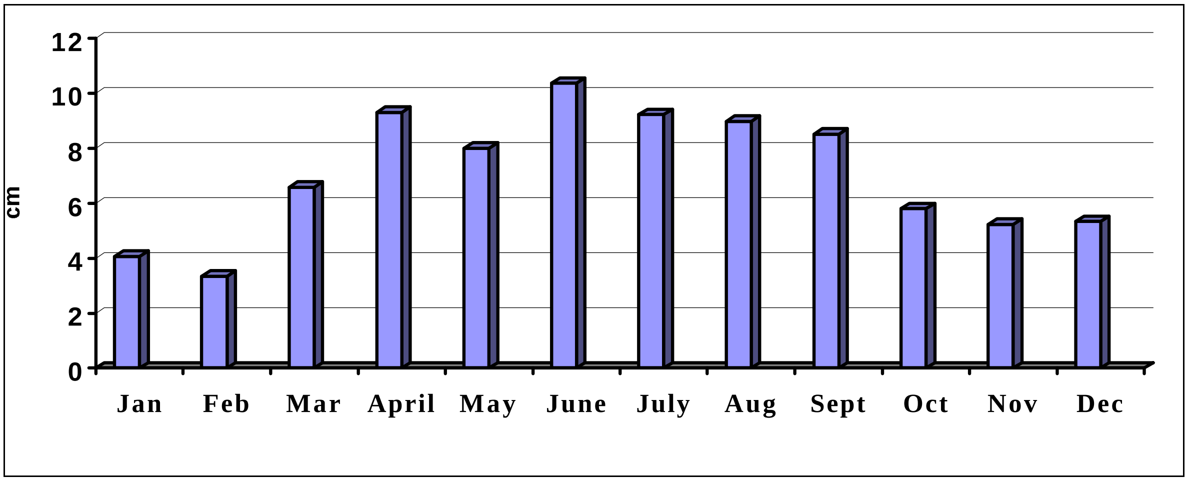


Figure 4.3.3-1. Annual monthly precipitation at ANL.

4.3.3.1 Severe Weather

The area experiences about 40 thunderstorms annually (Angel 1998). Occasionally, these storms are accompanied by hail, damaging winds, or tornadoes. From 1957 to 1969 there were 371 tornadoes in the state of Illinois with more than 65 percent of tornadoes occurring during the spring months. DuPage County has been subjected to 19 tornadoes for the period from 1955 to 1995.

The theoretical probability of a 150-mph (492 km/h) tornado strike at ANL is estimated to be 3.0×10^{-5} each year, a recurrence interval of one tornado every 33,000 years (Coats and Murray 1985). ANL property has been struck by milder tornadoes, which have resulted in minor damage to power lines, roofs, and trees.

Obscured visibility in the form of fog is observed about 39 days per year in the metro Chicago area.

4.3.3.2 Atmospheric Dispersion

The predominant wind direction is from the south, and wind from the southwest quadrant occurs almost 50 percent of the time (Figure 4.3.3.2-1). The average wind speed at a height of 9.19 ft (2.8 m) is 7.6 mph (35 km/h); calm periods occur 3.1 percent of the time.

4.3.3.3 Air Quality

The State of Illinois has adopted the NAAQS of the Federal Clean Air Act (DOE-CH 1997) and regulates these provisions through a State Implementation Plan. The ambient air quality standard of concern for the proposed construction of the SNS applies to fugitive dust that results from soil disturbance of particulate matter of less than or equal to 10 micron in aerodynamic diameter (PM_{10}). The PM_{10} standard is 150 µg/m³ for an averaging time of 24 hours (not more than one exceedance per year) and 50 µg/m³ as an annual arithmetic mean. In 1995, the Naperville monitoring station reported a maximum 24-hour PM_{10} concentration of 45 µg/m³, an annual arithmetic mean concentration of 19 µg/m³ (DOE-CH 1997).

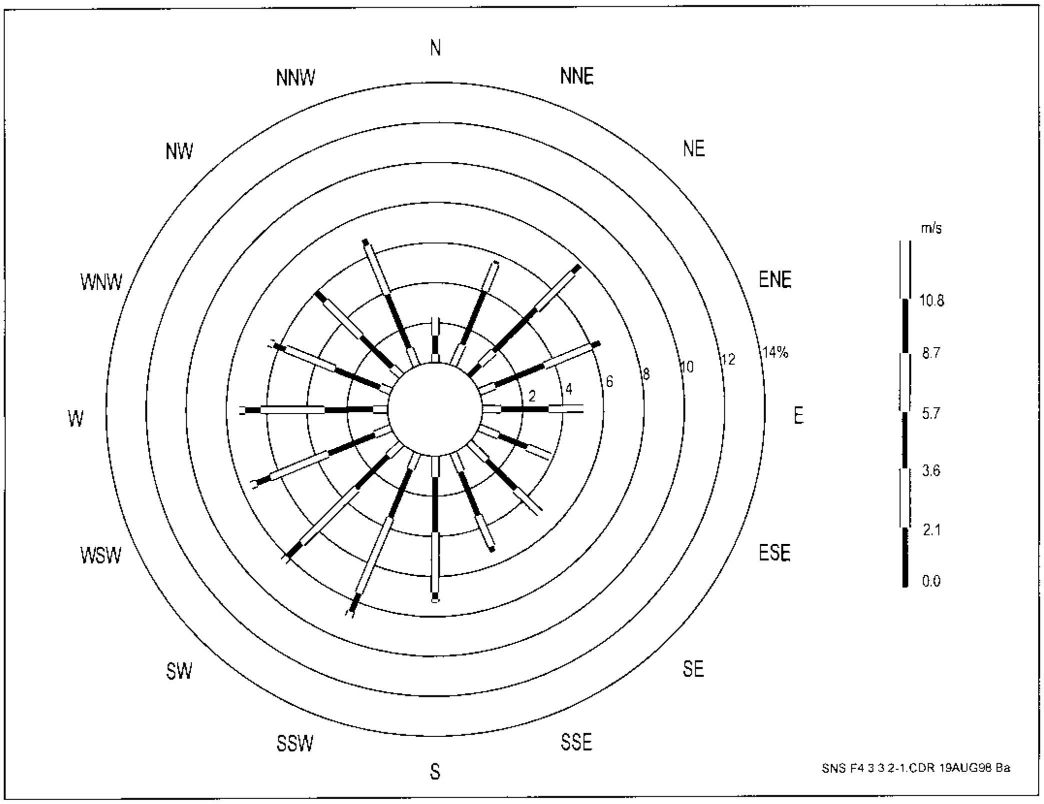


Figure 4.3.3.2-1. Windrose for ANL for the period 1992 to 1994.

Overall ambient air quality in the vicinity of ANL is best quantified in terms of recent ambient monitoring data collected by the IEPA at nearby locations. Table 4.3.3.3-1 summarizes these data and is taken from the *Illinois Annual Air Quality Report* for 1996.

ANL contains a number of sources of conventional air pollutants, including a steam plant, oil-fired boilers, fuel-dispensing facilities, bulk chemical tanks, dust collection system, and fire training activities. The operating air pollution control permit for the steam plant requires continuous opacity and sulfur dioxide monitoring of Boiler No. 5 equipped to burn coal. No exceedances occurred during 1996. Table 4.3.3.3-2 provides the annual emissions for ANL.

4.3.4 NOISE

The SNS site is proposed for the northwest portion of the ANL reservation in an area of obsolete buildings and structures scheduled for future demolition. Only ancillary storage is conducted in this area, and no estimate of ambient noise levels is available. The proposed SNS site is also located about 4,000 ft (1,220 m) north of the Advanced Photon Source (APS). The APS is a circular facility that produces high-energy photons similar to the SNS. The APS meets all Illinois State Noise Standards and DOE criteria for occupational safety and health.

Sensitive receptors would include both onsite workers and offsite residential populations. The proposed site would be located within 1,000 ft (305 m) of the 200 Area, which is the main

Table 4.3.3.3-1. Summary of 1996 monitoring data in the vicinity of ANL.

Pollutant Averaging Time	Nearest Monitor Location	Maximum 1st	2nd	3rd	4th	NAAQS IAAQS	Number of Exceedances
PM-10	DuPage Co.						
24-hour	Naperville	47.0	42.0	35.0	34.0	150.0 μg/m^3	0
Annual		20.0				50.0 μg/m^3	0
Ozone	DuPage Co.						
1-hour	Lisle	0.102	0.087	0.087	0.085	0.12 ppm	0
NO_x	Cook Co.						
Annual	Schiller Park	0.032	—	—	—	0.05 ppm	0
SO_2	DuPage Co.						
3-hour	Lisle	0.053	0.052	—	—	0.5 ppm	0
24-hour		0.021	0.019	—	—	0.14 ppm	0
Annual		0.003	—	—	—	0.03 ppm	0
CO	Cook Co.						
1-hour	Hoffman Estates	3.1	2.9	2.6	—	35.0 ppm	0
8-hour		1.9	1.9	1.8	—	9.0 ppm	0
Lead	DuPage Co.						
Quarterly	Bensenville	0.04	0.04	0.03	0.02	1.5 μg/m^3	0

Source: IEPA 1997.

Table 4.3.3.3-2. Annual emission report for ANL.

Pollutant	CO	NO_x	PM	SO_2	VOC
Total (tons/yr)	30.9	249.2	1.46	123.3	2.6

complex of offices and research laboratories for ANL. In addition, residential populations exist outside the ANL reservation. Population density for the northwest quadrant adjacent to ANL is estimated at: zero for 0-1.0 mi (0-0.6 km) buffer zone, 2,990 persons for 1.0-2.0 mi (0.6-1.2 km) range, and 12,124 persons for 2.0-3.0 mi (1.2-1.8 km) range (Golchert and Kolzow 1997).

4.3.5 ECOLOGICAL RESOURCES

This section provides a general description of the ecological resources for the proposed SNS site and the surrounding area. The discussions are based on information readily available from other sources. Site-specific surveys were done for protected species and wetlands. All other information was obtained from existing publications. For the most part, the impacts from construction and operation of the proposed SNS would be minor. Therefore, much of the information presented here is summary in nature. Greater detail can be obtained from the references compiled for this section.

4.3.5.1 Terrestrial Resources

The predominant vegetation community on the proposed SNS site is open grassland, consisting of scattered areas of old-field and intermittently mowed areas (Figure 4.3.5.1-1). The dominant graminoid species in both mowed and unmowed areas are non-native grasses commonly found on disturbed soils at ANL. Orchard grass *(Dactylis glomerata),* smooth brome *(Bromus inermis),* tall fescue *(Festuca elatior),* timothy *(Phleum pratense),* and quack grass *(Agropyron repens)* are abundant in these areas, while native species, such as big bluestem *(Andropogon gerardii),* indian grass *(Sorghastrum nutans),* and prairie cordgrass *(Spartina pectinate)* occur in small isolated patches in less disturbed areas. Other common herbaceous species in disturbed areas include crown vetch *(Coronilla varia),* wild carrot *(Daucus carota),* Canada thistle *(Cirsium arvense),* and yarrow *(Achillea millefolium),* all of which are non-natives. Old-field communities of less recent disturbance support a number of native species such as wild bergamot *(Monarda fistulosa),* Missouri ironweed (*Vernonia missurica),* and germander *(Teucrium canadense).* Undisturbed native prairie communities do not occur in the vicinity of the proposed site.

Scrub-shrub communities in early successional stages occur in the southwestern and southeastern portions of the proposed site. These communities have remained relatively undisturbed in the past decade or more and support many species found in the open grasslands. Low shrubs form scattered clumps in these areas and include gray dogwood *(Cornus racemosa),* honeysuckle *(Lonicera* spp.), and multiflora rose *(Rosa multiflora).* These communities often intergrade with forested areas, forming dense thickets of low shrubs in addition to common buckthorn *(Rhamnus cathartica),* wild black cherry *(Prunus serotina),* box elder *(Acer negundo),* and riverbank grape *(Vitis riparia).*

Woodland communities with relatively open canopies occur in the southern portion of the proposed site. Small woodlands of medium to large size box elder are scattered to the southwest. Associated species include wild black cherry, honeysuckle, and many herbaceous species such as white snakeroot *(Eupatorium rugosum),* garlic mustard *(Alliaria petiolata),* crown vetch, orchard grass, and smooth brome. A large open woodland, with less than 50 percent estimated canopy cover, lies to the southeast. Medium and large cottonwood *(Populus deltoides)* are the dominant trees, with medium size green ash *(Fraxinus pennsylvanica var subintegerrima),* and medium and small box elder. Scattered shrubs and small common buckthorn are interspersed among a predominantly graminoid herbaceous stratum of tall fescue and silky wild rye *(Elymus villosus).*

Forested communities in the vicinity of the proposed site include a wide variety of forest types. Several fairly large coniferous forests occur to the north and southwest. These areas were planted with young pines in the 1950s and consist of three types distinguished by the species planted. Jack pine *(Pinus banksiana)* forest is the most common and occurs in five distinct forest blocks to the north and southwest. Red pine *(Pinus resinosa)* forest occurs in seven areas of varying size to the north, and white pine

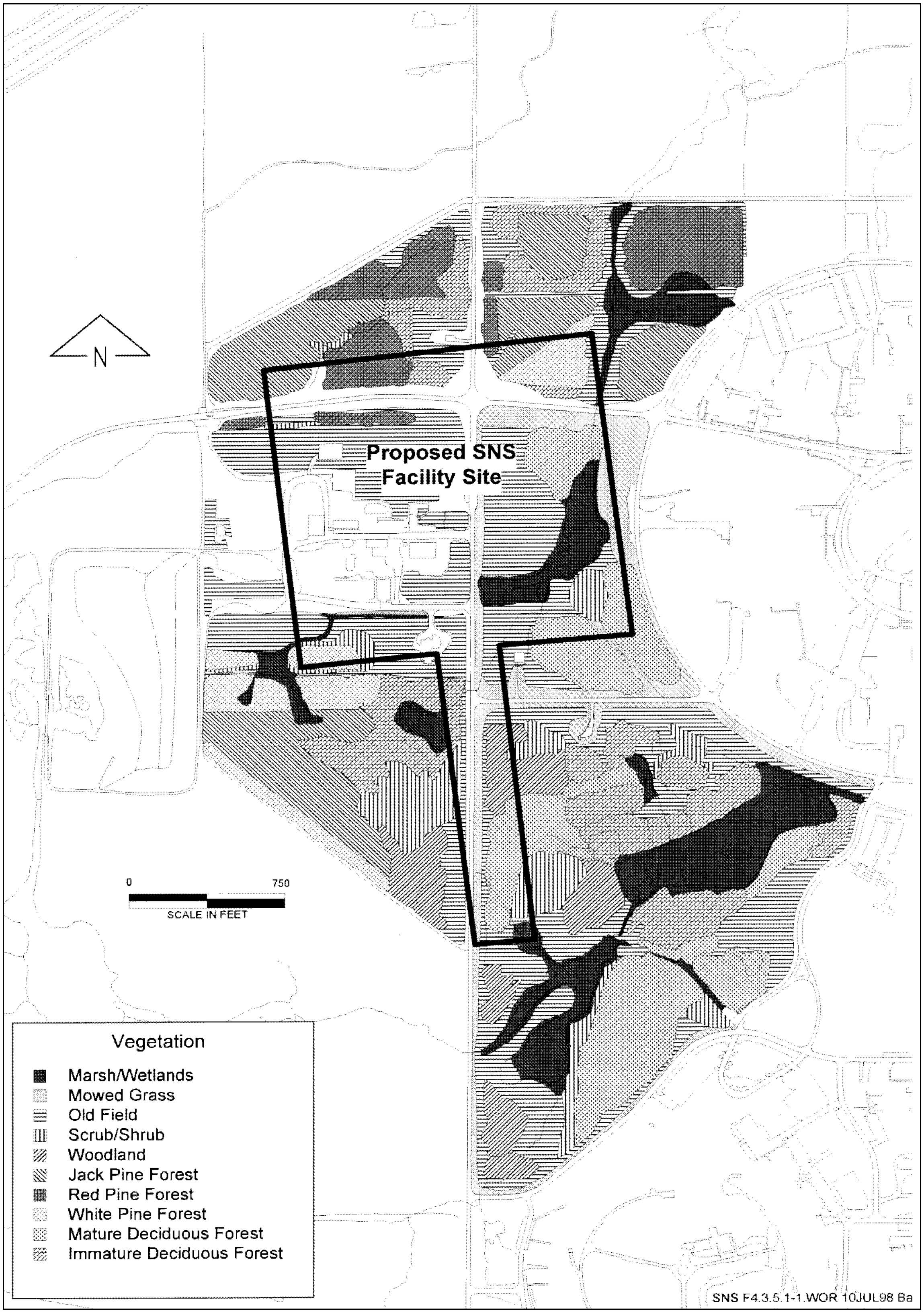


Figure 4.3.5.1-1. Vegetative cover at the proposed ANL SNS site.

(Pinus strobus) forest consists of six relatively small areas north and southwest. These pine forests are characterized by a high density of trees of uniform size. Associated deciduous species typically include scattered wild black cherry, with common buckthorn, box elder, and honeysuckle often present. Herbaceous species include garlic mustard, white snakeroot, stickseed *(Hackelia virginiana)*, and white avens *(Geum canadense)*.

Mature deciduous forest occurs in three blocks in the eastern portion of the site. These forests have an overstory of medium and large size red oak *(Quercus rubra)*, white oak *(Quercus alba)*, bur oak *(Quercus macrocarpa)*, and black oak *(Quercus velutina)*, in varying proportions. Understory species include various sapling oaks and wild black cherry. These forests support a high diversity of herbaceous, mostly native, species including common oak sedge *(Carex pensylvanica)*, white snakeroot, stickseed, woodland knotweed *(Polygonum virginianum)*, spring beauty *(Claytonia virginica)*, enchanter's nightshade *(Circaea lutetiana var canadensis)*, and the non-native garlic mustard. These oak forests contain many large oaks exceeding 2 ft (0.6 m) in diameter and have very low occurrences of invasive non-native species such as common buckthorn or honeysuckle.

Areas of immature deciduous forest occur throughout the proposed site. The dominant woody species are box elder, green ash, cottonwood, wild black cherry, and black locust *(Robinia pseudacacia)*. Associated species include common buckthorns, honeysuckle, garlic mustard, white snakeroot, and orchard grass.

A large portion of the proposed site was disturbed in 1996 and 1997 by activities associated with facility removal, resulting in limited wildlife use. However, an area of high diversity of habitats with little recent disturbance still exists in the vicinity of the proposed site, supporting a large number of wildlife species. Many species that have been observed on the ANL site are listed in Messenger et al. (1969, as cited in DOE-CH 1990) and include 9 species of amphibians and reptiles, 86 species of birds, and 26 species of mammals. Amphibians observed in wetlands on the site include leopard frog, spring peeper, and chorus frog. A variety of grassland, forest, and wetland bird species are found on or near the proposed site. Observed species include red-tailed hawk, American goldfinch, indigo bunting, downy woodpecker, red-winged blackbird, great blue heron, Canadian goose, mallard, great egret, pied-billed grebe, and black-crowned night heron. Canadian geese have been observed nesting on the proposed site. Mammals observed on the proposed site include muskrat, beaver, woodchuck, raccoon, fox squirrel, and northern gray squirrel. The proposed ANL site supports thriving populations of the native white-tailed deer and introduced fallow deer, which are frequently observed. Beavers and muskrats have intermittently occupied wetlands on and in the vicinity of the proposed site.

4.3.5.2 Wetlands

A variety of wetland types, totaling approximately 17.3 acres (7 ha), occur in and around the proposed SNS site. Although most of these wetlands have been disturbed to some degree in the past, they continue to retain wetland value, such as wildlife habitat and flood control.

A large wetland, approximately 4 acres (1.6 ha), lies in the northeast part of the proposed site.

This wetland receives surface flows from an intermittent stream to the south and storm sewer drainage to the east. Surface water is generally present throughout the year within the stream channel and storm drainage. Areas not inundated are saturated within 12 in. (30 cm) of the surface for extended periods. Common cattail *(Typha latifolia)* is the dominant species in the eastern portion of the wetland and in the southern part of the stream channel, while reed canary grass *(Phalaris arundinacea)*, a non-native species, is dominant within most of the stream channel and much of the central portion. Although beavers had built a dam and lodge in this wetland in the past, they have not occupied this area since 1993.

A 2.7-acre (1.1-ha) wetland in the eastern portion of the proposed site, almost totally within the footprint of the SNS, includes a small pond at the northern end. This wetland receives surface flows from storm sewer drainages to the east and west and an excavated channel to the west. Surface water is present throughout the year within the pond. The southwestern arm is inundated early in the growing season and generally has a narrow, shallow flow during dry months of the year. Most of this wetland, other than the pond, is dominated by narrow-leaf cattail *(Typha angustifolia)*. Beavers also built a dam and lodge in this wetland, yet they have not occupied this area since 1993.

A small, 0.4-acre (0.2-ha) wetland to the southeast of the proposed site receives surface water drainage from two nearby water towers. Drainage is present throughout the year and enters at the north end forming a shallow stream, which dissipates at the south end. The dominant species in this marshy wetland are common and narrow-leaf cattail.

A large wetland to the southeast of the proposed site contains surface water throughout the year that fluctuates in depth according to the level of a beaver dam at the northeast end. This wetland is 7.5 acre (3.1 ha) and receives surface flow from a small stream to the southwest (Freund Brook) and storm sewer drainages to the north. Lower water levels allow wetland plants to colonize areas that under higher levels support only submerged aquatic vegetation and non-rooted floating plants. The dominant species in this wetland are common and narrow-leaf cattail and common reed *(Phragmites australis)*. Three state-listed endangered bird species have been observed at this wetland: great egret, black-crowned night heron, and pied-billed grebe.

A shallow area along Freund Brook lies immediately upstream of the previous wetland. Surface water is present throughout most of the year, although flows are sluggish during summer months. Dominant species along the muddy stream margin are large-flowered water plantain *(Alisma triviale)*, rice cut-grass *(Leersia oryzoides)*, lady's thumb *(Polygonum persicaria)*, and marsh purslane *(Ludwigia palustris var americana)*. A low marshy area along a tributary to the southeast of Freund Brook contains shallow surface water much of the year and supports rice cut grass, large-flowered water plantain, and river bulrush *(Scirpus fluviatilis)*.

An 0.8-acre (0.3-ha) seasonally flooded wetland in the southern portion of the proposed site and within the SNS footprint is inundated early in the growing season, but surface water is absent by mid-summer. Dominant species are wild mint *(Mentha arvensis var villosa)*, smartweed, *(Polygonum* sp.), sedge *(Carex* sp.), and white grass *(Leersia virginica)*. The wetland margin is lined by mature cottonwood and black willow

(Salix nigra) trees. Hydrologic input is primarily groundwater discharge. However, a minor surface flow in spring is received from an excavated channel to the northwest.

A 1.4-acre (0.6-ha) wetland system to the south includes a narrow channel receiving surface water from the landfill area on the west and storm sewer drainage on the north. The southern portion of the wetland is saturated early in the growing season but is seldom inundated. Surface water is present in the channel throughout the year downstream of the storm drain outlet. Common cattail is the dominant species in the channel, while dominants in the remainder include reed canary grass, swamp marigold *(Bidens aristosa),* and sedges.

A small, 4,050-ft² (380-m²) seasonal wetland occurs within a drainage ditch in the western portion of the proposed site. Surface water is present early in the growing season but usually absent by late summer. Dominant species are narrow-leaved cattail, barnyard, grass *(Echinochloa crusgalli*), common beggar's ticks *(Bidens frondosa),* and great bulrush *(Scirpus validus* var *creber).*

4.3.5.3 Aquatic Resources

There is little information on aquatic biotic resources at ANL. Section 4.3.2.1 presents a physical description of the streams at ANL. Sawmill Creek flows through the eastern portion of the site and is classified by IEPA as a general use water body. This classification provides for the protection of indigenous aquatic life, primary and secondary contact recreation, and agricultural and industrial uses. The biotic community of Sawmill Creek is relatively sparse, reflecting the high silt load and steep gradient of the creek. The invertebrate fauna consists primarily of blackflies, midges, isopods, and flatworms. Clean water invertebrates, such as mayflies or stoneflies, are rare or absent. Fish populations in Sawmill Creek are scarce, represented by minnows, sunfishes, and catfish.

Freund Brook flows just south of the proposed SNS site. The gradient of this stream is relatively steep, and riffle habitat predominates. The substrate is coarse rock and gravel on a firm mud base. Aquatic macrophytes include common arrowhead, pondweed, duckweed, and bulrush. Invertebrate fauna consists primarily of dipteran larvae, crayfish, caddisfly larvae, and midge larvae. Few fish are present because of low summer flows and high temperatures.

4.3.5.4 Threatened and Endangered Species

DOE is in the process of consulting with the USFWS at the State of Illinois regarding whether or not construction and operation of the proposed SNS at ANL would jeopardize the habitat of any threatened or endangered species, and appropriate mitigation measures. USFWS responded, stating that the only federally listed species that may be affected by the proposed SNS project would be the Hine's emerald dragonfly. The State of Illinois has not yet responded. Appendix C presents the letters of consultation on protected species.

There are no federally listed threatened or endangered species known to occur in the vicinity of the proposed site or on the ANL site. The federally listed endangered Indiana bat *(Myotis sodalis)* and the federally listed endangered Hine's emerald dragonfly *(Somatochlora hineana)* are known to occur in the surrounding area.

Three state-listed endangered bird species, great egret *(Casmerodius alba),* black-crowned night heron *(Nycticorax nycticorax),* and pied-billed grebe *(Podilymbus podiceps),* have been observed in the wetlands in the southeast portion of the proposed site, but are not known to breed there or elsewhere on ANL. Hairy marsh yellow cress *(Rorippa islandica* var *hispida),* state-listed as endangered, and Kirtland's snake *(Clonophis kirtlandii),* state-listed as threatened, have been observed on the ANL site, but not in the vicinity of the proposed SNS site.

Five state-listed endangered species: river otter *(Lutra canadensis),* white lady's slipper *(Cypripedium candidum),* red-shouldered hawk *(Buteo lineatus),* slender sandwort *(Arenaria patula*), and inland shadblow *(Amelanchier interior),* and two state-listed threatened species: early fen sedge *(Carex crawei)* and marsh speedwell *(Veronica scutellata)* have not been observed at the ANL site but occur in the area.

4.3.6 SOCIOECONOMIC AND DEMOGRAPHIC ENVIRONMENT

The ROI for the SNS at the proposed ANL site includes Cook, DuPage, Kane, and Will Counties, as shown in Figure 4.3.6-1. Approximately 95 percent of ANL employees reside in this region. The region includes the cities of Chicago, Chicago Heights, Oak Park, Naperville, Elmhurst, Elgin, Aurora, and Joliet.

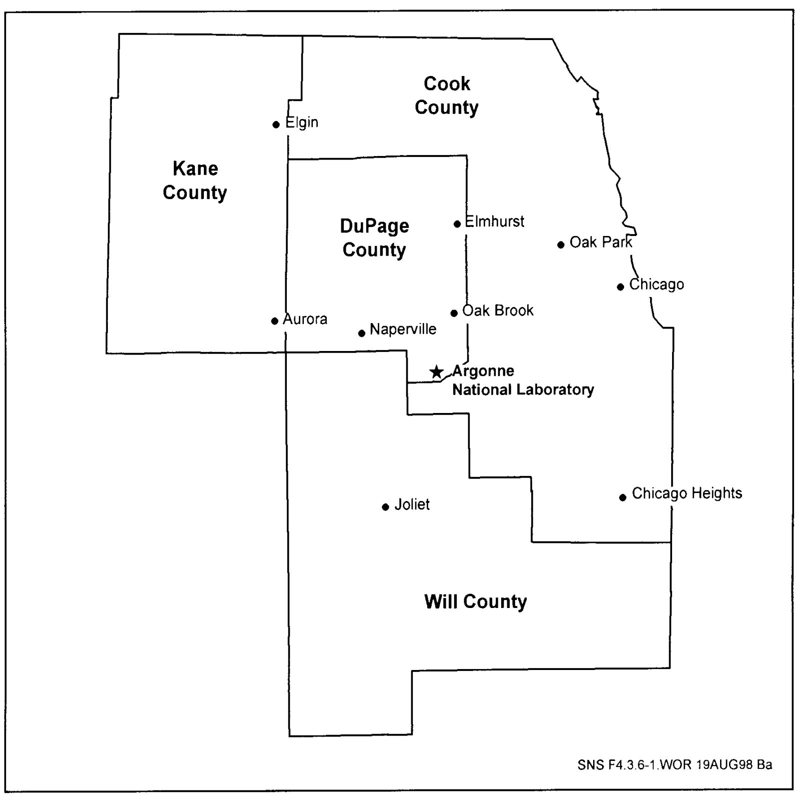


Figure 4.3.6-1. Map showing socioeconomic ROI for ANL.

This section provides a description of the following socioeconomic and demographic characteristics:

- Demographics
- Housing
- Infrastructure
- Local economy
- Environmental justice

4.3.6.1 Demographic Characteristics

Population trends and projections for each of the counties in the region are presented in Table 4.3.6.1-1. Of the four counties, Cook has the largest population, with 76 percent of the 1996 regional population of 6,754,029. DuPage County accounted for 13 percent of the regional population, Will County for 6 percent, and Kane County accounted for the remaining 5 percent. It is anticipated that the regional population will increase to more than 6.9 million by the year 2000 and to more than 7.2 million by the year 2010. (This is equivalent to an annual growth rate of more than 10 percent between 1990 and 2010.)

Population data for the cities in the region are presented in Table 4.3.6.1-2. During the 1990s Chicago's population decreased by over 15,000 individuals, while population in the surrounding eight communities increased by 3.2 percent between 1990 and 1997. During this period, communities such as Naperville and Joliet grew at a particularly rapid pace (42 percent and 20 percent, respectively).

Population by race and ethnicity for the region is presented in Table 4.3.6.1-3. The 1990 census data reflect different racial and ethnic compositions in the four counties. All four counties are predominantly White. The African-American population comprises 26 percent in Cook County, 11 percent in Will County, and less than 10 percent in the other two counties.

4.3.6.2 Housing

Regional housing characteristics are presented in Table 4.3.6.2-1. In 1990, vacancy rates in the region ranged between a low of 4 percent in Kane County to a high of 8 percent in Cook County. Median home values varied considerably among the cities and villages in the region in 1990, from a low of $62,500 in Chicago Heights to $477,000 in Oak Brook. Similarly, median rents varied from approximately $400 to $650 per month.

4.3.6.3 Infrastructure

This section characterizes the region's community services with indicators such as education, health care, and public safety.

4.3.6.3.1 Education

Information regarding school districts within the region is presented in Table 4.3.6.3.1-1.

The school districts in the region all receive funding from local, state, and federal sources, but the percentage received from each source varies. In 1994, expenditures for elementary and secondary schools ranged from a low of $3,146 per student to $10,416. By comparison, the state average was $6,158.

Table 4.3.6.1-1. ANL regional population trends and projections.

County	1980	1990	1995	2000	2010
Cook	5,253,628	5,105,044	5,136,877	5,200,563	5,271,891
DuPage	658,858	781,689	853,458	884,949	928,133
Kane	278,405	317,471	359,950	386,997	461,453
Will	324,460	357,313	413,379	468,930	608,606
Region	6,515,351	6,561,517	6,763,664	6,941,439	7,270,083

Sources: U.S. Bureau of Census 1996; U.S. Bureau of Census 1990.

Table 4.3.6.1-2. Population for incorporated areas within the ANL region.

Communities	1990	1997
Chicago	2,783,726	2,768,483
Chicago Heights	33,072	NA
Oak Park	53,468	53,648
Naperville	85,351	121,712
Elmhurst	42,029	43,080
Oak Brook	9,178	NA
Aurora	99,581	117,500[a]
Elgin	77,010	85,068
Joliet	76,836	90,647

[a] 1996 data.

NA - Not available.

Source: U.S. Bureau of Census 1990.

Table 4.3.6.1-3. 1990 population by race and ethnicity for the ANL region.

All Persons, Race/ Ethnicity	Cook County		DuPage County		Kane County		Will County		Total	
	Number	% [a]	Number	% [a]	Number	% [a]	Number	% [a]	Number	% [a]
All Persons	5,105,087	100	781,689	100	317,471	100	357,313	100	6,561,560	100
Caucasian	3,208,115	63	714,905	91	270,301	85	303,420	85	4,496,741	69
African American	1,314,859	26	15,462	2	18,981	6	38,361	11	1,387,663	2
American Indian[b]	10,387	<1	962	<1	612	<1	692	<1	12,653	<1
Asian/ Pacific Islander	188,467	3	55,096	7	4,320	1	4,774	1	252,657	4
Hispanic of any race[c]	677,949	13	34,567	4	42,234	13	19,524	5	774,274	12
Other Races	383,259	7	10,703	1	23,257	7	10,066	3	427,285	6

[a] Percentages may not total 100 due to rounding.
[b] Numbers for Aleuts and Eskimos were placed in the "other" category given their small number.
[c] In the 1990 Census, Hispanics classified themselves as White, Black, Asian/Pacific Islander, American Indian, Eskimo, or Aleut. To avoid double counting, the number of Hispanics was subtracted from the total for all persons.
Source: U.S. Bureau of Census 1990.

Table 4.3.6.2-1. Housing summary for the ANL region, 1990.

	Cook County		DuPage County		Kane County		Will County	
	Number	Percent[a]	Number	Percent[a]	Number	Percent[a]	Number	Percent[a]
Total Housing Units	2,051,833	100	292,537	100	111,496	100	122,870	100
Occupied	1,879,488	92	279,344	95	107,176	96	116,933	95
Vacant	172,345	8	13,193	5	4,320	4	5,937	5
Median Home Value, Owner Occupied	$102,100	NA	$137,100	NA	$102,500	NA	$89,900	NA
Gross Rent	$478	NA	$625	NA	$508	NA	$453	NA

[a] May not total 100 due to rounding.
N/A - Not applicable.
Source: U.S. Bureau of Census 1990.

Table 4.3.6.3.1-1. Public school statistics in the ANL region, 1995 - 1996 school year.

District	Number of Schools	Student Enrollment[a]	Teachers[a]	Teacher/Student Ratio (1998)
Cook	663	1,324,299	63,000	1:21
DuPage	221	138,000	8,900	1:16
Kane	136	87,000	5,000	1:17
Will	117	101,606	5,300	1:19
State	NA	2,267,061	116,000	1:19

[a] Full-time equivalent figures.
NA – Not available.
Source: Illinois Board of Education 1996.

4.3.6.3.2 Health Care

Table 4.3.6.3.2-1 shows that there are over 70 hospitals serving the Metropolitan Chicago Region (60 of which are in Cook County) with a combined total of nearly 21,000 acute care beds. In 1996, 51 percent of these beds were available on any given day, which is considered sufficient to meet the health care needs of the local population.

4.3.6.3.3 Police and Fire Protection

The Chicago Police Department has over 13,000 officers. The City has approximately 100 fire stations, 4,200 firefighters, and 630 paramedics. The fire department is equipped with 99 fire engines, 50 trucks, and 59 advanced cardiac units.

4.3.6.4 Local Economy

This subsection provides information on the economy of the region, including employment, education, income, and fiscal characteristics.

4.3.6.4.1 Employment

Regional employment data for 1995 are summarized in Table 4.3.6.4.1-1. Since 1990, unemployment has decreased in the four counties within the region: the largest reduction in unemployment occurred in Cook County (from 6.7 percent in 1990 to 5.6 percent in 1995). Total 1995 employment for the region was over 3.3 million jobs. The “services” sector made up 29 percent of this total, and about one-third was associated with “retail trade” and “manufacturing.”

Table 4.3.6.4.1-2 presents employment by industry for the region. Services, retail trade, and manufacturing are the principal economic sectors in the region.

4.3.6.4.2 Income

In 1995, total regional income was approximately $187 billion. Income data for the region are presented in Table 4.3.6.4.2-1. Per capita incomes in 1995 in the region varied from $22,869 in Will County to $34,840 in DuPage

Table 4.3.6.3.2-1. Hospital capacity and usage in the ANL region (1996).

County	Number of Hospitals	Number of Acute Beds	Annual Bed-Days Used[a] (%)
Cook	60	17,647	52
DuPage	5	1,489	52
Kane	5	1,135	44
Will	2	697	51

[a]Based on the number of people discharged and the average length of stay divided by total beds available annually.

Source: The American Hospital Directory, Inc., 1998.

Table 4.3.6.4.1-1. ANL regional employment data, 1995.

County	Civilian Labor Force	Employed	Unemployed	Unemployment Rate (%)
Cook	2,599,063	2,454,314	144,749	5.6
DuPage	493,989	477,183	16,806	3.4
Kane	193,742	184,303	9,439	4.9
Will	213,234	202,216	11,018	5.2
Region	3,500,028	3,318,016	182,012	5.2
State of Illinois	6,054,954	5,547,300	368,837	5.1

Sources: Illinois Center for Government Studies 1990 and 1995; U.S. Bureau of Census 1990.

Table 4.3.6.4.1-2. Employment by industry for the Argonne region of influence, by county, and for the State of Illinois - 1995.

Economic Characteristic	Cook County	DuPage County	Kane County	Will County	Region of Influence	State of Illinois
Employment by Industry (1995)						
Farm	570	319	1,332	1,421	3,642	99,044
Agricultural Services	13,749	5,051	2,396	2,897	24,093	57,723
Mining	3,497	799	330	378	5,004	27,679
Construction	114,757	33,387	11,359	14,042	173,545	983,542
Manufacturing	443,455	75,669	37,998	19,607	576,629	983,542
Transportation and Public	197,075	36,744	4,967	8,168	246,954	366,356
Wholesale Trade	185,204	56,170	10,180	6,317	257,871	375,073
Retail Trade	467,383	111,156	33,619	26,667	638,825	1,115,010
Finance, Insurance, and Real Estate	336,333	54,512	14,696	9,116	414,657	589,697
Services	1,050,535	208,787	59,542	43,484	1,362,348	2,068,377
Government	370,413	44,539	18,601	20,575	457,128	858,795
Total Employment	3182971	627,033	195,020	152,672	4,157,696	6,854,787

Source: Regional Economic Information for Cook, DuPage, Kane, and Will Counties, and State of Illinois, 1990-1995 (U.S. Bureau of Census 1990).

Table 4.3.6.4.2-1. Measures of ANL regional income.

Area	Median Household Income 1989($)	Per Capita Income 1995 ($)
Cook County	32,673	27,153
DuPage County	48,876	34,840
Kane County	40,080	24,796
Will County	41,195	22,869
State of Illinois	32,252	25,293

Sources: U.S. Bureau of the Census 1990; Northern Illinois Planning Commission 1985-95.

County. In 1989, the percentage of persons below the poverty level was approximately 14.2 percent in Cook County, 6.8 percent in Kane County, 6.0 percent in Will County, and 2.7 percent in DuPage County.

4.3.6.4.3 Fiscal Characteristics

Municipal and county general fund revenues in the ROI are presented in Table 4.3.6.4.3-1. The general funds support the ongoing operations of local governments as well as community services such as police protection and parks and recreation. Cook, Kane, and DuPage Counties rely on local taxes the most for general revenue finds. Intergovernmental transfers constitute less than 20 percent of the general fund in Kane and DuPage Counties and only 3 percent in Cook County. In contrast, Will County's general fund relies mainly on intergovernmental transfers for 40 percent of its revenue and local taxes for another 36 percent.

4.3.6.5 Environmental Justice

Figures 4.3.6.5-1 and 4.3.6.5-2 illustrate distributions for minority and low-income populations residing within 50 mi (80 km) of ANL. The definitions of minority and low-income populations and the methodology for assessing potential environmental justice effects are given in Section 5.4.6.5.

Approximately 8,030,000 people live within a 50-mi (80-km) radius of the proposed ANL site. Minorities comprise 33.5 percent of this population. In 1990, minorities comprised 24.1 percent of the population nationally and 22 percent of the population in Illinois. There are no federally recognized Native American groups within 50 mi (80 km) of the proposed site. The percent of persons below the poverty level is 11.4 percent, which compares with the 1990 national average of 13.1 percent and a statewide figure of 22 percent (U.S. Census 1990).

Table 4.3.6.4.3-1. Municipal and county general fund revenues in the ANL region, FY 1996.

	Cook County		DuPage County		Kane County		Will County	
Revenue by Source	**($)**	**Percent[a]**	**($)**	**Percent[a]**	**($)**	**Percent[a]**	**($)**	**Percent[a]**
Local Taxes	587,090	71	48,774	51	21,713	57	37,726	36
Licenses and Permits	162,239	20	0[a]	N/A	1,343	4	3,335	3
Fines and Forfeitures	0[a]	N/A	23,909	25	2,186	6	943	1
Charges for Service	0[a]	N/A	0[a]	N/A	6,238	16	16,682	16
Intergovernmental	21,260	3	11,476	12	5,914	16	41,441	40
Interest	3,805	<1	6,694	7	457	1	2,901	3
Miscellaneous Income	24,018	3	4,782	5	82	<1	423	<1
Total Revenues	827,195	100	95,635	100	37,933	100	103,452	100

[a] Accounted for in other revenue sources.
N/A - Not applicable.
Percentages may not total 100 due to rounding.
Source: Comprehensive Annual Financial Reports 1997b.

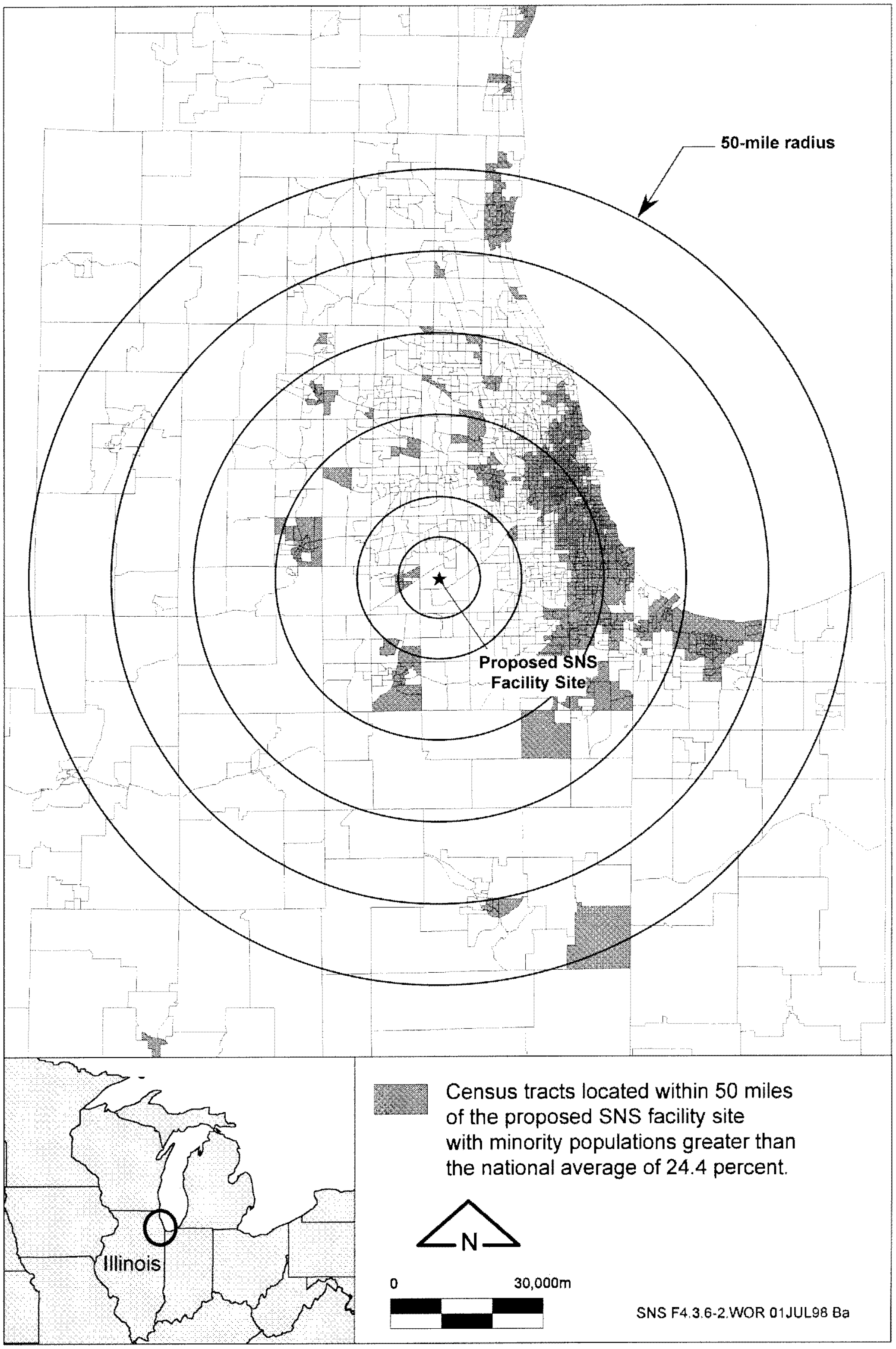


Figure 4.3.6.5-1. Distribution of minority populations at ANL.

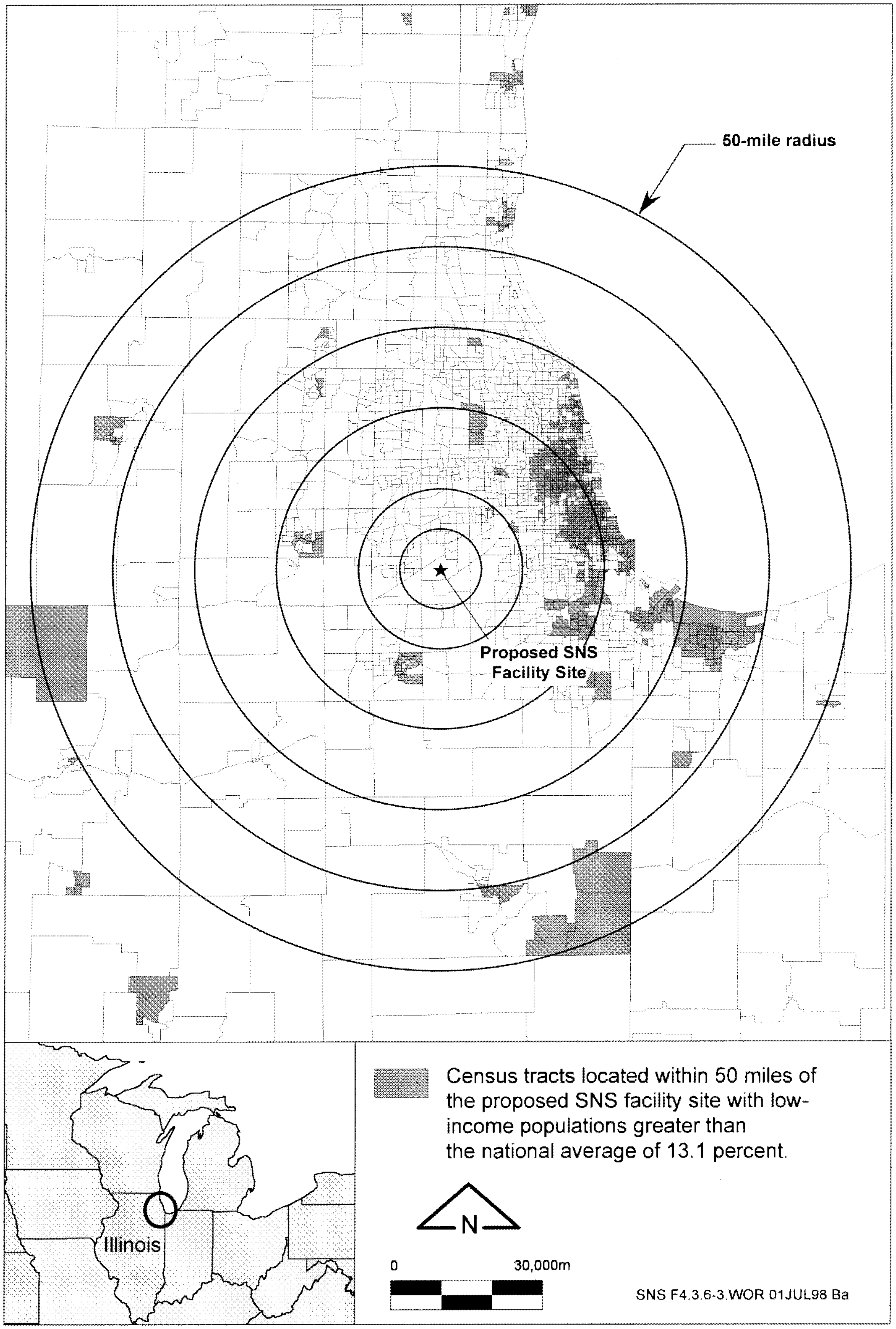


Figure 4.3.6.5-2. Distribution of low-income populations at ANL.

4.3.7 CULTURAL RESOURCES

ANL is located in the Illinois and Michigan Canal National Heritage Corridor, which is an area known to have a long and complex cultural history. With the exception of the Paleo Indian Period (13,000 to 8,000 B.C.), artifacts representative of all periods in the cultural chronology of Illinois have been documented in the ANL area through professional cultural resource investigations and interviews with local artifact collectors (Golchert and Kolzow 1997: 1-18).

Archaeological surveys have been conducted throughout all of ANL (Wescott 1997: 2). As a result of these surveys, 43 prehistoric archaeological sites have been identified. These include base camps, special purpose camps, and chert quarries (Golchert and Kolzow 1997: 1-18). Three of these sites are eligible for listing on the NRHP, and 19 sites are ineligible for listing. The eligibility of the remaining 21 prehistoric sites has not been determined.

Archaeological surveys of ANL have identified six Historic Period archaeological sites. Three of these exist as historic components on sites that also contain prehistoric components. These sites are representative of farmsteads that were active prior to 1946. One site has been determined to be ineligible for listing on the NRHP. The NRHP eligibility of the other five sites has not been determined.

A formal survey of ANL for historic resources other than archaeological sites (buildings, landscape features, equipment, etc.) has not been conducted (Wescott 1997: 2). However, the former CP-5 Reactor, Experimental Boiling Water Reactor, and Argonne Thermal Source Reactor date to the Cold War Period and may be of historical significance. A formal NRHP eligibility evaluation (Porubcan 1996, as cited in DOE-CH 1997) of these facilities was submitted to the Illinois Historic Preservation Agency on August 14, 1996. However, at the request of the agency, the final eligibility of these facilities for listing on the NRHP has not been determined, pending the development of a historic context addressing the role of ANL in the development of nuclear research, experimentation, and technology in the state of Illinois and the U.S. (Golchert and Kolzow 1997: 2-47).

The proposed SNS site at ANL and the area surrounding it have been surveyed for prehistoric and historic archaeological sites by ANL and Midwest Archaeological Research Services, Inc. (Wescott 1997: 3). The results of these surveys have been reported in Curtis et al. (1987), Elias and Greby (1990), Bird (1992), and Demel (1993a, 1993b) (all cited in Wescott 1997). However, this area has not been surveyed formally for historic structures and features. The occurrence of cultural resources on the proposed SNS site and at locations in its vicinity is discussed in this section of the EIS.

The SNS design team has not established the areas where construction or improvement of utility corridors and roads would be necessary to support the proposed SNS at ANL. In addition, the locations of ancillary structures such as a retention basin and a switchyard have not been determined. As a result, such areas could not be surveyed for cultural resources. However, the eventual establishment of these areas would proceed in such a manner as to avoid known cultural resource locations. If the proposed SNS site at ANL were chosen for construction, these areas would be surveyed for cultural resources prior to the initiation of construction-related activities within them.

The locations of archaeological and historical sites are not provided as part of the cultural resource descriptions in this section of the EIS. These omissions are consistent with DOE and University of Chicago efforts to protect cultural resources from vandalism by not revealing their locations in documents available to the general public. Because several of the original reports cited in this section show the locations of cultural resources in ANL, copies of them are not available in the DOE public reading rooms established as part of the SNS EIS process.

4.3.7.1 Prehistoric Resources

No prehistoric archaeological sites have been identified on the proposed SNS site. However, site 11DU207 is located adjacent to the proposed SNS site in an area that may be subject to construction activities and heavy equipment movement under the proposed action. It is characterized by a low-density surface scatter of chert debris resulting from the manufacture and/or sharpening of stone tools. The prehistoric cultural association of these remains is unknown. ANL has not assessed this site for NRHP eligibility.

4.3.7.2 Historic Resources

No Historic Period archaeological sites have been identified on the proposed SNS site at ANL. Furthermore, no such sites are located adjacent to the site perimeter in locations that may be subject to activities under the proposed action.

The 800 Area is located within the perimeter of the proposed SNS site. This area contains a small number of now substandard buildings and associated roads constructed by the initial site development contractor. This construction began about 1950 (ANL 1994a: 2-32). During the Cold War Period, the site development contractor used these buildings for storage and shop support. They were also used for accounting activities, plant maintenance shops, electronics development, and a motor pool. Most of the buildings in the 800 Area have been demolished, and several were removed as part of environmental restoration efforts in the area. As a result, only Buildings 809, 826, and 829 remain. The 800 Area is currently used for the storage of trailers and lumber (White, B. 1998a: 1).

The Historic Period buildings and features in the 800 Area are less than 50 years old. Although a formal inventory of historic structures related to the Cold War Period has not been conducted at ANL (Wescott 1997: 2), DOE does not consider the remains in the 800 Area to be historically significant to this period of laboratory history. This is reflected by the extensive past demolition of buildings in this area. Historical remains of this age and nature are not normally considered to be eligible for listing on the NRHP. Furthermore, the entire 800 Area lies within a zone of the laboratory that cultural resource management staff at ANL has cleared for future development (Wescott 1997: 2-3).

4.3.7.3 Traditional Cultural Properties

DOE-CH has found no Native American tribal representatives in the ANL area. Consequently, it has not been possible for DOE-CH to consult with them about the potential occurrence of TCPs on the proposed SNS site and at locations in its immediate vicinity. In addition, no Native American TCPs have been identified in the ANL area, and no Native American groups have expressed an interest in the occurrence and preservation of TCPs in ANL. As a result, it has been concluded that no TCPs occur on the proposed site or anywhere else on laboratory land (White, B. 1998c: 1; Wescott 1998a: 1).

4.3.7.4 Consultation with the State Historic Preservation Officer

DOE-CH is in the process of performing the required consultations under Section 106 of the NHPA. This section will be written when the consultations have been completed and documented. A copy of the consultation letter from the SHPO will be included in Appendix C.

4.3.8 LAND USE

Descriptions of land use in the vicinity of ANL, within the boundaries of ANL, and on the proposed SNS site are provided in this section. The descriptions cover past, current, and future uses of the land in these areas. In addition, they include descriptions of environmentally sensitive land areas that have been set aside for public use, environmental protection, or research. These areas include parks, natural areas, environmental education centers, and public recreation areas. The section concludes with a discussion of visual resources.

4.3.8.1 Past Land Use

The land surrounding ANL was wilderness during the early 19^{th} century. As people from the eastern U.S. gradually immigrated to the area and established settlements, this wilderness gave way to increasing agricultural and residential land use. The establishment and rapid growth of urban Chicago and Cook County, as well as its suburbs in adjacent counties, acted to minimize wilderness and agricultural land use while maximizing land uses typical of densely populated areas. As a result of being sandwiched between the growing suburban communities of Downers Grove to the north and Lemont to the south, the land surrounding ANL has developed a largely suburban character over the years. The predominant land use in this area has been residential mixed with commercial, industrial, and other typical suburban uses.

The land occupied by ANL was acquired originally as a 3,705-acre (1,500-ha) unit by the Atomic Energy Commission in 1947. At this time, it was largely agricultural land consisting of approximately 75 percent plowed fields and 25 percent pasture, oak woodlots, and oak forests. These agricultural lands were later reforested. Most of the original buffer area [2,001 acres (810 ha)] around ANL was transferred to the DuPage County Forest District in 1973 (ANL 1994a: 2-1; Golchert and Kolzow 1997: 1-16).

The development of ANL for research operations began in 1947 and generally followed the initial architectural site development planning of the 1940s and 1950s. Over the years, the current pattern of land use in ANL gradually developed (ANL 1994a: 2-1).

The proposed SNS site fully encloses the 800 Area, which currently consists of a few substandard buildings, a number of former building locations, and associated infrastructure such as roads. The northern and southern portions of the site overlap Ecology Plot Nos. 6, 7, and 8, which were once established as potential areas for ecological research. However, they were rarely used. The northern boundary of the proposed SNS site overlaps a small area that was used as a small arms firing range from the early 1950s to the late 1970s. In addition, the proposed site contains land that was previously unused Open Space (ANL 1994b: 11).

A large portion of the proposed SNS site and the land in its immediate vicinity have been a focus of intensive past use. Many of the buildings in this area were once used in support services operations for ANL. These operations included grounds maintenance, transportation center (motor pool), vehicle maintenance, and transformer storage. They involved the use of oils, fuels, and hazardous materials. As a result, a number of contaminated areas and waste disposal areas developed within the 800 Area, in other areas of the proposed SNS site, and in nearby areas outside the proposed site. For environmental restoration management purposes, these areas have been designated as Solid Waste Management Units (SWMUs) and Areas of Concern (AOC). These areas are described in Sections 4.3.8.2 and 4.3.9.2.3.

4.3.8.2 Current Land Use

The land in the vicinity of ANL continues to be suburban in character, and most of it is devoted to various kinds of residential use. Much smaller total areas of land are officially categorized as Commercial, Office/Research/ Development, Manufacturing (industrial), Institutional (schools, hospitals, etc.), Open Space (parks, recreation, reserved residential), Transportation/Commercial/ Utilities, and Forest Preserve. The ANL boundary is surrounded on all sides by forest preserve land that functions as a buffer between the laboratory and developed areas (DuPage County 1985, as cited in ANL 1994a). This area of land is the Waterfall Glen Nature Preserve (ANL 1994a: 3-103).

ANL occupies 1,500 acres (607 ha) of land in southern DuPage County (Golchert and Kolzow 1997: 1-4). Most of the buildings, research facilities, and support facilities on this land are distributed among 10 major activity areas: East Area, 100 Area, 200 Area, 300 Area, 360 Area, 400 Area, 500 Area, 600 Area, 800 Area, and ANL Park. The activities conducted in each area and the various laboratory facilities that support them are described extensively in the *Laboratory Integrated Facilities Plan* (ANL 1994a: 2-5 to 2-53).

Current land use at ANL is classified according to 10 major categories. Three categories are associated with separate programmatic research missions: Programmatic Mission–200 Area, which contains laboratory and office facilities; Programmatic Mission–APS Project, which contains the APS and related research facilities; and Programmatic Mission–Other Areas, which encompasses other mission-related research facilities. The other categories are Support Services (heating, maintenance, supplies, etc.); Housing/Amenities; Ecology Plots; ANL Park (employee recreation area and a child care facility); and ANL Landfill (inactive). Although not given a formal designation (ANL 1994a), the tenth category is land located between the preceding nine categories. This category is Open Space where very little development has occurred, except for roads and utilities (ANL 1994b: 11). Environmentally sensitive areas, such as wetlands, are present within portions of this area. Figure 4.3.8.2-1 delineates the current land use categories and shows their distribution relative to the 10 major activity areas.

The land on and in the vicinity of the proposed SNS site is not being used for environmental research projects. The Ecology Plot land use designation refers to open, undeveloped land that would be potentially suitable for certain types of ecological research. However, the

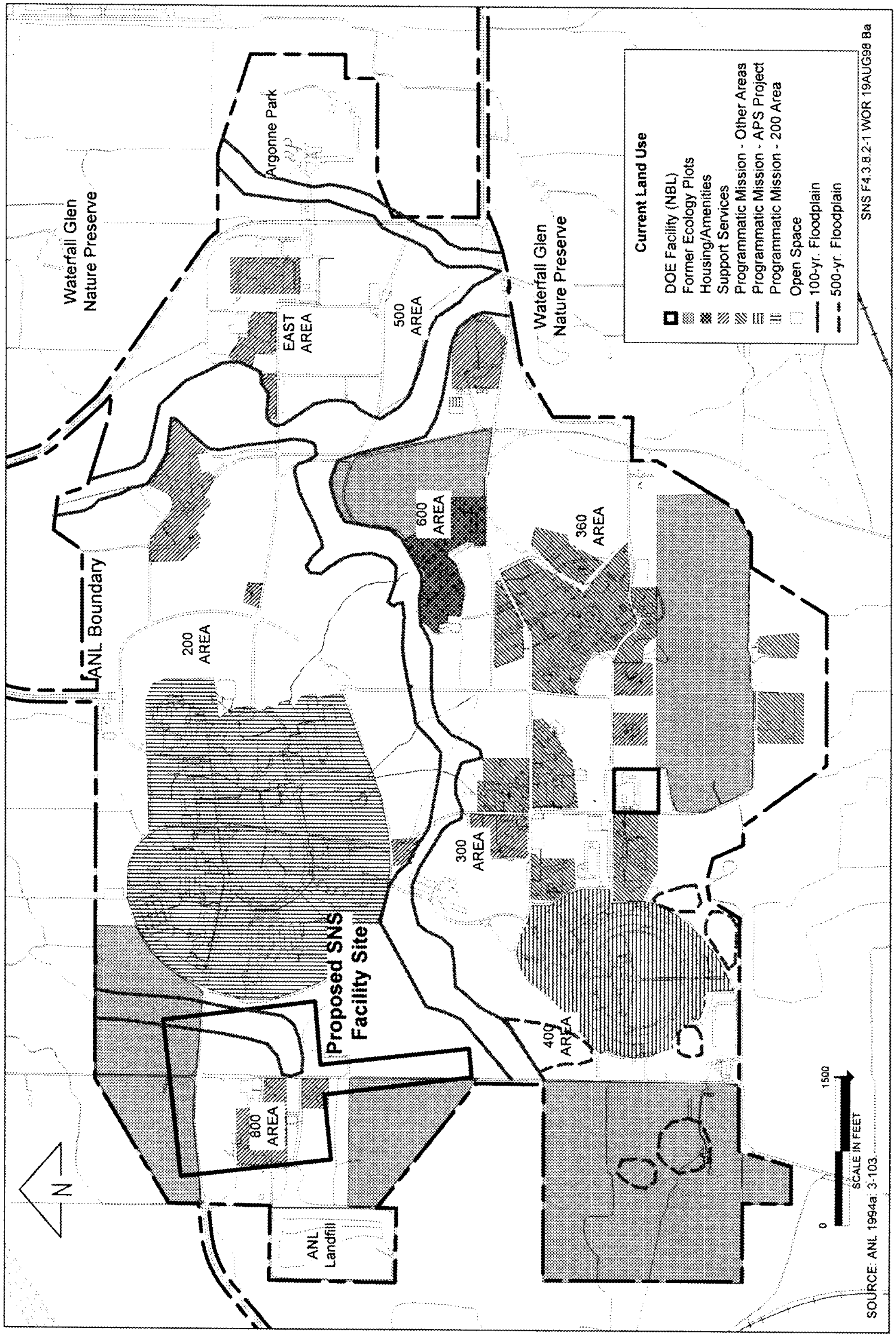


Figure 4.3.8.2-1. Map of current land use in ANL.

ecology plots have no official protection status relative to other areas of the laboratory, and little, if any, actual ecological research has ever been conducted in these areas. There are no currently on-going ecological research projects in Ecology Plot Nos. 6, 7, and 8 (LaGory 1998: 1).

The proposed SNS site overlaps portions of several current land use areas. These are Ecology Plot Nos. 6, 7, and 8 that support no current ecological research; Support Services (developed portions of the 800 Area); and Open Space (ANL 1994b: 11; LaGory 1998: 1). The relative proportions of land associated with these use designations on the proposed site are shown in Figure 4.3.8.2-1.

Three SWMUs and one AOC are located within the boundaries of the proposed SNS site in ANL. Another five SWMUs and two AOCs are located outside the proposed site but in relatively close proximity to it. All are formally identified, located, and described in Section 4.3.9.2.4. This description includes the current status of characterization and remediation efforts in each SWMU and AOC.

4.3.8.3 Future Land Use

Land use planning for the area surrounding ANL has been presented in the land use plan for DuPage County, Illinois. In the future, residential land use would continue to be predominant in this area. Smaller total areas of land would be used for Commercial, Office/ Research/Development, Manufacturing, Institutional, Open Space, and Transportation/ Commercial/ Utilities purposes. The large forest preserve immediately surrounding ANL would continue as the Waterfall Glen Nature Preserve. Moreover, its function as a buffer between ANL and nearby developed areas would continue (DuPage County 1985, as cited in ANL 1994a).

The plans for future land use in ANL reflect the pattern of past development at the laboratory and basic elements of the current land use pattern. These plans would involve continued expansion of current functional uses (programmatic research missions, housing/amenities, and support services) into dedicated expansion areas. These expansion areas would consume large portions of the existing open space at the laboratory. In addition, all of some ecology plots and portions of others would be used. However, the land use plan for ANL calls for the delineation and preservation of environmentally sensitive areas and retaining some open space and ecology plot land. These areas would function as permanent green belts or zones of transition between developed areas of the laboratory.

Future land use in ANL is zoned according to nine official categories. Three categories encompass the expansion of research facilities: Programmatic Mission–200 Area, land reserved for expansion of the current 200 Area office and laboratory facilities; Programmatic Mission–APS Project, land reserved for uses related to the APS; and Programmatic Mission–Other Areas, land reserved for special-purpose research and technology transfer facilities. The remaining categories are Support Services, Open Space, Environmentally Sensitive Areas, ANL Park, and ANL Landfill.

Figure 4.3.8.3-1 shows the future land use categories and zoning for ANL. A comparison of the future or dedicated land use zones on this map to the ecology plots and open space shown in Figure 4.3.8.2-1 reveals the amounts of current ecology plot and open space land slated

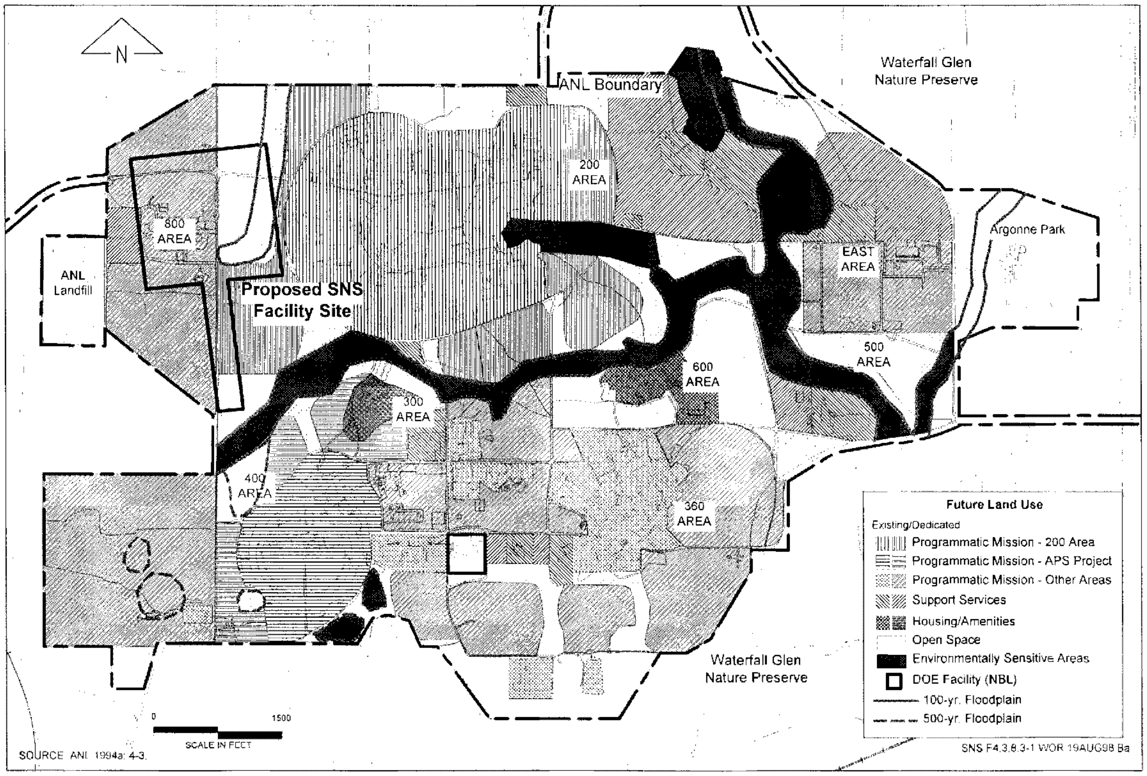


Figure 4.3.8.3-1. Land use zoning map of ANL.

for future expansion of laboratory facilities and operations.

The land on the proposed SNS site is distributed among five future land use categories—Programmatic Mission–Other Areas, Programmatic Mission–200 Area, Ecology Plot No. 8, Open Space, and Support Services. The largest category within the proposed site is Programmatic Mission–Other Areas, which would include portions of current Ecology Plot Nos. 6 and 7, two current support services areas (old 800 Area developments), and Open Space. The western edge of the proposed site overlaps a portion of SWMU-744, which is also within the Programmatic Mission–Other Areas category. The amount of proposed SNS site land within each zoning category is illustrated in Figure 4.3.8.3-1. The land immediately adjacent to the proposed SNS site is zoned for future use according to these same categories.

No future uses of proposed SNS site and vicinity land for environmental research are planned. The future use of Ecology Plot Nos. 6 and 7 for ecological research is precluded by their incorporation into zoning designations for future programmatic uses. No future ecological research is planned for Ecology Plot Nos. 6, 7, and 8 (LaGory 1998: 1).

4.3.8.4 Parks, Preserves, and Recreational Resources

A number of parks, nature preserves, and recreation areas are located outside ANL but in the general vicinity of the laboratory. Several forest preserves within the Forest Preserve

District of Cook County are located approximately 7 mi (11.3 km) east and southeast of ANL. They include McGinnis Slough, Saganashkee Slough, and a few smaller lakes. These areas are used by the public for picnicking, boating, fishing, and hiking (Golchert and Kolzow 1997: 1-16). Sawmill Creek and the Des Plaines River receive very little recreational use, but some duck hunting and fishing occur in areas downstream from ANL (Golchert and Kolzow 1997: 1-15; DOE-CH 1990: 32).

The principal recreation area near ANL is the Waterfall Glen Nature Preserve, which is adjacent to the laboratory on all sides. It contains 2,240 acres (907 ha) of largely forested land dedicated to ecological and forest demonstration activities, preservation of nature, and public recreation. The recreational opportunities in the preserve include hiking, skiing, and equestrian sports (DOE-CH 1990: 35; Golchert and Kolzow 1997: 1-16).

A portion of the southern ANL boundary is built around Saint Patrick's Cemetery. An area adjacent to the southwest boundary of ANL is used by visitors to the cemetery, occasional hikers, and model airplane enthusiasts who use the area for access to a field where their models are flown (DOE-CH 1990: 35).

The ANL Park is on laboratory land at the east end of ANL. This park is used for recreational activities by ANL and DOE employees. One of the local municipalities uses the park for athletic events (Golchert and Kolzow 1997: 1-16).

4.3.8.5 Visual Resources

The land in the vicinity of ANL is topographically flat. As a result, there are no naturally elevated vantage points that provide spectacular and varied views of the area. Because of the massive suburban development in the area, many ground level views of the landscape involve a mixture of buildings, roads, and utility features with trees and grassy open spaces. However, within natural areas, such as the Waterfall Glen Nature Preserve, pristine natural views are available. Because this densely forested nature preserve completely surrounds ANL, the laboratory is essentially hidden from the view of persons at ground level outside the preserve. However, developed areas of ANL are visible from some interior points within the preserve.

Most views within ANL are a varied mixture of research facilities, office buildings, roads, parking lots, tree stands, and cleared land with low vegetation cover. For persons inside ANL, the nature preserve creates a green visual backdrop around the laboratory perimeter.

The proposed SNS site and the land immediately surrounding it are largely clear of trees, which affords clear views of developments in the 800 Area and some other areas of the laboratory. These views are a mixture of roads, old buildings, existing buildings, open land with low vegetation cover, and a background of trees, especially in the direction of the nature preserve. The nature preserve is located approximately 400 ft (122 m) west of the proposed SNS site.

4.3.9 Radiological and Chemical Environment

This section describes the radiological and chemical environment at ANL.

4.3.9.1 Radiological Environment

The principal sources of radiation at ANL are: the APS; the Argonne Tandem Linac Accelerating System, which is a superconducting heavy ion linear accelerator; a 22-MeV pulsed electron linac; several other charged particle accelerators (principally Van de Graaff and Dynamitron types); the Intense Pulsed Neutron Source (IPNS), which is a large fast neutron source; chemical and metallurgical laboratories; and several hot cell laboratories.

4.3.9.1.1 Air

ANL operates under emission limits set for radionuclides, asbestos, and halogenated solvents by NESHAP. ANL uses continuously operating air samplers to collect samples of airborne particulate matter potentially contaminated by radionuclides. Radionuclides detected included hydrogen-3, carbon-11, nitrogen-13, oxygen-15, argon-41, krypton-85, radon-220 plus decay progeny, and a number of actinides. Of total dose from airborne pathway, 80% is due to Ra-220 and decay progeny. Air samplers are placed at 14 locations around the ANL perimeter and at 6 offsite locations to determine background concentrations. Currently nonradiological air contaminants in ambient air are not monitored.

From the air pathway, the dose to the maximally exposed offsite individual in 1996 was 0.053 mrem/yr, which is well below the EPA standard of 10 mrem/yr. The full-time resident who would receive this dose is located approximately 0.5 mi (0.8 km) north-northwest of the proposed site boundary. The cumulative population dose from gaseous radioactive effluents from ANL operations in 1996 was 2.64 person-rem to the population within a 50-mi (80-km) radius.

4.3.9.1.2 Water

Surface water quality is monitored by the collection of water samples from Sawmill Creek both above and below the point at which ANL discharges its treated waste into the creek and at several outfalls within the ANL boundary. Control samples are collected from the Des Plaines River and from remote locations during the spring and fall. The results of radiological analysis of water samples collected below ANL are compared to upstream and offsite results to determine ANL contributions. In 1996, the only surface water location where radionuclides attributable to ANL operations were detected was Sawmill Creek below the wastewater outfall. Although this water is not used for drinking water purposes, the 50-year EDE was calculated for the hypothetical individual ingesting water at the sampled location. The resulting dose was estimated to be 0.0343 mrem, which is well below the DOE standard of 100 mrem/yr.

Groundwater at ANL is monitored through the collection and analysis of samples obtained from a series of groundwater monitoring wells located near several sites that have the potential of causing groundwater impact. Samples are collected from 34 monitoring wells located near the 800 Area Landfill, the 317/319 waste management area, and the site of the inactive CP-5 reactor. The Illinois EPA-approved sanitary landfill groundwater monitoring program continues to indicate that the Ground Water Quality Standards of some routine indicator parameters are consistently being exceeded. Contamination in this area will be addressed under the RCRA Corrective Action Program under way at ANL.

4.3.9.1.3 Soils

ANL collects annual soil samples from 10 perimeter and 10 remote locations. Comparative soil sampling in 1996 indicated that average radionuclide concentrations were similar for offsite and onsite soils, supporting a conclusion that soil contaminants are the result of global fallout and not ANL operations. The average annual dose equivalent in the U.S. population from fallout is < 1 mrem.

4.3.9.1.4 Ambient Gamma Radiation

Measurements of gamma radiation emanating from several sources within the ANL are collected from 14 locations at the site perimeter and onsite and at 5 offsite locations. Above-normal fence-line doses attributable to ANL operations in 1996 were found at the southern boundary near the Waste Storage Facility. The closest residents are about 1 mi (1.6 km) south of the fence line. At this distance the dose rate, extrapolated from measured fence-line doses, was calculated to be 0.004 to 0.012 mrem/yr. At the fence line, where higher doses were measured, the land is wooded and unoccupied. Occasionally visitors may conduct activities near the ANL site boundary that could result in exposure to radiation from this site. Examples of these activities could be cross-country skiing, horseback riding, or running in the fire lane next to the perimeter fence. If the individual spent 10 min per week adjacent to the 317 Area boundary, the annual dose would be 0.03 mrem at the 317 Area fence. Longer presence would result in linearly scaled higher doses (10 min per day every day of the year would result in 0.2 mrem annually). This dose is well below the DOE standard of 100 mrem/yr.

4.3.9.2 Chemical Environment

The principal nonnuclear activities at ANL that have the potential to cause environmental impacts are the use of a coal-fired boiler, studies of the closed-loop heat exchanger for heat recovery, and the use of large quantities of chlorine for water treatment. The closed-loop heat exchanger studies involved the use of moderately large quantities of toxic or flammable organic compounds, such as toluene, freon, as well as others.

4.3.9.2.1 Air Pathway

Nonradiological contaminants in air are not currently monitored at ANL.

4.3.9.2.2 Water Pathway

Surface-water samples were collected from NPDES-permitted outfalls and Sawmill Creek and compared with permit limits and IEPA effluent standards. During 1996 permit limits were exceeded only two times, once each for zinc and iron. The results of chemical analyses are compared with applicable IEPA stream quality standards to determine if the ANL is degrading the quality of the creek. Nonradiological analyses performed in the vicinity of the proposed SNS site (800 Area) were conducted for outfalls in that area. Monthly monitoring showed no exceedances for storm-water runoff (flow, pH, temperature, oil, and grease) during 1996 (Golchert and Kolzow 1997).

4.3.9.2.3 Soil

Soils are not monitored for nonradiological contaminants as part of environmental surveillance activities at ANL.

4.3.9.2.4 Solid Waste Management Units

The 800 Area at ANL, the proposed location of the SNS, has served several functions during its history, but it has been primarily the grounds and transportation center, the vehicle maintenance center, as well as the location for one (or possibly two) sanitary landfills. As such, a number of sites within the 800 Area have been identified as being potentially contaminated with chemicals or construction debris. Table 4.3.9.2.4-1 lists the sites that are under active consideration (for example, these sites have not been remediated or determined not to impact the environment).

Some of the sites within the 800 Area have mitigated or proposed mitigation measures that would eliminate contaminant exposure by capping and isolating specific areas. Some of these areas would fall within the construction footprint of the proposed SNS (Figure 4.3.9.2.4-1).

4.3.10 SUPPORT FACILITIES AND INFRASTRUCTURE

The Support Facilities and Infrastructure section characterizes the local vehicular transportation routes around the proposed SNS site. The existing utilities that are available to provide needed services to support the proposed SNS are also described.

4.3.10.1 Transportation

ANL is located in DuPage County, Illinois, approximately 30 mi (48 km) from the city of Chicago. Figure 4.3.10.1-1 gives the location of the proposed SNS facility site and the transportation routes around the site. ANL is bordered on the north by I-55, on the east by State Highway 83, and to the south by State Highway 171, which intersects with Lemont Road. Lemont Road runs north-south on the western border of the site.

Onsite travel is provided by motor vehicle. However, within each area employees walk between buildings. Vehicular circulation is controlled by the existing road configuration, but road use during most of the day differs from that between 7 a.m. and 9 a.m., or 4 p.m. and 6:30 p.m., when employees are arriving or departing the ANL. The main (north) gate is open 24 hours a day, 365 days a year. The west gate is open Monday through Friday from 6:30 a.m. to 7 p.m. The east gate remains operable to alleviate potential bottlenecks caused by road maintenance and other related disruptions to normal flow. Many truck deliveries are made directly to the Supply Facility dock between Buildings 4 and 5 with fenced direct access from Cass Avenue. These deliveries do not contribute to onsite traffic. Other truck traffic is light so that only minor problems occur occasionally at entrance gates. At the present, no marked difficulties have been noted for onsite traffic either during peak periods of arrival and departure or during midday work hours. According to Illinois Department of Transportation standards, vehicle accumulation at intersections and gates is minor, even during rush hours.

Table 4.3.9.2.4-1. Active SWMUs in the vicinity of the SNS site[a] at ANL.

	Description	Status
SWMU 4	**800 Area Landfill** 21.78-acre landfill used for disposal of demolition debris, refuse, boiler-house ash, and other nonradioactive waste.	Because of proximity these three SWMUs have been combined—groundwater contamination of the dolomite aquifer observed—landfill was closed and capped in October 1993. An RCRA Facility Investigation was conducted and an extension to the 800 Area cap is proposed. IEPA is currently evaluating a NFA request that post closure care will identify any future releases or maintenance problems and that any remedial actions will be conducted as part of post closure care.
SWMU 20	**800 Area French Drain** From 1969-78 about 28,700 gal of liquid waste (organic and inorganic chemicals) were poured into a pipe inserted into a limestone bed located in NE corner of landfill.	
AOC-C	**800 Area Landfill Leachate Seep** Seeps escaped from the edge of the landfill and flowed into the accompanying wetlands (AOC-B) but have not been active since installation of the cap.	
SWMU 29	**Waste Oil Storage Area** Fenced area used since early 1980s for the storage of waste oil and lead-acid batteries—oil was contained in drums and a remaining UST.	Sampling has indicated a release has occurred and a Tier 1 analysis of data was started in December 1997 for both sites.
SWMU 170[b]	**Waste Oil Satellite Accumulation Area (Bldg. 815)** Waste oil accumulation for interim storage prior to transfer to Waste Oil Storage Area.	
SWMU 176[b]	**Scrap Metal Storage** From the 1950s to 1975 scrap metal and car batteries were placed in dumpsters in an area west of Bldg. 827—exact location is unknown—and nonhazardous and nonradioactive scrap was stored at this location.	Additional sampling was performed after surface and subsurface soils indicated a release had occurred—Tier 2 soil levels were exceeded for methylene chloride.
SMWU 182[b]	**Waste Oil Spread On Road** Until the 1970s waste oil was spread on one road that led to the landfill.	Request for NFA was denied by IEPA, and a Tier 1 analysis of data was started in December 1997.

Table 4.3.9.2.4-1. Active SWMUs in the vicinity of the SNS site[1] at ORNL (continued).

	Description	Status
SWMU 736[b]	**800 Area Transformer Storage Pad** Area east of Bldgs 821, 822, and 823 suspected as being a former transformer pad.	Sampling indicated that PCB concentrations were less than Tier 1 levels (25 mg/kg), but an NFA was denied. IEPA stated that a 10-in. cover was needed.
SWMU 744[b]	**Newly Identified, Suspected Solid Waste Landfill** Area northeast of the gate to the landfill suspected to contain buried waste material—dates of operation and quantities of waste are unknown.	A geophysical survey has concluded that buried metal occurs in two separate cells north and east of SWMU 29. Subsequent investigations were reported in the RFI Report
AOC-B	**800 Area Landfill Wetland Area** Located in SW corner of landfill.	Investigation indicated that contaminant levels are very low and no human receptors are at risk—preparing an NFA and ecological risk assessment.
AOC-F*	**Contaminated Soil near Bldg 827** USTs 18 and 19 near Bldg. 816.	During removal of tanks and adjacent soils for UST 18 and 19, soil contaminated from another source was discovered—work plan is in preparation to assess that source.

NFA **-** No further action.
PCB **-** Polychlorinated biphenyls.
UST **-** Underground storage tank.
[a]Source: Gowdy 1998.
[b]Sites located within footprint of the proposed SNS facility.

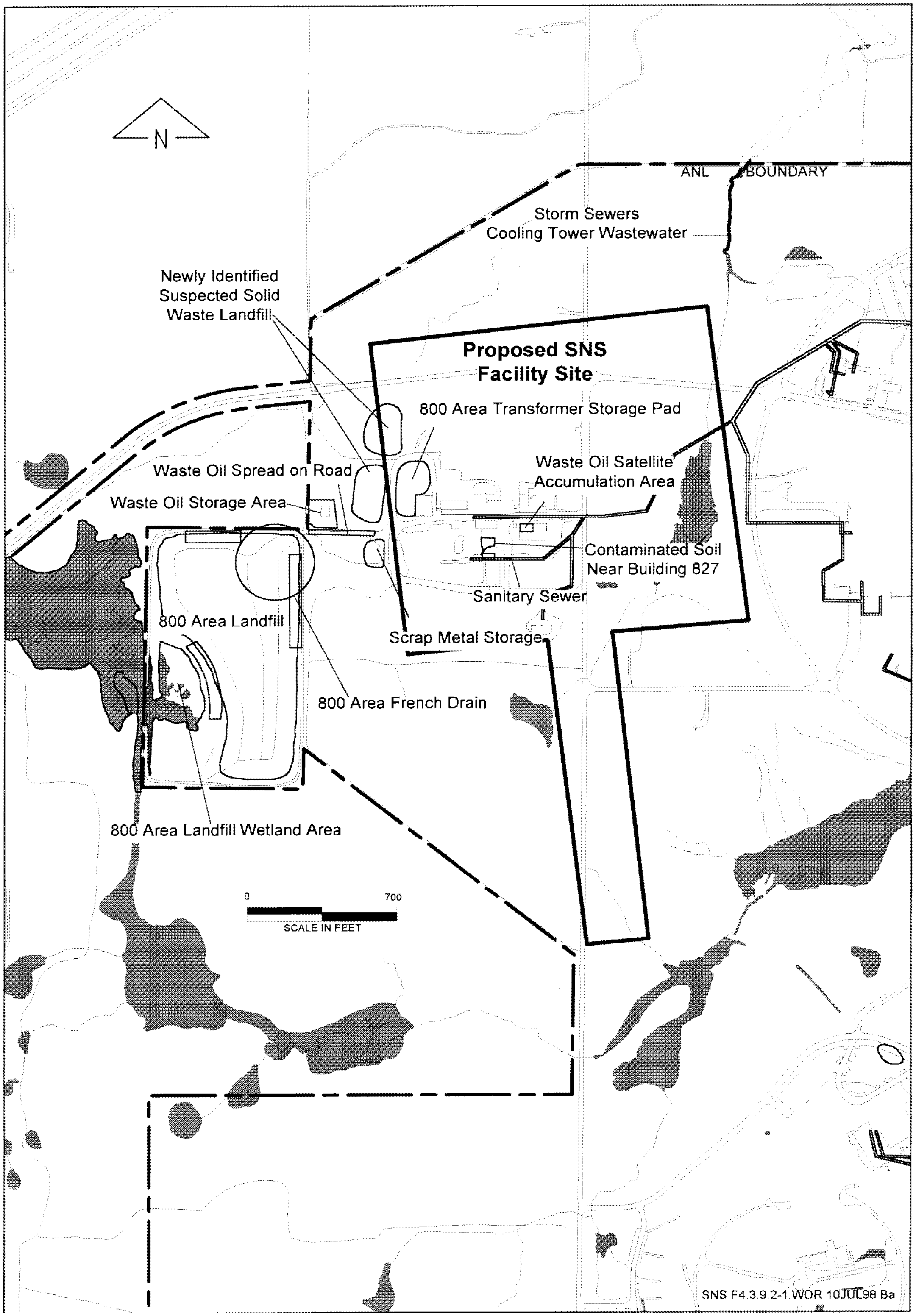


Figure 4.3.9.2.4-1. Locations of SWMUs in the 800 Area.

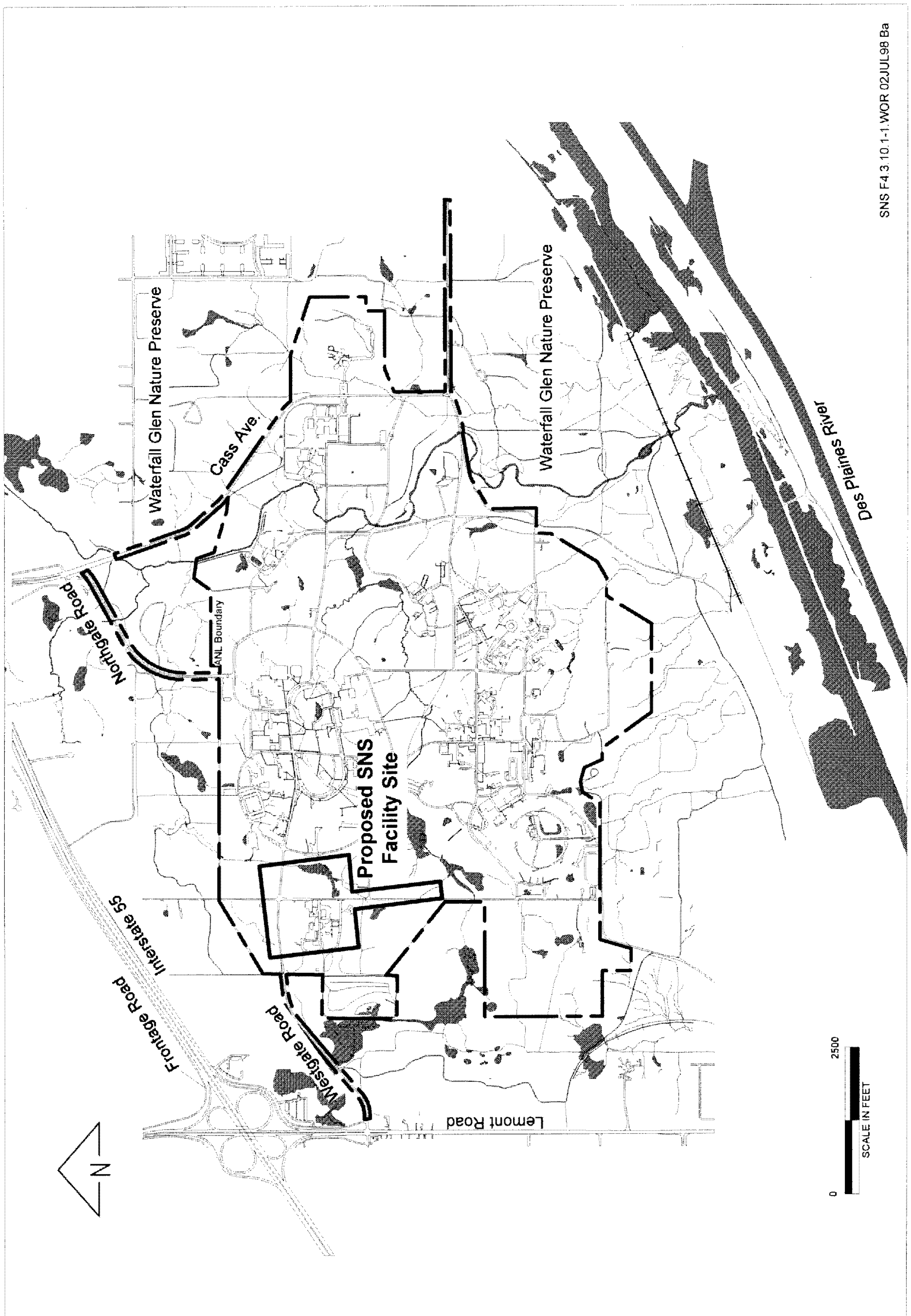


Figure 4.3.10.1-1. Transportation routes at ANL and surrounding areas.

4.3.10.2 Utilities

This section provides a description of the utility infrastructure at ANL. The following is based upon existing documentation and discussions with select ANL staff.

4.3.10.2.1 Electrical Service

ANL purchases electric power from the Commonwealth Edison Company (Edison) at 138 kV. Two Edison 138-kV lines enter ANL at Facility 543, located south of the laboratory. The majority of ANL's electricity needs are serviced by two 13.2-kV transmission lines that originate from Facility 543. The exception is the 300 Area, which uses a separate power distribution system to meet its heavy load requirements. A 138-kV overhead line connects the Edison line at Facility 543 to transformers at 549-A and -B in the 300 Area.

4.3.10.2.2 Steam

Steam is used primarily for central heating and for steam turbine-driven emergency generators. Most of the steam for ANL is produced at the Central Heating Plant (CHP) located in the 100 Area and distributed by an extensive piping network to a majority of onsite buildings. The CHP consists of five conventional (Wickes) boilers and various auxiliary systems. The CHP's maximum steam-generating capacity is 340,000 lb/hr of saturated steam at 200 psi. APS use is approximately 60,000 lb/hr (Fornek 1998a) ANL's present service distributes steam at 200 psig to all buildings onsite, where it is typically reduced to 15 psig for use in space heating and miscellaneous building services.

4.3.10.2.3 Natural Gas

Natural gas is distributed to ANL from a nearby high-pressure main. A 6-inch branch line supplies gas from the main to Building 108 at 150 psig. The gas pressure is reduced to 60 psig before being piped to the CHP. A branch line extends to the north side of the CHP where the site-wide gas supply is metered and pressure regulated to 10 psig. Gas is distributed to the site for use in laboratory areas and to boilers and furnaces that are not served by the central heating system. ANL plans to upgrade its natural gas distribution system around the site in 1999.

4.3.10.2.4 Water Service

Potable water at ANL is purchased from the DuPage County Water Commission. Nonpotable water is obtained from the Chicago Sanitary and Ship Canal, located south of the laboratory. Canal water is treated onsite and piped to a 250,000-gal (946,350-L) holding tank for distribution through the canal water distribution system. Water for domestic use and fire suppression is distributed through a common network that serves most of the site. The system has three elevated storage tanks and one ground-level storage tank with capacities of 500,000, 150,000, 300,000, and 650,000 gal (1.9 million, 567,810, 1.1 million, and 2.5 million L) respectively. The water system for laboratories is segregated from the domestic and fire water systems to prevent potential contamination from backflow. Laboratory water is stored in the 800 Area in a 75,000-gal (283,905-L) elevated tank. ANL currently has a remaining capacity of approximately 2 mgpd (7.6 million lpd) of nonpotable water. The existing capacity of the process wastewater treatment system is over 1 mgpd (3.8 million lpd). ANL currently treats about 300,000 gpd (1.1 million lpd) (Fornek 1998a).

4.3.10.2.5 Sanitary Waste Treatment

Sanitary sewage from various buildings is conveyed by underground sewers to the SWTP located at Bluff Road and Railroad Drive. The treatment facility has approximately 500,000 gpd (1.9 million lpd) of remaining capacity (Fornek 1998a).

4.4 BROOKHAVEN NATIONAL LABORATORY

Brookhaven National Laboratory (BNL), a 5,000-acre (2,024-ha) site, is located close to the geographical center of Suffolk County, Long Island, about 60 mi (97 km) east of New York City. The developed area is approximately 2.6 mi² (6.7 km²). There are more than 300 structures on the laboratory property. The balance of the site is largely wooded. BNL is in a section of the Oak-Chestnut Forest Region known as the Atlantic Coastal Plain Physiographic Province. BNL was established in 1947 at the former Camp Upton, a World War I and II Army training and recovery center. BNL evaluated four potential sites for the proposed SNS facility. The preferred site is situated in the north-central part of the reservation east of the Relativistic Heavy Ion Collider (RHIC) and west of the STP (see Figure 4.4-1).

4.4.1 GEOLOGY AND SOILS

This section identifies the characteristics of the geology and soils associated with the region.

4.4.1.1 Stratigraphy

Long Island shares many of the same coastal features common to the barrier island of Massachusetts, the New Jersey Coastal Plain, and coastal regions as far south as Cape Hatteras. Surface features of eastern Long Island were shaped by the cyclical advance and retreat of glacial ice during the late Wisconsin Stage of the Pleistocene Epoch. BNL is located on the Ronkonkoma Moraine and consists of undulating morainal topography of relatively low relief with erratics present throughout. The elevation of the area is approximately 82 ft (25 m) with a total relief of 30 ft (9 m). The area of greatest relief is in the southernmost portion of the site.

Remnant glacial features include the Harbor Hill Moraine and the Ronkonkoma Moraine as prominent topographic ridges near BNL. The Harbor Hill Moraine is oriented east-west and lies to the north of BNL. The Ronkonkoma Moraine is characterized by an irregular band of hills with elevations ranging from 100 to 180 ft (30 to 55 m) above mean sea level. The laboratory lies between moraines on a relatively flat outwash plain, with elevations ranging from 40 to 120 ft (12 to 37 m), and is situated on the west rim of the shallow Peconic River watershed.

BNL is underlain by a wedge of unconsolidated sediments that thickens and dips to the southeast toward the Atlantic Ocean. These unconsolidated sediments range in age from Late Cretaceous to Recent and rest unconformably on crystalline bedrock consisting of Precambrian-age metamorphic rocks. Surficial Holocene deposits of soil and bog accumulations occur locally throughout the island, but the province is primarily covered by

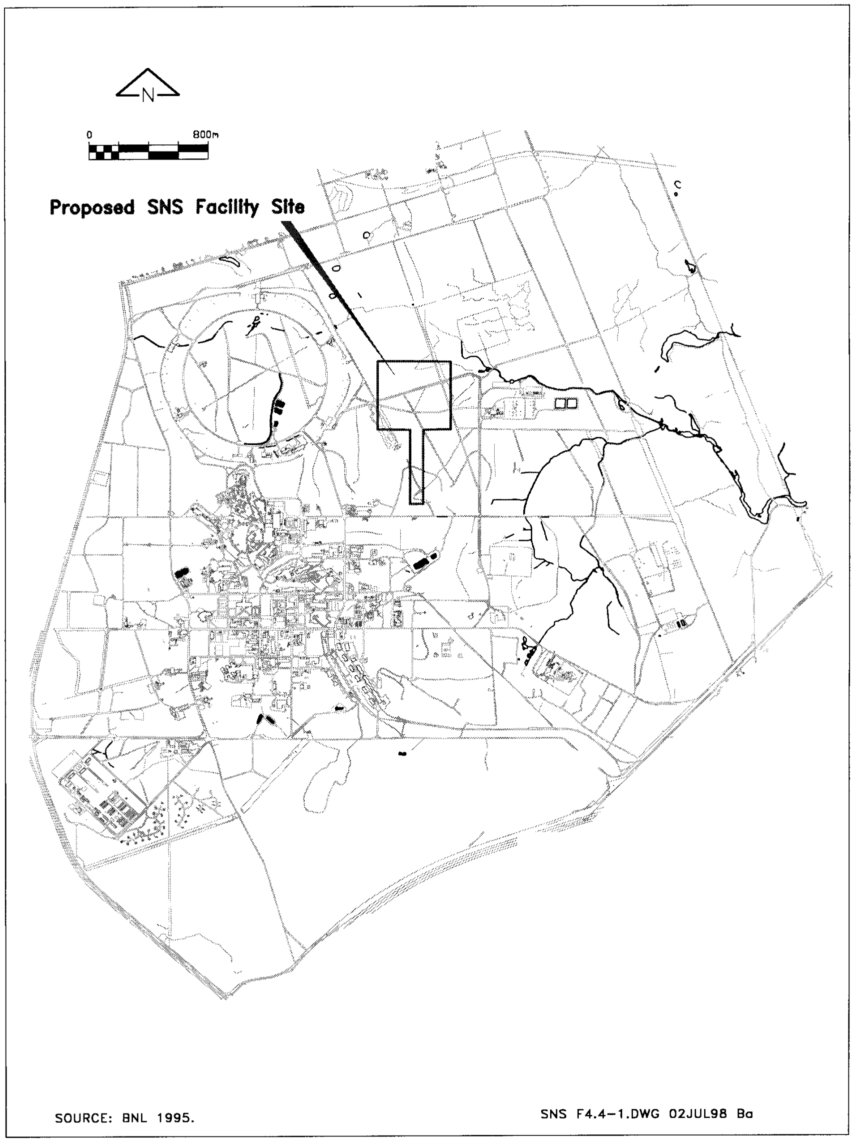


Figure 4.4-1. Proposed SNS site at BNL.

unconsolidated surface sediments that have been deposited and reworked by glaciation processes. Table 4.4.1.1-1 summarizes the stratigraphy in the vicinity of BNL.

Deposits of glacial origin cover the surface of the mid-island area, and range in thickness from 20 ft (6 m) to more than 600 ft (182 m) in buried valleys. Most of the glacial materials were deposited in Wisconsin time about 14,000 to 43,000 years ago and are collectively referred to as upper Pleistocene deposits. These deposits include terminal moraines, outwash deposits, ground moraine, and lake deposits. The Ronkonkoma terminal moraine marks the farthest advance of glaciation on Long Island. The moraine lies mostly above the water table and is composed of crudely stratified sand, gravel, and boulders. Outwash deposits derived from melted glacial ice lie south of the Ronkonkoma moraine. Some glacial lake deposits lie within outwash deposits but below

Table 4.4.1.1-1. Stratigraphy of Long Island, New York.[a]

Series	Geologic unit	Aquifer unit	Character of deposits	Water-bearing properties
Quaternary				
Holocene	Recent stream and salt marsh, alluvium and shoreline deposits	Recent deposits	Sand, gravel, clay, silt, organic mud, peat, loan, and shells.	Beach deposits are highly permeable; marsh deposits poorly permeable. Locally hydraulically connected to underlying aquifers.
Pleistocene	Upper Pleistocene deposits	Upper glacial aquifer	Till composed of clay, sand, gravel, and boulders, forms Harbor Hill and Ronkonkoma terminal moraines. Outwash deposits consist of quartzose sand, fine to very coarse, and gravel, pebble to boulder sized. Also contains lacustrine, marine, and reworked deposits.	Till is poorly permeable. Outwash deposits are moderately to highly permeable. Glacio-lacustrine and marine clay deposits are mostly poorly permeable but locally have thin, moderately permeable layers of sand and gravel. Average horizontal K=200ft/d.
	Gardiners Clay	Gardiners Clay	Clay, silt, and few layers of sand. Contains marine shells and glauconite.	Poorly permeable conditions constitute a confining layer of underlying aquifer. Sand lenses may be permeable.
Upper Cretaceous	Matawan Group-Magothy Formation; undifferentiated	Magothy aquifer	Sand, fine to medium quartzose, clayey in parts; interbedded with lenses and layers of coarse sand and sandy clay. Gravel in basal zones. Lignite, pyrite, and iron oxide common.	Most layers are poorly to moderately permeable; locally permeable. Unconfined in upper parts and confined elsewhere. Average horizontal K=50ft/d.
	Raritan Formation–unnamed clay unit	Raritan confining unit	Clay, solid and silty; few lenses and layers of sand. Lignite and pyrite are common.	Poorly to very poorly permeable; constitutes confining layer for underlying Lloyd aquifer. Average vertical K=0.001 ft/d.
	Raritan Formation–Lloyd Sand member	Lloyd aquifer	Sand, quartzose, fine to coarse, and gravel with clayey matrix; some lenses of solid and silty clay; contains thin lignite layers.	Poorly to moderately permeable. Confined aquifer conditions created by overlying Raritan clay. Average horizontal K=40/ft/d.
Precambrian	Bedrock	Bedrock	Crystalline metamorphic and igneous rocks; muscovite-biotite schist, gneiss, and granite. Soft clayey zone of weathered bedrock locally greater than 70 ft (21.3 m) thick.	Poorly permeable to impermeable; constitutes lower boundary of groundwater reservoir. Some hard freshwater in joints and fractures.

[a] IT and G&M 1997.

the land surface and occur mostly between the terminal moraines. Because of the varied materials carried by the glacier, outwash deposits are stratified but consist of a heterogeneous suite of rock types. The large diversity of rock and mineral types in the Pleistocene deposits along with the presence of chemically unstable mineral suites allows differentiation from Cretaceous deposits on Long Island.

The Gardiners Clay is a marine interglacial deposit of Sangamon age. It is composed of variable amounts of massive green clay; silty and sandy green clay; and clayey silt and sand. The representative color is derived from trace amounts of glauconite and green clay minerals. The Gardiners Clay has a representative microfossil assemblage that is distinctive from the Upper Pleistocene units and the underlying Magothy Formation. The northern limit of Gardiners Clay is located south of BNL; however, lobes of the clay extend to BNL. The irregular occurrence of the clay inland suggests that it was greatly affected by erosion.

The Monmouth Group is a Late Cretaceous age marine deposit consisting of a green to black clay, silt, or clayey to silty sand. It exists along the south shore of Long Island but is absent under BNL.

The undifferentiated Matawan Group/Magothy Formation comprises the Magothy aquifer of Long Island. This unit is composed of beds and lenses of fine to coarse, white to brown quartz sand with variable quantities of interstitial clay and silt. Interbedded layers of clay and silts are present, along with pyrite and lignite. The surface of this unit is highly irregular because of erosion during Tertiary and Pleistocene times. Depth to the upper surface of the Magothy aquifer range from about 100 to 500 ft (30.5 to 152.4 m).

The Late Cretaceous Raritan Formation is subdivided into the Lloyd Sand and the Raritan Clay. The Lloyd Sand overlies the bedrock and is approximately 300 ft (91 m) thick. The Lloyd Sand consists of coarse to fine quartzose sand with gravel and interbedded clay. The Raritan Clay overlies the Lloyd Sand and is approximately 200 ft (61 m) thick beneath BNL. The Raritan Clay is comprised of lignitic clay with some silt and sandy clay and lenses of sand and gravel. The Clay is present throughout Suffolk County and mimics the surface of the Lloyd Sand and underlying bedrock.

Two deep U.S. Geologic Survey exploratory wells encountered bedrock at approximately 1,600 ft (488 m) below the land surface at BNL. The bedrock consists of a banded granitic gneiss without significant primary porosity and with no indication of fracturing that would provide appreciable amounts of water. The bedrock slopes to the southeast, and represents an advanced erosional surface with little relief. It is overlain by remnant paleosoil consisting of a tough white clay.

4.4.1.2 Structure

No structures are preserved in the unconsolidated surface sediments of Long Island, and there are no known active faults in the Long Island area. Data for bedrock is limited for the BNL and elsewhere on the island by the lack of well penetrations. It is assumed to be similar to bedrock outcrops exposed on the mainland in nearby parts of New York and Connecticut. The basement rocks have a maximum relief of about 100 ft (30 m) except where modified by erosion in Pleistocene or

Recent time. The low relief and localized weathering of the bedrock suggests that the surface had reached an advanced stage of peneplain. The bedrock surface slopes southeast at about 80 ft/mi (15 m/km), and its relief in the vicinity of BNL is not expected to be greater than 50 to 100 ft (15 to 30 m).

4.4.1.3 Soils

The Soil Survey of Suffolk County, New York, (IT and G&M 1997) has mapped several soil units across the BNL. The Plymouth Series is a deep, well-drained, coarse-textured sandy soil. It typically forms in a mantle of loamy sand or sand over thick layers of stratified coarse sand and gravel. These soils have very low available moisture capacity and rapid water intake. The soil type occurs on moraines and outwash plains. Slopes range from zero to 35 percent, and colors range from dark grayish brown to yellowish brown with depth.

The Carver Series consists of deep, excessively drained, coarse-textured sandy soils. This series is similar to, and often associated with, the Plymouth Series but contains more iron and humus. These soils also have slopes ranging from zero to 35 percent and are typically found on moraines and outwash plains. Color ranges from gray near the surface to brown and yellowish brown with depths greater than 8 in. (20 cm).

The Riverhead Series is a deep, well-drained, moderately coarse-textured soil that forms over stratified coarse sand and gravel. These soils occur on moraines and outwash plains and can have slopes ranging from zero to 15 percent. Riverhead soils are less sandy than Plymouth and Carver soils.

The Haven Series is a deep, well-drained, moderately coarse-textured soil that forms over stratified coarse sand and gravel. The soils most commonly occur between moraines and have slopes that range from zero to 12 percent. Haven Series soils are also less sandy than the Plymouth Series.

The southern portion of BNL is dominated by the Riverhead Series and grades into a mixture of Riverhead and Haven Soil near the center of BNL. The northern part of BNL, including the proposed site for the SNS, is covered by Plymouth loamy sands. Limited areas of Haven and Riverhead Series soils are present west of the proposed SNS location.

Approximately 69 acres (28 ha) are currently used for growing crops at BNL for biological research. While no future expansion of this use is anticipated (BNL 1996), identical soils and environmental conditions exist in open spaces of the BNL reservation which could be considered prime farm lands.

4.4.1.4 Stability

Construction of the proposed SNS would not be affected by site stability problems at BNL. The soil material is excellent for construction and there are no foundation or other associated problems. Soil conditions typically provide for 6,000-psi design loads (Schaeffer 1998). Neither soil liquefaction nor subsidence is a potential problem in this area. Because of the gentle rolling topography, landslides are not common to the site.

BNL is in an area of quiescent seismic activity compared to other potential sites for the proposed SNS (Figure 4.3.1.4-1). A seismic assessment suggested that a peak ground acceleration (horizontal) of 0.2 gravity be used for the Design Basis Earthquake for the High-Flux Beam Reactor (HFBR) (Kelley 1998). A study for Shoreham Nuclear Power Plant indicates that 26 earthquakes have been capable of being felt at the site with an intensity of IV [Modified Mercalli (MM)] or greater. Four major earthquakes located more than 200 mi (322 km) from the site are estimated to have been felt with a maximum intensity at BNL of IV (Table 4.4.1.4-1).

Within a 200-mi (322-km) radius of the site, five earthquakes have been noted that may have influenced the site with an intensity of IV (MM) or slightly greater (Table 4.4.1.4-2).

It is indicated that 90 earthquakes are known to have occurred within 50 mi (80 km) of the site historically, but only two of these earthquakes were actually felt onsite (Table 4.4.1.4-3).

4.4.2 WATER RESOURCES

The following section discusses the water resources at BNL.

4.4.2.1 Surface Water

BNL is near the western boundary of the Manorville drainage basin and contains the headwaters of the Peconic River (Figure 4.4.2.1-1). Surface drainage is poor in the

Table 4.4.1.4-1. Earthquakes greater than 200 mi (322 km) from BNL.

Date	Location	Intensity
June 11–12, 1638	Three Rivers, Quebec	IX
February 5, 1663	St. Lawrence Valley (Quebec City)	X
September 16, 1732	Montreal, Canada	IX
March 1, 1925	St. Lawrence Valley (Quebec City)	IX

Table 4.4.1.4-2. Earthquakes less than 200 mi (322 km) from BNL.

Date	Location	Intensity
November 10, 1727	Cape Ann, Mass.	VII
December 18, 1737	New York, N.Y.	VII
November 18, 1755	Cape Ann, Mass.	VIII
May 16, 1791	East Haddam, Conn.	VI–VII
August 10, 1884	New York, N.Y.	VII

Table 4.4.1.4-3. Earthquakes within 50 mi (80 km) from BNL.

Date	Intensity	Estimated BNL Intensity
May 16, 1791	VI-VII	IV-V
July 19, 1937	IV	III

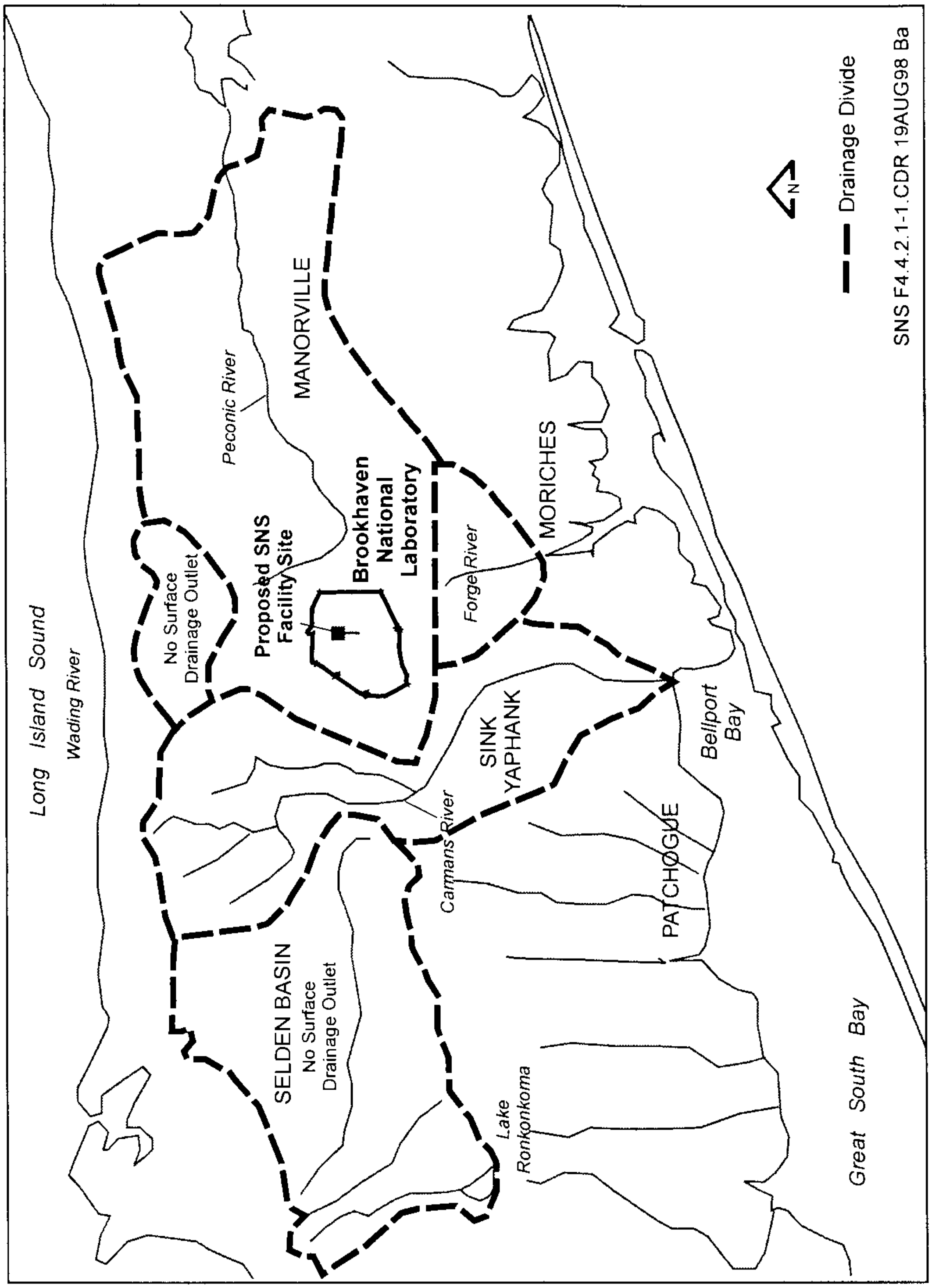


Figure 4.4.2.1-1. Drainage basin surrounding BNL.

Manorville basin which accounts for the marshy and swamp areas near the river. East of the Manorville drainage basin, the Peconic River valley widens and forms the Riverhead Basin. The Peconic River drains in an easterly direction and flows into Flanders Bay, an arm of the Great Peconic Bay. Like other coastal-plain streams, the Peconic River is a low-gradient, low-velocity stream with slightly acidic waters and a moderate-to-dense growth of aquatic vegetation. Stream flows are heavily influenced by groundwater levels, with discharge of groundwater to streams during periods of high rainfall and infiltration of stream flow during periods of low rainfall. The marshy area in the northern and eastern section of BNL has the potential to be a principal tributary of the Peconic River. However, this tributary has been essentially dry during the regional drought over the past 10 years. It should be noted that there has been no year-round sustained flow from BNL since 1983 (Naidu et al. 1996) even with the contribution of 242 million gal (916 million L) from the STP.

Coastal-plain ponds are naturally occurring or manmade ponds with permanent standing water. A number of such ponds with water depths usually less than 4 ft (1.22 m) occur in the northern portion of BNL. In addition, cooling and industrial process water recharges the groundwater system via discharge into small streams or man-made recharge basins.

One-hundred-year floodplains and wetlands encompass approximately 346 acres (140 ha) of the BNL site, mostly in the areas bordering the headwaters of Peconic River. The 100-year flood maps of the Federal Emergency Management Agency's National Flood Insurance Program indicate that in the vicinity of the Relativistic Heavy Collider, immediately west of the proposed SNS location, the elevation of the 100-year floodplain is approximately 52.5 ft (16 m) above mean sea level.

Land bordering the Peconic River up to 0.5 mi (0.8 km) from the river's bank is regulated by New York State because of its designation as "Scenic" under the State's Wild, Scenic and Recreational Rivers Systems Act. Freshwater wetlands in the north and east quadrant of the BNL reservation remain in an area once part of a principal tributary to this river system. The Peconic River is not used for a drinking water supply or for irrigation.

4.4.2.2 Groundwater

The groundwater system beneath Long Island exists as a distinct well-defined system delineated by natural hydrologic boundaries. The upper boundary is defined by the water table surface [at about 45+ ft (13.7 m) mean sea level] in the Upper Glacial sediments modified by the numerous streams and surface water bodies that intersect the water table. The base of the system is bounded by the impermeable crystalline bedrock surface. The entire system is bounded laterally by salty groundwater and saltwater bodies. Along the shore, groundwater discharges from the upper glacial deposits flow directly into these saltwater bodies. Offshore, fresh groundwater flows vertically upward across the confining layers. Where the overlying groundwater is salty, the water discharges from the fresh system and mixes with salty groundwater. These areas are referred to as subsea discharge boundaries and are considered part of the lateral groundwater system boundaries. Under natural conditions, all water enters and leaves the groundwater system across these boundaries.

Precipitation on Long Island averages 45 in. (114 cm) per year, of which 23 in. (58 cm) recharges to replenish the groundwater. Trending east-west, the main groundwater divide for Long Island lies about 1 to 2 mi (1.6 to 3.2 km) north of BNL (Figure 4.4.2.2-1). Water entering the groundwater system north of the divide generally flows north into the Long Island Sound. Water entering the system south of the divide (including BNL) flows south and/or east toward the Peconic River, the Forge River, the Carmans River, or toward the south shore of Long Island. Groundwater eventually discharges either into the rivers or directly into the Great South Bay or the Atlantic Ocean across a subsea discharge boundary. The higher water table to the west of the BNL area generally inhibits westward movement.

The hydrogeologic units (Figure 4.4.2.2-2) that comprise the groundwater system are the Upper Glacial aquifer, the Gardiners Clay (aquitard), the Magothy aquifer, the Raritan confining unit, the Lloyd aquifer, and the crystalline bedrock (confining unit). Groundwater in the Upper Glacial aquifer exists under unconfined conditions except where locally continuously clay lenses create semi-confined conditions. When the Magothy aquifer is overlain by the confining Gardiners Clay unit (south of BNL) groundwater exists under confined conditions. Where the Magothy is in direct hydraulic connection with the Upper Glacial aquifer, semi-confined to confined conditions are present from localized clay layers. The Lloyd aquifer is under confined conditions as a result of the continuous presence of the overlying Raritan Clay unit. Limited recharge is available to support the Lloyd aquifer, and therefore, it is very sensitive to pumpage and drawdown.

McClymonds and Franke (IT and G&M 1997) have estimated the distribution of hydraulic conductivities (K) from pump tests for the three primary aquifers underneath Long Island. The Upper Glacial aquifer has the highest and greatest range of horizontal hydraulic conductivity values (K) 20 to 300 (0.007 to 0.106 cm/s) which reflects the variations in the unconsolidated deposits. Stratification in this unit is common, yielding varied values at different locations and depths. The stratification also has a pronounced effect on the vertical K with a 10:1 ratio of horizontal to vertical hydraulic conductivity. The K of the Magothy aquifer ranges from 30 to 80 ft/d (0.011 to 0.028 cm/s) for the thicker upper zone and 45 to 120 ft/d (0.016 to 0.042 cm/s) for a coarse basal sand unit. Ratios of horizontal to vertical K approach 100:1 because of the stratified nature of the Magothy. The Lloyd aquifer is estimated to have a K in the 35 to 75 ft/d (0.012 to 0.027 cm/s) range with horizontal to vertical ratios of 100:1. Approximations of K for the confining unit are several orders of magnitude less than for the aquifers (0.01 to 0.001 ft/d).

Horizontal groundwater flow directions across BNL are generally south to southeast (see Figure 4.4.2.2-3). The overall groundwater table gradient from the northwest corner to the southern boundary of BNL averages 0.001. Using 160 ft/d (0.056 cm/s) as the mean value of the range of K estimates [20 to 300 ft/d (0.007 to 0.106 cm/s)] for the Upper Glacial aquifer and a porosity of 0.33 (Warren et al. 1963), a horizontal groundwater velocity is calculated to be 0.48 ft/d. This calculation is in close agreement with the results (0.53 ft/d) of a tracer test reported by Warren (Warren et al. 1963), where the velocity of an injected solution of ammonium chloride was recorded between two

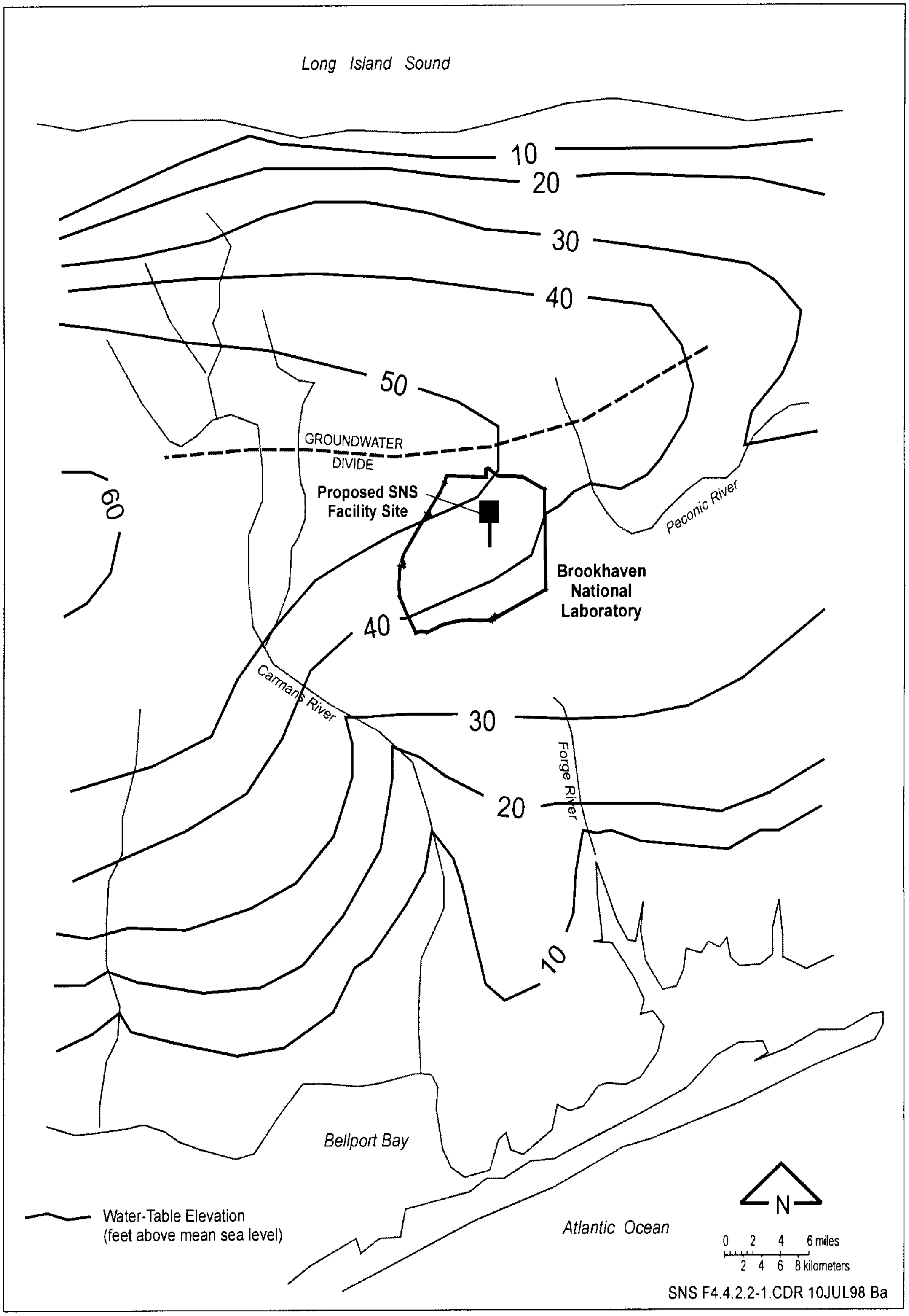


Figure 4.4.2.2-1 Groundwater divide in vicinity of BNL.

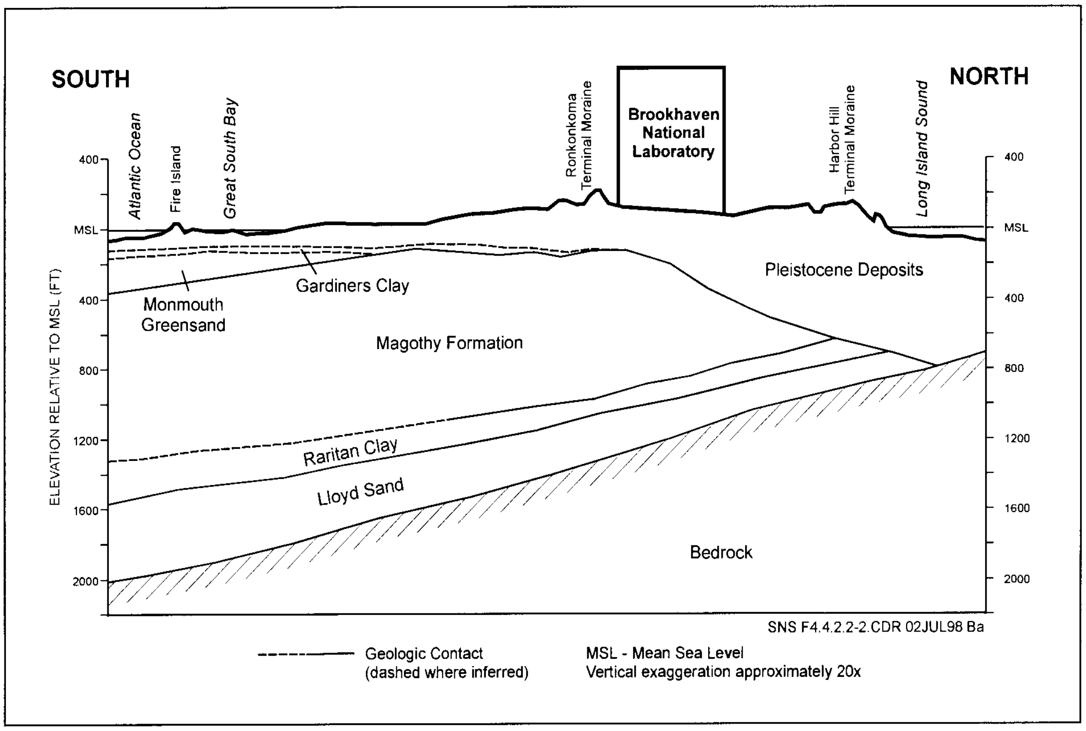


Figure 4.4.2.2-2. Stratigraphic cross section through Long Island and BNL.

shallow wells. Data for the Magothy aquifer suggests a velocity range of 0.1 to 0.2 ft/d for horizontal groundwater flow, but the confidence of measurements is not as reliable as in the upper aquifer. Based on a 24-hr pump test, the velocity of the Lloyd aquifer is estimated to be 0.025 ft/d, substantially less than in either of the principal overlying aquifers (Warren et al. 1963).

Six wells (BNL-4, 6, 7, 10, 11, and 12) were used to supply potable water at BNL during 1995 (Naidu et al. 1996). Monitoring requirements included quarterly analyses for principal organic compounds; monthly bacteriological analyses; annual analysis for asbestos, micro-extractables, synthetic organic compounds, and pesticides; and semiannual inorganic analyses. Review of the data shows the BNL potable water supply to meet all New York State Drinking Water Standards (NYSDWS) in 1995.

In addition, BNL's Safety and Environmental Protection Division maintains a comprehensive sampling and analysis program for the potable water supply system. Specific analyses include: pH, conductivity, chlorides, sulfates and nitrates for water quality; Ag, Cd, Cr, Cu, Fe, Hg, Mn, Na, Pb, and Zn for metal analysis; and chloroform, dichloroethylene, 1,1,1 trichloro-thane, and trichloroethylene for volatile organic analysis. Their monitoring showed that water quality parameters met NYSDWS. Values for pH range from 5.8 to 6.6 which are typical for Long Island, but water from three wells is adjusted to reduce the corrosivity of the groundwater. The majority of metals were not detected in the potable water supply wells. Common constituents, such as Mn, Cu, Pb, and

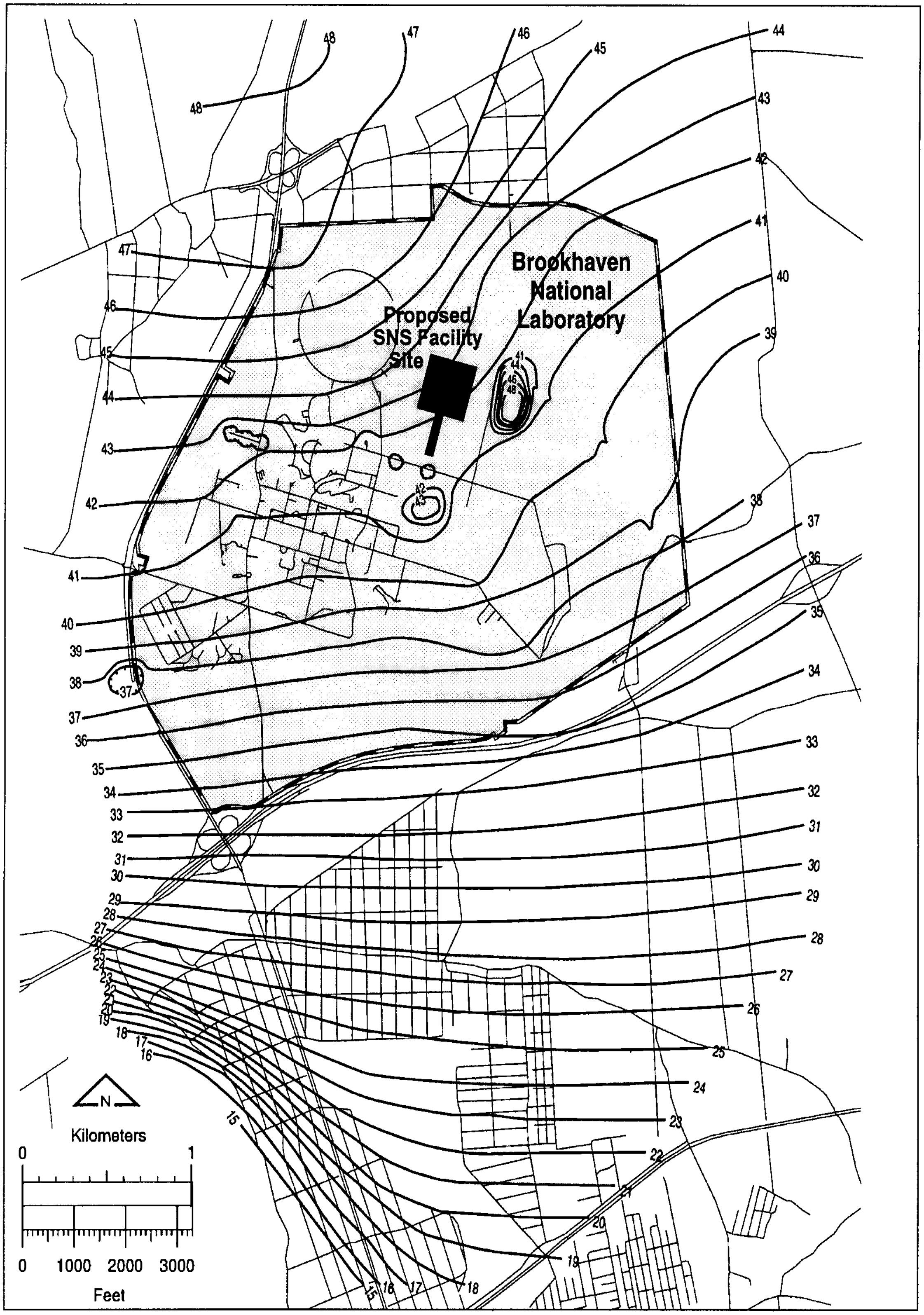


Figure 4.4.2.2-3. Water table contour map for the BNL site.

Zn, were observed at levels below their respective NYSDWS. Sampling of the water supply wells at the well-head showed that of 10 organic compounds, only chloroform and TCA were detected in the potable wells. However, only TCA exceeded the NYSDWS, and Well No. 11 is fitted with a carbon-adsorption treatment system that reduces the concentration to acceptable levels.

During 1995, 1,715 groundwater samples were taken from over 200 surveillance wells and over 100 temporary vertical profile wells at various waste sites at BNL. These samples were analyzed for constituents similar to the potable and process wells. Results indicate that except for pH, water quality parameters are below the New York State Ambient Water Quality Standards (AWQS) even in areas of potential contamination. Metal and volatile organic compounds (VOCs) exceed AWQS in a number of areas across the site. The VOCs are usually traceable to known spills or chemical-waste storage or former disposal areas. In several areas of BNL, iron is above AWQS reflecting natural background concentration. However, in areas such as the Current Landfill (closed in 1990), elevated iron and sodium concentrations are related to releases from the landfill.

Groundwater wells in the immediate vicinity of BNL's preferred site for the proposed SNS indicate slightly elevated levels of iron and sodium.

Long Island's drinking water supply comes from groundwater. Long Island's Upper Glacial Aquifer has been designated as a sole source aquifer by the EPA.

Human consumption utilizes 4 percent of the total pumpage. Approximately 70 percent of the total pumpage is returned to the aquifer through onsite recharge basins, and about 15 percent is discharged into the Peconic River. The area occupied by BNL was identified by the Long Island Regional Planning Board and Suffolk County as being over a deep-flow recharge zone for Long Island. It is estimated that 50 percent of the precipitation recharges the lower aquifer systems (Magothy and Lloyd aquifers) lying beneath the Upper Glacial Aquifer.

4.4.3 CLIMATE AND AIR QUALITY

BNL has a climate typical to most eastern seaboard areas. Temperatures average 49.7 °F (7 °C) on an annual basis, but have ranged from a low of –23 °F (–30 °C) in 1961 to a high of 100.5 °F (38 °C) in 1991. By comparison, the average temperature in 1995 was 51 °F (10.6 °C) and the range was 44 °F (6.9 °C) to 84 °F (29.1 °C). Precipitation averages 48.13 in. (122 cm) per year with a maximum of 68.66 in. (174 cm) and a minimum of 34.55 in. (87 cm) since 1949 (Figure 4.4.3-1). Snowfall averages about 30.2 in. (76 cm) per year with a maximum annual accumulation recorded at 90.8 in. (230 cm) in the 1995-96 season. The months of December through March account for the majority of accumulations.

4.4.3.1 Severe Weather

The most severe weather for Long Island is related to hurricane occurrences with associated winds and precipitation. The peak wind speed at BNL was recorded during Hurricane Carol at 125 mph (201 km/hr) in 1954. Similarly, the maximum hourly [2.1 in. (5.3 cm)] and daily [9.02 in. (22.9 cm)] precipitation were recorded during Hurricane Edna in 1954. In addition,

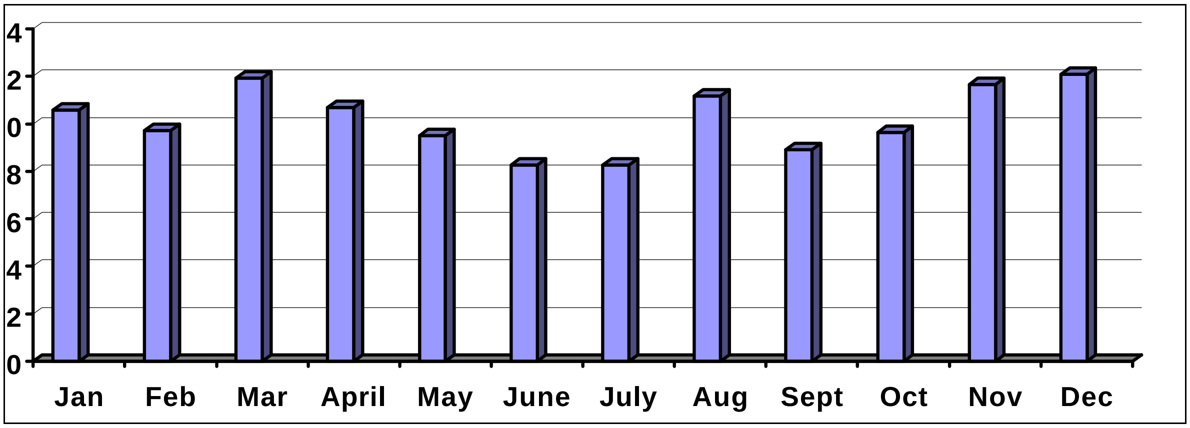


Figure 4.4.3-1 Average monthly precipitation at BNL.

Suffolk County has experienced 10 tornadoes during the 1950 to 1995 period (refer to Figure 4.1.3.1-1). However, the severity of these tornadoes has been relatively minor (F0-3, F1-6, F2-1) as measured on the F-scale.

4.4.3.2 Atmospheric Dispersion

BNL can be characterized as a well-ventilated area. The prevailing ground level winds are from the southwest during the summer, from the northwest during the winter, and about equally from these two directions during the spring and fall. Figure 4.4.3.2-1 displays an annual wind rose diagram for BNL (Naidu et al. 1996).

4.4.3.3 Air Quality

Existing ambient air quality in the vicinity of BNL is best quantified in terms of recent ambient monitoring data collected by the New York State Department of Environment Conservation (NYSDEC) at nearby locations. Table 4.4.3.3-1 summarizes these data and is taken from *New York State Air Quality Report: Ambient Air Monitoring System* (1997) for 1996.

4.4.4 NOISE

The SNS site is proposed for the north-central portion of the BNL reservation, which is situated between the STP and the RHIC. The proposed site is removed from the main area of offices, laboratories, and onsite workers. Ambient noise levels are not available for the proposed SNS site (Note: The RHIC will not be operational until 1999). Sensitive populations would include onsite workers and offsite residential populations. Approximately 8,000 residents live within 0.3 mi (0.5 km) of BNL's boundary, and the proposed SNS would be positioned roughly 1 mi (1.6 km) from the northern border and 2 mi (3.2 km) from the southern border. Natural buffering of sound levels is provided by the undeveloped forested buffer zone between the laboratory property and residential development.

4.4.5 ECOLOGICAL RESOURCES

This section provides a general description of the ecological resources for the proposed SNS site and the surrounding area. The discussions

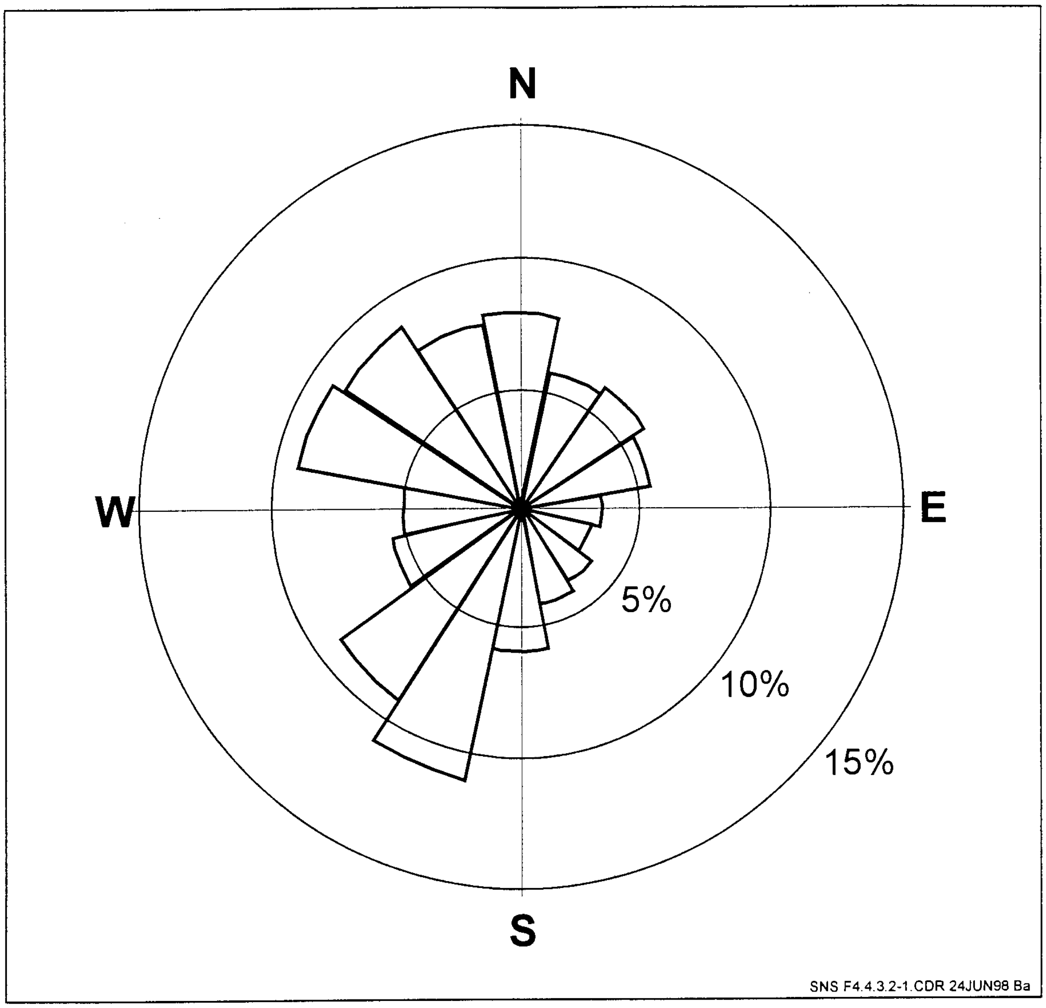


Figure 4.4.3.2-1. Annual wind rose for BNL during 1995.

are based on information readily available from other sources. Site-specific surveys were done for protected species and wetlands. All other information was obtained from existing publications. For the most part, the impacts from construction and operation of the proposed SNS would be minor. Therefore, much of the information presented here is summary in nature. Greater detail can be obtained from the references compiled for this section.

4.4.5.1 Terrestrial Resources

The proposed SNS site at BNL lies within the Long Island Pine Barrens (see Section 4.4.8.4).

The southern portion of the proposed site consists of a stand of white pine *(Pinus strobus)* apparently planted during the 1930s, most likely as a Civilian Conservation Corps project. Communities composed of planted white pine

Table 4.4.3.3-1. Summary of 1996 monitoring data in the vicinity of BNL.

Pollutant Averaging Time	Nearest Monitor Location	Maximum 1st	2nd	3rd	4th	NAAQS NYAAQS	Number of Exceedances
PM-10 24-hour	Babylon 41 km SW	57.0	40.0	34.0	—	150.0 μg/m^3	0
TSP 24-hour	Oster Bay 55 km NW	61.0	60.0	50.0	—	150.0 Sec. 260.0 Pri. μg/m^3	0
Ozone 1-hour	River Head 19 km NE	0.121	0.116	0.102	0.101	0.12 ppm	0
NO_x Annual	Eisenhower Park 68 km SW	0.026	—	—	—	0.05 ppm	0
SO_2 3-hour	Babylon 41 km SW	0.085	0.050	0.043	—	0.5 ppm	0
24-hour		0.029	0.025	0.024	—	0.14 ppm	0
CO 1-hour	Eisenhower Park 68 km SW	6.9	6.6	6.6	—	35.0 ppm	0
8-hour		5.8	4.9	4.3	—	9.0 ppm	0

Source: NYSDEC 1997. NYAAQS – New York Ambient Air Quality Standards.

are common in Suffolk County. Self-sown pitch pine *(Pinus rigida)* is scattered within this area. The understory consists of huckleberry *(Gaylussacia* sp.*)* with lesser amounts of blueberry *(Vaccinium* sp.) but is sparse because of shade and pine needle litter. Occasional oaks *(Quercus* sp.) are found along the edges of the firebreaks and lanes in this area. A native oak-pine woodland is present just north of the white pines.

There is evidence of extensive disturbance associated with operations at Camp Upton during World War I. These disturbed areas include an extensive system of trenches, as well as a complex of deep pits and banks that are found within a narrow area of the site and the adjacent buffer zone. Mounded areas formed in the course of trenching operations are vegetated by large white pines. Confirmation that these areas were disturbed during World War I comes from the presence of the white pines planted in the 1930s. These pines are presently overgrowing the trenches and pits.

In the extreme southern portion of the proposed SNS site, there is an assemblage of species not found elsewhere on the proposed site. These species include introduced ornamental shrubs, such as Japanese barberry *(Berberis thunbergii)* and jetbead *(Rhodotypos scandens),* as well as black locust *(Robinia pseudoacacia).* The native red maple *(Acer rubrum),* wild black cherry *(Prunus serotina),* and grape (*Vitis* sp.) are also present. The presence of these species may be the result of the somewhat moister conditions within the deep pits.

In the more open areas along the firebreaks and lanes throughout this area the vegetation primarily consists of broomsedge *(Schizachyrium* sp.*),* sedges (*Carex* spp.), including the Pennsylvania sedge *(C. pensylvanica)* and lichens *(Cladina* sp.*).*

The remainder of the proposed site is composed of pine-oak or oak-pine communities. In the pine-oak community, pitch pine may make up as much as 90 percent of the total population. The only obvious recruitment of new individuals is along the edges of the firebreaks and lanes where pitch pine saplings are common.

The oaks inhabiting the entire site are predominantly scarlet oak *(Q. coccinea)* and white oak *(Q. alba)*, with the scarlet oak being the most common. The understory is huckleberry and blueberry with occasional individuals of scrub oak (*Q. ilicifolia)* and, rarely, highbush blueberry (*V. corymbosum)*.

The northeast corner of the proposed site approaches the wetlands associated with the headwaters of the Peconic River. The community structure in this section shifts abruptly from the upland vegetation of pitch pine, white and scarlet oak to a wetland vegetation of red maple, tupelo *(Nyssa sylvatica)*, swamp azalea *(Rhododendron viscosum)*, and sweet pepperbush *(Clethra alnifolia)*. Widely dispersed, large individual pitch pine also occur in this area.

In severely disturbed portions of the proposed SNS site, where the subsoils are exposed, monospecific stands of young pitch pines are found. In addition, a 2.5-acre (1.0-ha) abandoned borrow pit located on the east side of the site is exclusively occupied by a mature stand of pitch pines.

An inventory of mammals at BNL was done in 1994 and 1995. This survey did not include the proposed SNS site. However, the survey did include areas with the same type of habitat as found on the proposed site. White-tailed deer, the most common mammal reported in this study, were found throughout both natural and developed areas. Within forests and wetlands, deer browse on saplings, grasses, and greenbrier. White-tailed deer are less common in the pine plantation areas than in the pitch pine/oak forest and wetland areas, probably because of a smaller food supply.

Other species commonly observed at BNL, but in low numbers, were raccoon, muskrat, cottontail rabbits, gray squirrel, eastern chipmunk, and red fox. White-footed mouse and indications (such as droppings or tracks) of other small mammals were found throughout the BNL site. Meadow voles, or indications of their presence, were found in fields and emergent wetland areas. Other species observed included woodchuck, pine vole, and meadow jumping mouse.

4.4.5.2 Wetlands

Information about the wetlands in the vicinity of the proposed site for the SNS is summarized from *Final Phase II — Sitewide Biological Inventory Report* (CDM 1995). There are three jurisdictional wetlands in the vicinity of the proposed site for the SNS at BNL **(**Figure 4.4.5.2-1**)**. These wetlands are associated with the upper reaches of the Peconic River.

The NYSDEC has prepared a wetland delineation manual that uses the same three parameters (soils, vegetation, and hydrology) as the 1987 USACOE manual to define and map wetlands. The delineation of the wetlands at BNL meet the regulatory criteria of both USACOE and NYSDEC. One important difference between the two sets of regulations is that NYSDEC places a 100-ft (30.5-m) wide buffer upland of wetland area boundaries whereas the USACOE does not. Hence, work

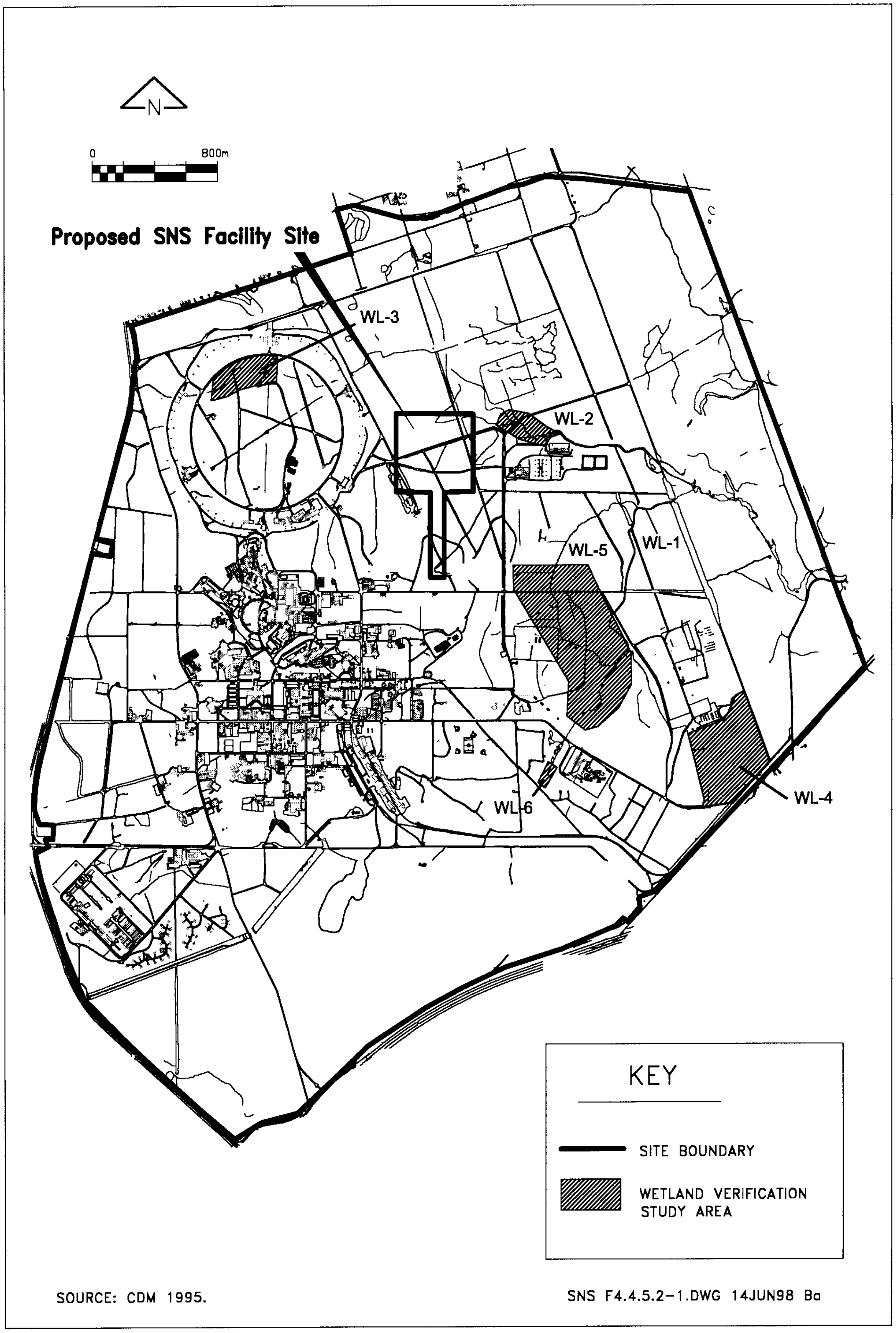


Figure 4.4.5.2-1. BNL wetlands.

NYSDEC Class I Wetland: A wetland is classified as a Class I wetland in New York State if it has any of the following seven enumerated characteristics:

It is a classic kettlehole bog;
It is a resident habitat of an endangered or threatened animal species;
It contains an endangered or threatened plant species;
It supports an animal species in abundance or diversity unusual for the State or for the major region of the State in which it is found;
It is tributary to a body of water which could subject a substantially developed area to significant damage from flooding or from additional flooding should the wetland be modified, filled or drained;
It is adjacent or contiguous to a reservoir or other body of water that is used primarily for public water supply, or it is hydraulically connected to an aquifer which is used for public water supply; or
It contains four or more of the enumerated Class II characteristics.

performed outside a wetland regulated jointly by NYSDEC and USACOE but within the NYSDEC buffer zone requires a permit from NYSDEC under ECL Part 663.4.

Wetland WL-1 is a palustrine forested wetland with broad-leaved deciduous vegetation and is considered by NYSDEC as a Class I wetland. This wetland is split by the Peconic River. The parcel to the north is drier and characterized by a dense red maple canopy. The parcel south of the river is frequently inundated. Tree growth is sparse and there is a dense growth of annual grasses and wetland indicative plants, such as spiked bur-reed, marsh pepper smartweed, and tussock sage. Soils in the wetland are listed as Wareham loamy sand, which is a hydric soil. The discharge from the BNL STP, located just west of this wetland, is sufficient to support aquatic plant, invertebrate, and vertebrate species. As part of the delineation of this wetland, one south-to-north transect was described. The transect began in an upland oak-pine forest, crossed the flooded forested wetland and the Peconic River channel, crossed an upland peninsula of grassed-over fill, reentered the forested wetland, and ended in the oak-pine forest north of the wetland.

Wetland WL-2 also borders the Peconic River. NYSDEC considers this a Class I wetland. This wetland is described as a palustrine forested wetland with broad-leaved deciduous vegetation, seasonally saturated, and as a palustrine shrub/sapling wetland with broad-leaved deciduous vegetation, and emergent narrow-leaved persistent vegetation, seasonally saturated. This wetland is dominated by a red maple canopy forest with a weak tree canopy in the center and a tussock sedge ground cover.

Soils in the wetland are listed as Wareham loamy sand, which is a hydric soil. Three ponded areas within the wetland probably serve as a refuge for fish, amphibians, and reptiles during periods of low water. Based on field observations, the Peconic River upstream of the STP flows only from late winter to late spring. Most of the wetland appears to be inundated during spring. Therefore, the wetland probably functions as a control of flood and stormwater and potentially absorbs nutrients and sediments from upstream portions of the Peconic River. As part of the delineation of this wetland, one southwest-to-northeast transect was described. The transect began in an upland oak-pine forest, crossed a dense red maple dominated wetland, crossed the dry Peconic River channel, reentered the dense forested wetland, and ended in an oak forest.

Wetland WL-5 is a forested wetland north and south of Fifth Avenue and east of First Avenue. NYSDEC considers this a Class I wetland. This is a palustrine forested wetland with broad-leaved deciduous vegetation, seasonally saturated. Soils in this wetland are listed as Atsio sand, Berryland mucky sand, Muck, and Walpole sandy loam, all of which are hydric soils. There is evidence that the wetland was extensively ditched in the past. A series of east-west-oriented ditches merge to form a central north-south ditch that eventually enters the Peconic River. The ditches probably reduce the inundation of the wetland, encouraging growth of a red-maple-dominated palustrine forest over a shrub/sapling or herbaceous wetland community. A 2-acre (0.81-ha) area of recently killed red maples south of Fifth Avenue is indicative of poor drainage and/or an increase in the period of inundation or saturation of the soils. This wetland functions principally in the control of stormwater and flood water and as habitat for wildlife. Wildlife observed in this wetland include white-tailed deer, cottontail rabbit, gray squirrel, red-bellied woodpeckers, and several species of warblers. Many of the larger red maples are either hollow or contain holes, providing nesting sites for birds, such as flickers and wood ducks. As part of the delineation of this wetland, two west-to-east transects were described. The transect north of Fifth Avenue began in an upland pitch pine forest, crossed the red-maple-dominated palustrine forest, and ended in an upland pitch pine forest. The south transect began in an upland oak forest, crossed through a red-maple-, black-gum-, and greenbrier-dominated palustrine forest, and ended in an upland forest.

NYSDEC
Surface Water "C" Classification for the Peconic River (Summary)

Best Use – Fishing. Suitable for fish survival and propagation. Suitable for primary and secondary contact recreation.

pH – Not less than 6.5 nor more than 8.5.

Dissolved Oxygen – The minimum daily average shall not be less than 5.0 mg/L and at no time less than 4.0 mg/L.

Temperature – Water temperature at the surface of the stream shall not be raised to more than 90 °F (32 °C).

Turbidity – No increase that will cause a substantial visible contrast to natural conditions.

4.4.5.3 Aquatic Resources

The Peconic River flows through the northern portion of BNL. The northeast corner of the proposed SNS site is approximately 300 ft (91 m) from the river. The headwaters of the Peconic River are located approximately 0.75 mi (1.2 km) to the west of BNL and exit the site to the east. Currently the BNL STP accounts for 90 percent of the water flow in the Peconic River in the spring and early summer and almost 100 percent during late summer and fall.

The Peconic River is protected under the Freshwater Wetlands Program as it is a Class I wetland. Two reaches of the Peconic River downstream of BNL were designated as a scenic river in 1986 under the New York State Wild, Scenic, and Recreational River Act. The two reaches represent the last significant undeveloped river corridor within the Long Island Pine Barrens area. The reaches extend

10.5 mi (16.8 km) from the western boundary of the red maple swamp to the Long Island Railroad bridge between Connecticut and Edwards Avenues 3 mi (4.8 km) from Middle Country Road to its confluence with the main channel of the Peconic River.

The Peconic River downstream of the potential site for the proposed SNS is described as a Coastal Plain Stream. In general, upstream of the STP, the habitat of the river consists of a narrow, often channelized stream with dense, overhanging brush. There is a weir upstream of the STP that may restrict fish movement both upstream and downstream. A man-made pond, approximately 6 ft (1.8 m) deep and 30 ft by 30 ft (9 m by 9 m) in size is located approximately 50 ft (15.2 m) upstream of the weir. Downstream of the STP, the habitat consists of a shallow [average depth is less than 1 ft (0.3 m)], wide [10 to 15 ft (3 to 4.6 m)], low-gradient stream channel with fallen logs, brush, and aquatic vegetation providing cover for fish. A dense stand of red maple trees farther to the east precludes the growth of aquatic vegetation in that portion of the stream. Another weir is located just above the east firebreak. Farther downstream the river becomes shallow, with no distinct channel or streambed in some areas. The stream and associated wetlands are heavily vegetated with a mix of emergent herbaceous plants. Several shallow, open-water areas are located approximately 0.25 mi (0.4 km) downstream of the firebreak. The flow in the Peconic River ceases about midway between the east firebreak and the east BNL property line. No standing water was found downstream of this point to the BNL property line.

Results of fish collections above the weir and wastewater discharge (CDM 1995) show that the fish community in this portion of the river is characterized by certain species (Table 4.4.5.3-1).

The dominant aquatic vegetation in these reaches of the Peconic River included water-starwort *(Callitriche palustris)*, reported to be very common and very dense. Other common plants include manna grass *(Glyceria grandis)*, arrow arum *(Peltandra virginica)*, and pickerel weed *(Pontederia cordata)*.

The Peconic River was designated as a Wild and Scenic River by the State of New York in 1986 because it represented the last significant undeveloped river within the Long Island Pine Barrens area. Approximately 14 mi (22.4 km) of the Peconic River are now listed as “scenic river” by the State of New York, of which 7.5 mi (12 km) are also listed as a “recreational river.” Scenic rivers are rivers or sections of rivers that are “free of diversions or impoundments (except for log dams), with limited road access and are very primitive and largely undeveloped river areas; or areas that are partially or predominantly used for agriculture, forest management, and other human activities which would not substantially interfere with public use and enjoyment of the rivers and their shores” (NYSDEC 1988a, as cited in CDM 1995: 2-3). Recreational rivers are “rivers or river sections readily accessible by road or railroad, which may have undergone development, impoundment, or diversion in the past” (NYSDEC 1988a, as cited in CDM 1995: 2-3), such as those reaches downstream of BNL.

Recreational activities afforded by the Peconic River include bird-watching, fishing, hunting, and canoeing. The entire Peconic River drainage is a Class I wetland. The Peconic River headwaters area is also identified as an

Table 4.4.5.3-1. Fish community above the wastewater discharge point within BNL.

Common Name	Scientific Name
Chain pickerel	*Esox niger*
Goldfish	*Carassius auratus*
Golden shiner	*Notemigonus chrysoleucas*
Creek chubsucker	*Erimyzon oblongus*
Brown bullhead	*Ameiurus nebulous*
Mummichog	*Fundulus heteroclitus*
Largemouth bass	*Micropterus salmoides*
Banded sunfish	*Enneacanthus obesus*
Pumpkinseed	*Lepomis gibbosus*
Yellow perch	*Perca flavescens*

"S1" habitat by the Natural Heritage Program, indicating that it is one of five or fewer coastal plain stream communities in the state.

4.4.5.4 Threatened and Endangered Species

DOE is in the process of consulting with the USFWS and the New York Department of Environmental Conservation regarding whether or not construction and operation of the proposed SNS at BNL would jeopardize the habitat of any federal or state protected species, and appropriate mitigating measures. No responses were received in time for inclusion in the draft EIS. Responses will be summarized in the final EIS. Appendix C presents the letters of consultation.

New York State endangered species are defined as native species in imminent danger of extirpation or extinction in the state or listed as endangered by USFWS. State threatened species are native species likely to become endangered within the foreseeable future in New York or listed as threatened by USFWS. Special-concern species are native species for which a welfare concern or risk of endangerment has been documented by NYSDEC. Table 4.4.5.4-1 lists the state and federally listed threatened, endangered, or special-concern species. The tiger salamander is known to be breeding on laboratory property (CDM 1995).

The northwest portion of the proposed SNS site approaches wetlands associated with the Peconic River. This area may be suitable habitat for the tiger salamander and the spotted salamander.

Thirteen species of plants found on BNL are protected in New York State under Environmental Conservation Law (ECL) 9-1503 and New York State Regulation 193.3, which states the "no one may knowingly pick, pluck, sever, remove or carry away (without the consent of the owner thereof) any protected plant." (This is a designation distinct from threatened, endangered, rare, or special concern.) (Table 4.4.5.4-2). Three of these plants, the spotted wintergreen, bayberry, and swamp azalea, have been found on the proposed SNS site (Black 1998).

Table 4.4.5.4-1. State and federally listed protected species reported to occur at BNL.

Common Name	Scientific Name	NYS Status	Federal Status
Osprey	*Pandion haliaetus*	T	
Peregrine falcon	*Falco peregrinus*	E	E
Common nighthawk	*Chordeiles minor*	SC	
Eastern bluebird	*Sialia sialia*	SC	
Spotted turtle	*Clemmys guttata*	SC	
Eastern hognose snake	*Heterodon platirhinos*	SC	
Spotted salamander	*Ambystoma maculatum*	SC	
Eastern tiger salamander	*Ambystoma tigtinum*	SC	
Banded sunfish	*Enneacanthus obesus*	SC	

T – Threatened
E – Endangered
SC – Special concern.

Table 4.4.5.4-2. Plants protected by ECL 9-1503 and New York State Regulation 193.3.

Common Name	Scientific Name
Butterfly weed	*Asclepias tuberosa*
Spotted wintergreen	*Chimaphila maculata*
Lady's slipper	*Cypripedium acaule*
Bayberry	*Myrica pensylvanica*
Flowering dogwood	*Cornus florida*
Swamp azalea	*Rhododendron viscosum*
Hayscented fern	*Dennestaedtia punctilobula*
Shield fern	*Dryopteris* sp.
Sensitive fern	*Onoclea sensibilis*
Cinnamon fern	*Osmunda cinnamomea*
Clayton's fern	*Osmunda claytoniana*
Royal fern	*Osmunda regalis*
Marsh fern	*Thelypteris palustris*
Virginia chain fern	*Woodwardia virginica*

Among the protected wildlife found in the Peconic River Basin are one endangered species, the tiger salamander; two special concern species, the spotted turtle and banded sunfish; and one candidate for threatened species, the swamp darter. The Peconic River is one of only two locations in the state known to support a population of banded sunfish. The distribution of the swamp darter in New York is limited to the eastern two-thirds of Long Island.

Four species of wildlife cited as unique (locally uncommon or color variants) are reported by NYSDEC to occur in the Peconic River drainage: a polymorphic variety of the northern water snake *(Nerodia sipedon)*, a population of lead-backed salamander (color variant of the red-backed salamander), the stinkpot or musk turtle, and the river otter *(Lutra canadensis)*. Although the four species are not recognized as endangered, threatened, or of special concern by NYSDEC, they are considered unique because the first two are color variants of a common species and the latter two are locally uncommon but widespread in New York. These four species were previously reported as occurring well downstream of the BNL site. Recently, the lead-backed salamander and the musk turtle have been reported on BNL property (CDM 1995).

4.4.6 SOCIOECONOMIC AND DEMOGRAPHIC ENVIRONMENT

The ROI for the SNS at the proposed BNL site includes Nassau and Suffolk Counties, as shown in Figure 4.4.6-1. Approximately 90 percent of BNL employees reside in this region. The region includes the cities of Levitown and Hicksville.

This section provides a description of the following socioeconomic and demographic characteristics:

- Demographics
- Housing
- Infrastructure
- Local economy
- Environmental justice.

4.4.6.1 Demographic Characteristics

Population trends and projections for each of the counties in the ROI are presented in Table 4.4.6.1-1. Nassau and Suffolk Counties are of similar size, each having a population of

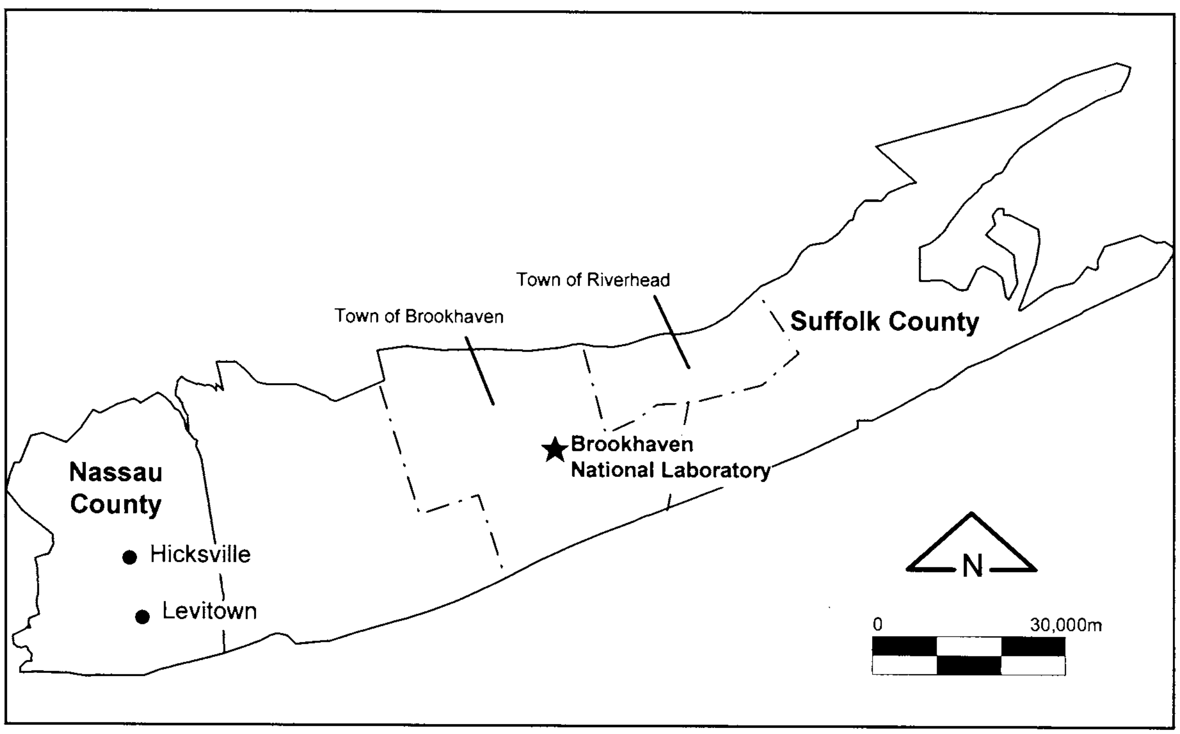


Figure 4.4.6-1. Map showing socioeconomic ROI for BNL.

Table 4.4.6.1-1. Regional population trends and projections.

County	1980	1990	1995	2000	2010
Nassau	1,321,582	1,287,444	1,305,772	1,316,000*	1,346,000*
Suffolk	1,284,231	1,321,768	1,353,704	1,364,000*	1,418,000*
Region	2,605,813	2,609,212	2,659,476	2,680,000*	2,764,000*
State	17,558,165	17,990,778	18,136,000	18,146,000	18,916,000

* Estimated figure.
Sources: U.S. Bureau of Census 1990; U.S. Bureau of Census 1996.

approximately 1.3 million in 1995. Although the population of Suffolk County increased steadily since 1980, Nassau County was larger in 1980 than in 1995 (the county's population declined by 3 percent between 1980 and 1990).

Population data for selected cities in the region are presented in Table 4.4.6.1-2. Population growth has been slow throughout the region since 1980, with an increase of only 54,000 individuals (about 2 percent). Some communities, such as Levitown, have experienced population decreases between 1990 and 1997.

Population by race and ethnicity for the region is presented in Table 4.4.6.1-3. Both counties are predominantly Caucasian (87 to 90 percent). African Americans are the second largest racial group, comprising 6 to 9 percent of the two counties.

4.4.6.2 Housing

Regional housing characteristics are presented in Table 4.4.6.2-1. In 1990, vacancy rates in the region ranged between a low of 3 percent in Nassau County to a high of 12 percent in Suffolk County.

In 1990, median home values were highest in Hicksville and Brookhaven (approximately $175,00 and above) and lowest in Riverhead and Ridge (approximately $135,000 and below). The median housing unit price in 1990 was $209,500 for Nassau County and $165,900 in Suffolk County.

4.4.6.3 Infrastructure

The infrastructure section characterizes the region's community services with indicators such as education, health care, and public safety.

4.4.6.3.1 Education

New York is divided into 774 school districts, 126 of which (626 schools) are located in the region. Information regarding school districts within the region is presented in Table 4.4.6.3.1-1. Teacher-student ratios of below 1:15 are regarded as exceptional. By comparison, many public school districts throughout the U.S. staff classrooms at a ratio of around 1:20. Student enrollment in the Nassau-Suffolk area could increase by a substantial margin and still not exceed the 1:20 ratio.

The school districts in the region all receive funding from local, state, and federal sources, but the percentage received from each source varies.

Table 4.4.6.1-2. Population for incorporated areas within the region.

Communities	1990	1997
Levitown CDP	52,286	52,542
Hicksville	40,174	N/A
Brookhaven	407,779	419,745
Riverhead	23,011	24,589
Ridge CDP	11,734	11,935

N/A: Data for 1997 are not available.
Source: U.S. Bureau of Census 1990.

Table 4.4.6.1-3. 1990 population by race and ethnicity for the region.

All Persons, Race/ Ethnicity	Nassau		Suffolk	
	Number	Percent[a]	Number	Percent[a]
All Persons	1,287,444	100	1,321,768	100
Caucasian	1,116,949	87	192,236	90
African American	110,991	9	82,473	6
American Indian[b]	1,626	<1	3,233	<1
Asian/ Pacific Islander	38,914	3	22,185	2
Hispanic of any race[c]	77,386	6	87,852	7
Other Races	18,868	1	21,737	2

[a] Percentages may not total to 100 due to rounding.
[b] Numbers for Aleuts and Eskimos were placed in the “other” category given their small number.
[c] In the 1990 Census, Hispanics classified themselves as White, Black, Asian/Pacific Islander, American Indian, Eskimo, or Aleut. To avoid double counting, the number of Hispanics was subtracted from each of the race categories.
Sources: U.S. Bureau of Census 1990; U.S. Bureau of Census 1996.

Table 4.4.6.2-1. Housing summary for the region, 1990.

	Nassau County		Suffolk County	
	Number	Percent[a]	Number	Percent[a]
Total Housing Units	446,292	100	481,317	100
Occupied	431,515	97	424,719	88
Vacant	14,777	3	56,598	12
Median Home Value	$209,500	N/A	$165,900	N/A
Gross Rent	$749	N/A	$802	N/A

N/A = not applicable
[a] May not total 100 due to rounding
Sources: U.S. Bureau of Census 1990; U.S. Bureau of Census 1996.

Table 4.4.6.3.1-1. Public school statistics in the region, 1995–1996 school year.

County	Number of Schools	Student Enrollment[a]	Teachers[a]	Teacher/ Student Ratio (1998)	Per Student Operational Expenditures
Nassau	295	317,875	24,450	1:13	$11,697
Suffolk	331	347,688	24,830	1:14	$11,168
Region	626	665,563	49,280	1:14	$11,421

[a] Full-time equivalent figures.
Source: New York State Education Department 1996.

4.4.6.3.2 Health Care

There are currently 27 hospitals serving the region with 8,600 acute care beds (Table 4.4.6.3.2-1). On the average, these hospitals have a relatively high use rate, with less than 10 percent of beds available.

4.4.6.3.3 Police and Fire Protection

Nassau County has 2,981 officers with an approved FY 1998 budget of $469,344,000, and Suffolk County has 4,077 officers. Because of the potential severity of the consequences of a BNL emergency, the fire department has been specially trained to respond to a variety of incidents.

4.4.6.4 Local Economy

This subsection provides information on the economy of the region, including employment, education, income, and fiscal characteristics.

4.4.6.4.1 Employment

Regional employment data for 1997 are summarized in Table 4.4.6.4.1-1. Since 1994, the regional unemployment rate has decreased from 5.6 percent to only 3.4 percent. The majority of new jobs in the ROI are associated with retail trade and services.

Table 4.4.6.4.1-2 presents employment industry for the ROI. Government, services, and retail trade are the principal economic sectors in the region, making up about 65 percent of all 1995

Table 4.4.6.3.2-1. Hospital capacity and usage in the region.

Hospital	Number of Hospitals	Number of Beds[a]	Annual Bed-Days Used[a](%)
Nassau	14	4,746	93
Suffolk	13	3,902	94
Region	27	8,648	93

[a] Based on the number of people discharged and the average length of stay divided by total beds available annually.

Source: New York State Department of Health 1996.

Table 4.4.6.4.1-1. Regional employment data, 1997.

County	Civilian Labor Force	Employed	Unemployed	Unemployment Rate
Nassau	695,155	674,300	20,855	3.0
Suffolk	711,007	684,700	26,307	3.7
Region	1,406,162	1,359,000	47,162	3.4

Source: New York State Department of Labor 1998.

Table 4.4.6.4.1-2. Employment by county, region, and the State of New York (1995).

Economic Character	Nassau County	Suffolk County	Region	State of New York
Employment by Industry (1995)				
Farm	107	2,547	2,654	60,966
Agriculture Services	5,795	8,998	14,793	67,572
Mining	579	422	1,001	10,748
Construction	26,481	37,237	63,718	373,361
Manufacturing	47,324	72,533	119,857	982,532
Transportation and Public Utility	31,377	28,501	59,878	476,424
Wholesale Trade	45,442	39,910	85,352	463,204
Retail Trade	127,254	106,647	233,901	1,403,944
Finance, Insurance, and Real Estate	95,237	50,570	145,827	1,049,318
Services	273,388	212,722	486,110	3,433,419
Government	80,555	100,867	181,422	1,419,305
Total Employment	733,539	660,954	1,394,513	9,740,793

Source: Regional Economic Information for Nassau and Suffolk Counties, Nassau-Suffolk, NY PMSA and NYS 1990–1995 (U.S. Bureau of Census 1990).

jobs. By comparison, in 1990 these three sectors comprised around 60 percent of all jobs.

4.4.6.4.2 Income

In 1995, total regional income was approximately $85.3 billion. Income data for the ROI are presented in Table 4.4.6.4.2-1. Only 3 percent of all families in the region had 1989 incomes below the poverty level, which was considerably less than the statewide average.

4.4.6.4.3 Fiscal Characteristics

Municipal and county general fund revenues in the ROI are presented in Table 4.4.6.4.3-1. The general funds support the ongoing operations of local governments, as well as community services such as police protection and parks and recreation. The largest single component for the two ROI counties was local taxes, which includes real estate, property, hotel/motel, and sales taxes. ROI local taxes represented about 60 percent of the general fund revenues in that year, and intergovernmental were about 30 percent.

4.4.6.5 Environmental Justice

Figures 4.4.6.5-1 and 4.4.6.5-2 illustrate distributions for minority and low-income populations residing within 50 mi (80 km) of BNL. The definitions of minority and low-income populations and the methodology for assessing potential environmental justice effects are given in Section 5.5.6.5.

Approximately 5,260,000 people live within a 50-mi (80-km) radius of BNL. Minorities comprise 21.4 percent of this population. In 1990, minorities comprised 24.1 percent of the population nationally and 26 percent of the population in New York. There are no federally recognized Native American groups within 50 mi (80 km) of the site. The percentage of persons below the poverty level is 5.4 percent, which compares with the 1990 national average of 13.1 percent and a statewide figure of 23 percent (U.S. Census 1990).

4.4.7 CULTURAL RESOURCES

BNL is located in an area of Long Island that has a long cultural history. The first inhabitants of the area were Native American groups, many with cultures adapted to life in a marine coastal setting. European settlement of the area began in the 17th century. The first European settlement in Suffolk County can be traced historically to A.D. 1640, when English settlers established Southampton and Southold (BNL 1995: 4-1). Since this time, the area has been inhabited continuously, primarily by Euroamerican settlers and their descendants. Given the depth of local history, the citizens of the area are actively involved in the preservation of cultural resources such as historic sites and buildings (BNL 1995: 4-1).

The prehistory of BNL land remains largely unknown because most of it has never been surveyed for prehistoric archaeological sites (BNL 1995: 4-5). Prior to initiation of this EIS, only two archaeological studies had been conducted at BNL. One of these studies was a reconnaissance survey limited to the periphery of three ponds, a wooded area covering approximately 20 acres (8.1 ha), and areas along the Peconic River (Johannemann 1974: B-2 to B-3). The other study consisted of archaeological test excavations in the area that was to be impacted by the ISABELLE/Colliding

Table 4.4.6.4.2-1. Measures of BNL regional income.

Area	Median Household Income 1989 ($)	Per Capita Income 1996 ($)
Nassau County	54,283	23,352
Suffolk County	49,128	18,481
New York State	32,965	16,501

Source: U.S. Bureau of Census 1990.

Table 4.4.6.4.3-1. Municipal and county general fund revenues in the region, FY 1997.

Revenue by Source	($1,000)	Percent[a]	($1,000)	Percent[a]
Local Taxes[a]	779,293	63	697,076	57
Licenses and Permits	3,445	<1	0[b]	N/A
Fines and Forfeitures	8,853	<1	0[b]	N/A
Charges for Service	0[b]	NA	103,784	9
Intergovernmental[c]	407,192	33	349,357	29
Interest	47,999	4	0[b]	N/A
Miscellaneous Income	450	<1	64,588	5
Total	1,247,232	100	1,214,804	100

[a] Local taxes include real estate and personal property taxes, hotel/motel taxes, and local sales taxes.
[b] This revenue item accounted for under other revenue sources.
[c] Includes payments of state and federal funds.
N/A = not available.
Source: U.S. Bureau of Census 1990; Comprehensive Annual Financial Reports 1997c.

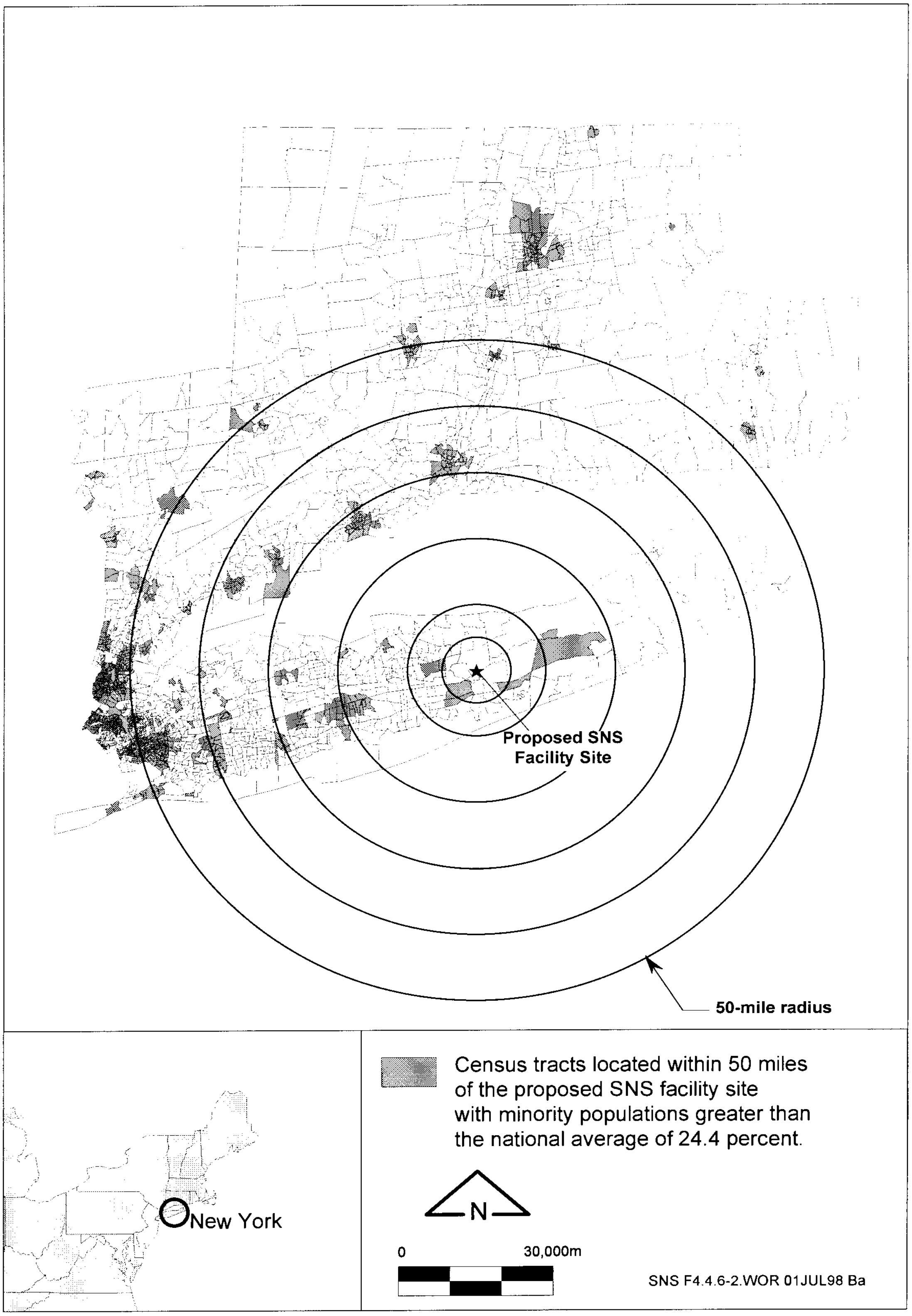


Figure 4.4.6.5-1. Distribution of minority populations at BNL.

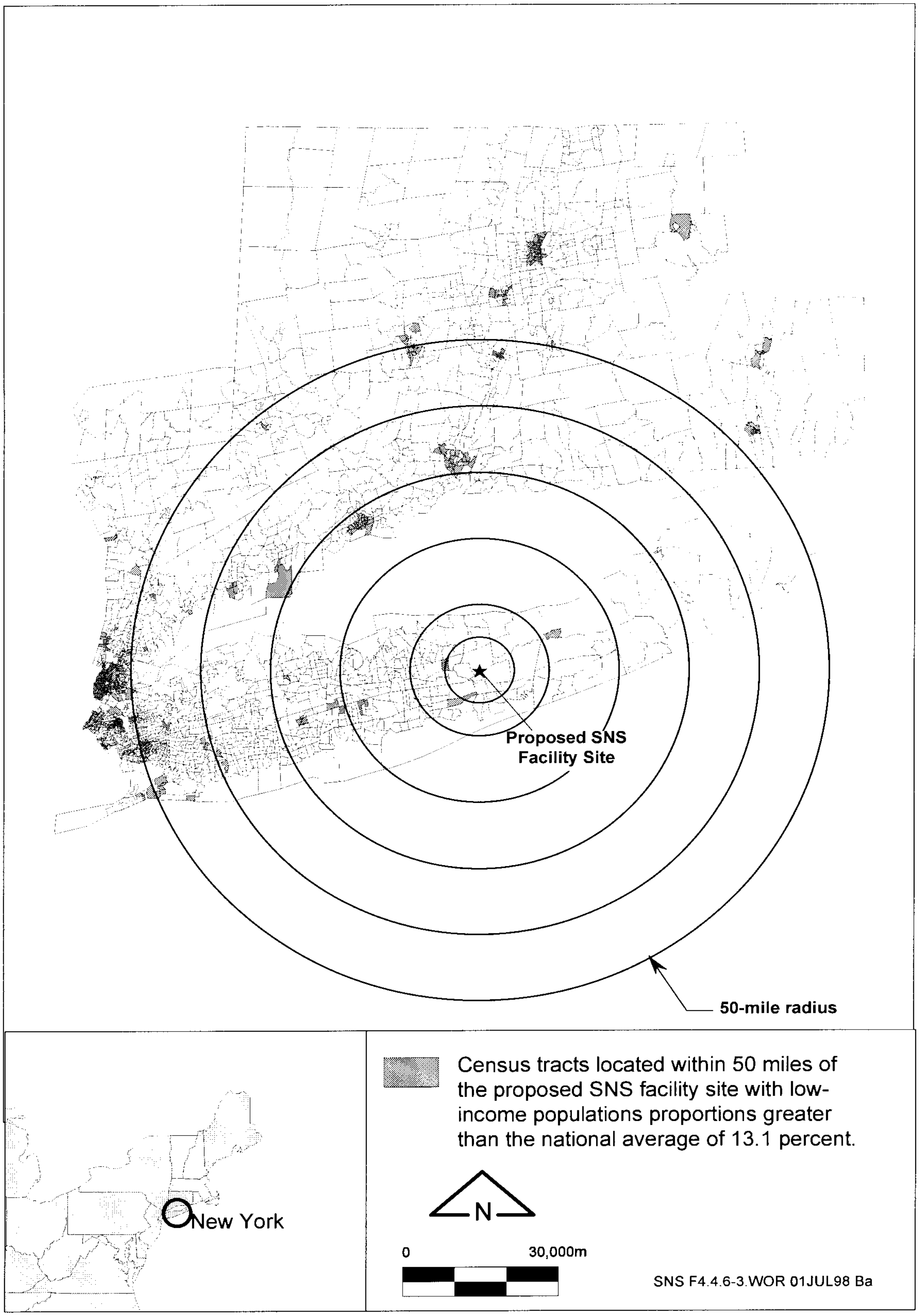


Figure 4.4.6.5-2. Distribution of low-income populations at BNL.

Beam Accelerator (CBA), which was begun during the 1970s and later canceled (Johannemann and Schroeder 1977). Both studies covered small portions of the 5,261 acres (2,130 ha) of land at BNL, and no evidence of prehistoric human activity was encountered.

A brief history of land use at BNL has been prepared and published by Associated Universities, Inc. (BNL 1995), the former management and operating contractor for the laboratory. This history begins in 1917 with the establishment of Camp Upton, a large U.S. Army induction center and hospital that was occupied until about 1921. It continues with the demise of Camp Upton shortly after World War I, its reestablishment during World War II, and its final closure at the end of the war. The history concludes by tracing the general development of BNL during the period 1947 to 1997. However, this history has never been supplemented with a detailed, site-wide survey for historic archaeological sites and other types of historic cultural resources.

Fourteen historic archaeological sites dating to the Camp Upton occupation of BNL land have been identified and partially excavated within the ISABELLE project area (Johannemann and Schroeder 1977: 33-53). This area and the partially constructed accelerator facilities in it have been incorporated into construction of the RHIC.

A limited review of all BNL properties for historical resources was conducted in June 1990 by representatives from the SHPO for the state of New York. As a result of this review, three potentially significant historic resources were identified: a group of World War I trenches dating to the Camp Upton occupation, the Graphite Reactor Building (Building 701), and the Old Cyclotron Enclosure (Building 902). These resources are considered to be potentially eligible for listing on the NRHP (DOE-BNL 1994a: 19; Naidu et al. 1996: 2-44). A formal historical context for these resources has not been developed.

A cultural resources survey of the proposed SNS site and an adjacent buffer zone was conducted in January 1998. This survey focused on identifying prehistoric and historic remains in these areas. The results of the survey are summarized in Sections 4.4.7.1 and 4.4.7.2.

The SNS design team has not established the areas where construction or improvement of utility corridors and roads would be necessary to support the proposed SNS at BNL. In addition, the locations of ancillary structures such as a retention basin and a switchyard have not been determined. As a result, such areas could not be surveyed for cultural resources. However, the eventual establishment of these areas would proceed in such a manner as to avoid known cultural resource locations. If the proposed SNS site at BNL were chosen for construction, these areas would be surveyed for cultural resources prior to the initiation of construction-related activities within them.

The occurrence of cultural resources on the proposed SNS site and in its vicinity is described in this section of the EIS. However, the locations of archaeological and historic sites are not indicated in the descriptions. To better protect these sites, DOE and Brookhaven Science Associates do not reveal the locations of cultural resources in documents available to the general public. Because several of the original reports cited in this section show the locations of cultural resources on BNL, they are not included in the DOE public reading rooms established as part of the SNS EIS process.

4.4.7.1 Prehistoric Resources

No prehistoric cultural resources have been identified on or adjacent to the proposed SNS site (Black 1998: 5).

4.4.7.2 Historic Resources

A number of earthen berms, linear trenches, pits, and mounds have been identified at four separate locations throughout the proposed SNS site. These locations were designated as Stations 2, 4, 8, and 10. The landscape features at these stations may have been associated with World War I trench warfare training at Camp Upton. At Station 2 on the proposed SNS site, a group of berms and pits may be the remains of a command post associated with adjacent trenches. If they were associated with World War I training exercises, all of these features would date to 1917–1918. No standing Historic Period structures were identified on or adjacent to the proposed SNS site (Black 1998: 4-6).

The earthen features at Stations 2, 4, 8, and 10 are considered potentially eligible for listing on the NRHP, based on the results of the 1997 site survey and past New York SHPO concern for World War I trench warfare training features at BNL (DOE-BNL 1994a: 19; Black 1998: 6; Brown 1998b: 1). However, no surface artifacts definitively dating to World War I were found in association with these features during the survey. As a result, archaeological testing would be necessary to positively determine their historical context and to obtain additional data relevant to a formal eligibility determination. Until such assessments can be made, the indicated course of action is to manage these features as significant cultural resources that are eligible for listing on the NRHP.

4.4.7.3 Traditional Cultural Properties

No Native American tribal representatives have been identified in the BNL area, and no Native American lands are located on the BNL site. Because no Native American groups have been identified, it has not been possible for DOE to consult with such groups concerning the potential occurrence of TCPs on and near the proposed SNS site. A survey of the proposed site and limited surveys of other areas at BNL have encountered no evidence of prehistoric occupations. In addition, no Native American TCPs have been identified in the BNL area. Based upon these results, it has been concluded that no TCPs occur on the proposed SNS site or anywhere else on laboratory land (White, B. 1998b: 1).

4.4.7.4 Consultation with the State Historic Preservation Officer

DOE Chicago Operations Office is in the process of performing the required consultations under Section 106 of the NHPA. This section will be written when the consultations have been completed and documented. A copy of the consultation letter from the SHPO will be included in Appendix C.

4.4.8 LAND USE

Land uses in the vicinity of BNL, within the boundaries of BNL, and on the proposed SNS site are described in this section. The descriptions cover past, current, and future uses of the land in these areas. In addition, they include descriptions of environmentally sensitive land areas that have been set aside for public use, environmental protection, or research. These areas include parks, natural areas, environmental education centers, and public recreation areas. The section concludes with a discussion of visual resources.

4.4.8.1 Past Land Use

The land occupied by BNL and the surrounding area was largely wilderness prior to 1917. Although this remote inland landscape probably supported a sparse residential population and some agricultural activities during this period, most of the residential, commercial, industrial, and recreational land use in the area were centered in nearby coastal areas and urban centers such as Brookhaven and Southampton.

The U.S. Army established and operated Camp Upton on BNL land from 1917 to 1920. Because it functioned as an induction and convalescent center during this period, much of the camp land was devoted to residential use and soldier training. Considering the wide range of activities typically conducted at large military installations, some areas of the camp may have been devoted to industrial, commercial, agricultural, and recreational uses. With closure of the camp in 1920, a major shift in land use occurred. The federal lands at Camp Upton were managed for the next 20 years as Upton National Forest. From 1940 to 1945, Camp Upton was reestablished and operated once again as an induction and convalescent center. During both military periods, portions of camp land probably remained as undeveloped open space (BNL 1995: 4-1 to 4-2 and 4-5).

BNL was established on the Camp Upton site in January 1947, and the new research center began by using many of the remaining Camp Upton facilities. During the ensuing 50 years, the current pattern of land use at BNL developed (BNL 1995: 1-4 and 4-2).

The land on the proposed SNS site has been undeveloped open space for at least the past 50 years, but the major historical centers of laboratory activity surround the site and are located within 492 to 2,297 ft (150 to 700 m) of it. The only major activity that appears to have been conducted at this location was construction of several roads that crisscross the site. As a result, none of the surficial soils on the site have been contaminated by past laboratory uses of the land (BNL 1995: 4-19). The site overlaps the boundary between environmental restoration Operable Units III and V, which indicates the possibility of groundwater contamination beneath the proposed SNS site. If such contamination is present, it has probably arrived through subsurface migration from past BNL waste disposal, accidental spill, or routine release locations outside of the proposed site (BNL 1995: 7-6 to 7-9).

4.4.8.2 Current Land Use

Most of the land surrounding BNL is developed for commercial, industrial, or residential use. With respect to residential use, the area in the vicinity of BNL is lightly settled, especially compared to the dense population on west Long Island. Combined commercial, industrial, and residential use account for 38 percent of the land in the area. Another 32 percent of the land is used for recreational (parklands), institutional (educational facilities, hospitals, etc.), and transportation (airports, roads, etc.) purposes. The remaining 30 percent of the land is undeveloped woodlands and agricultural areas (BNL 1995: 6-2 to 6-4 and 8-1).

Land clearing has been initiated for a new 150-acre (60.7-ha) shopping mall (Brookhaven Town Center) located in close proximity to BNL. The mall site is at the intersection (northwest corner) of the Long Island Expressway and William Floyd Parkway. The parkway serves as a buffer between BNL and the mall site (Yadav 1998:1).

BNL occupies 5,261 acres (2,130 ha) of land near the geographic center of Suffolk County (BNL 1995: 4-5). The current use of this land is classified according to four major categories: Industrial/Commercial, Agricultural, Residential, and Open Space. The locations of these land use areas are shown in Figure 4.4.8.2-1.

Approximately 75 percent of the land within the BNL boundaries is Open Space, and with the exception of firebreaks, environmental monitoring wells and stations, utility rights-of-way, and recreation fields, most of this land is in a natural state. The large expanse of Open Space surrounding the developed central area of BNL serves as a buffer zone for the Industrial/Commercial land use in this area.

The land areas categorized as Industrial/Commercial contain most of BNL's buildings and major research facilities. These areas of land include the central portion of BNL, RHIC ring, STP, Hazardous Waste Management Facility, and NEXRAD weather radar facilities.

The latter are on 7.4 acres (3.0 ha) of land leased by DOE to the U.S. Department of Commerce, NOAA. The major research facilities in the Industrial/Commercial areas are the Alternating Gradient Synchrotron, National Synchrotron Light Source, Scanning Transmission Electron Microscope, HFBR (BNL 1995: 8-4).

Two areas in the southwest corner of BNL are devoted to Residential use by laboratory visitors and temporary staff. The total area of land devoted to Residential use is 170 acres (69 ha). The largest of these areas is surrounded entirely by Open Space. The smaller area is adjacent to the Industrial/Commercial use area. Apartment buildings, dormitories, summer cottages, efficiencies, mobile homes, houses, guest rooms, and a child care facility are located within the Residential use areas (BNL 1995: 8-7).

The proposed SNS site is located entirely within an area categorized as Open Space. Industrial/Commercial use areas surround this site in relatively close proximity. The location of the proposed site relative to current land use areas is shown in Figure 4.4.8.2-1.

Two small areas of BNL land [69.2 acres (28 ha)] are used for agricultural purposes. They are located in the eastern area of BNL, and each is completely surrounded by land categorized as Open Space. The crops grown on this land are used for biological research (BNL 1995: 8-7). None of the areas designated as Open Space are used for ecological research (BNL 1995: 9-3). Thus, the land on and in the vicinity of the proposed SNS site is not being used for environmental research projects.

4.4.8.3 Future Land Use

Future use of the land surrounding BNL has been set forth in local government master plans. These plans call for retention of residential land use on the Long Island shores. The central areas of Long Island would be developed for commerce, culture, light industry, and high technology. Adjoining areas would be devoted to high-density cluster housing and medium-density housing for single families. The local

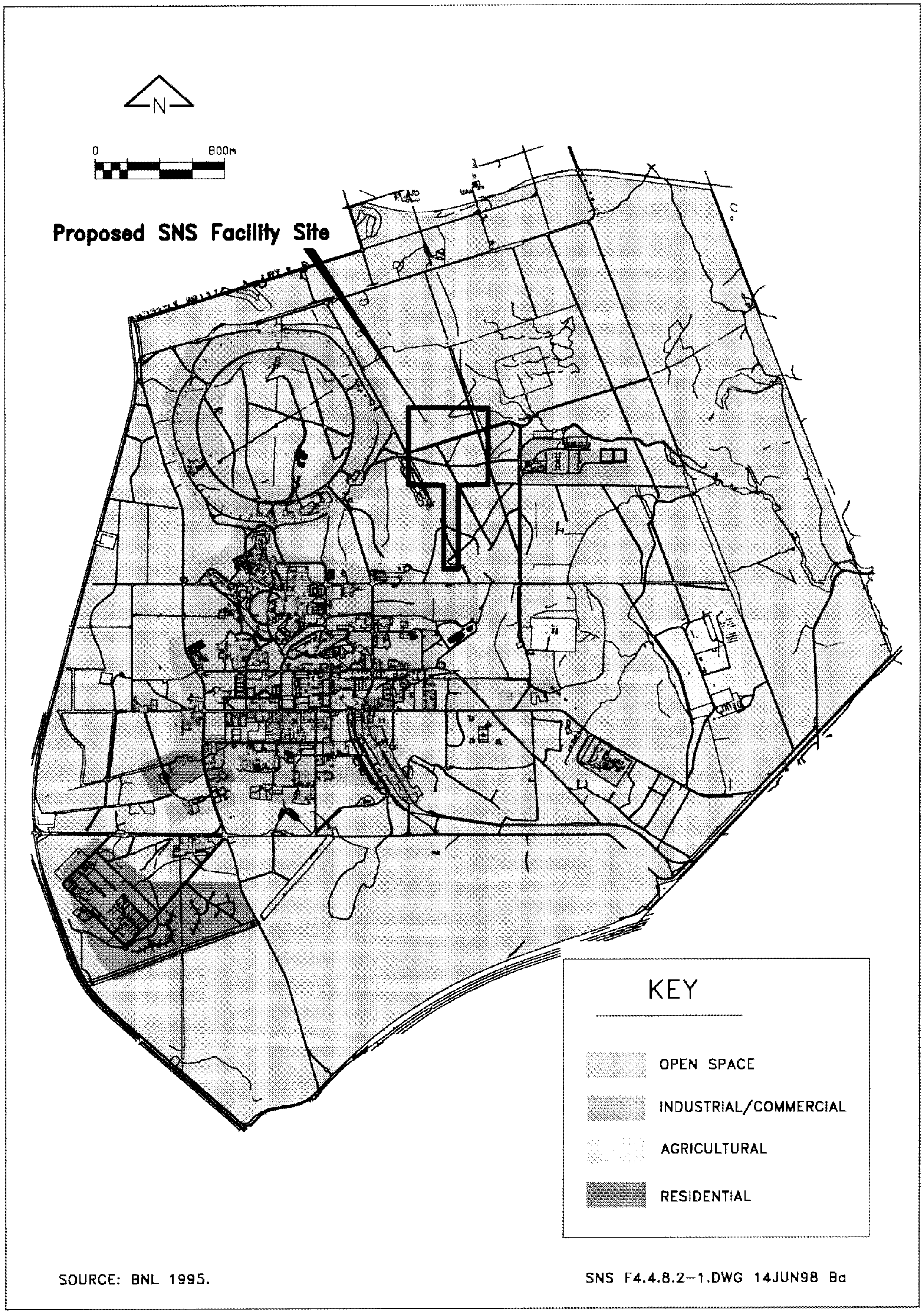


Figure 4.4.8.2-1. Map of current land use at BNL.

plans would preserve agricultural lands, parks, and open wooded areas (BNL 1995: 6-2).

Proposals for an industrial park and housing developments adjacent to BNL have been presented to the Town of Brookhaven. The area immediately to the north and west of BNL is wooded, privately owned, and zoned for residential development. BNL reviews local government master plans and proposed development actions such as these to assess potential impacts on its operations (BNL 1995: 6-4).

Land use at BNL has been projected for the next 20 years through a formal land use planning process. Up to 20 percent of the land that is now Open Space is zoned for future Industrial/ Commercial use. Two different versions of Industrial/Commercial zoning at BNL are available, and each version is related to a large facility acquisition that might occur within the next 20 years. One is based on possible construction of a new linear accelerator (Figure 4.4.8.3-1). The other version is based on possible construction of a muon-muon collider (Figure 4.4.8.3-2). Land in the Commercial/ Industrial zoning category could be used for other types of new research facilities, as well.

The areas of BNL land zoned as Open Space would remain as natural areas, except for the addition of groundwater monitoring wells on the site perimeter. Several stakeholders in the area have indicated that some Open Space could be used for short- and long-term ecological research. However, the laboratory has made no plans for ecological research, and no Open Space areas have been set aside for that purpose (BNL 1995: 9-3). The current pattern of agricultural land use would continue unchanged into the future. The Residential zoning anticipates a future contraction of the small housing area now in use in the southwest corner of BNL and an expansion of the larger residential area to meet gradually growing demands for housing (BNL 1995: 9-1 to 9-9).

The proposed SNS site is located on land that is zoned for Open Space and Industrial/ Commercial use. A comparison of Figures 4.4.8.3-1 and 4.4.8.3-2 indicates that slightly more Industrial/Commercial land would lie within the proposed site under the muon-muon collider version of zoning. No future uses of proposed SNS site and vicinity land for environmental research are planned.

The end uses of BNL land upon eventual closure of the laboratory have been considered in the land use planning process. The zoning for end use is shown in Figure 4.4.8.3-3. This zoning pattern reflects environmental restoration considerations and solicited input from citizen stakeholders living in the surrounding area. This zoning does not account for the possible presence of the proposed SNS, because construction of the proposed SNS at BNL was not an issue when this zoning was completed in 1995.

4.4.8.4 Parks, Preserves, and Recreational Resources

The laboratory is located in an area of Long Island where much of the land is preserved in its natural state as parkland. In 1993, the state of New York passed the Long Island Pine Barrens Protection Act, requiring the comprehensive management of environmentally sensitive pine barrens areas [100,035 acres (40,500 ha)] in the vicinity of the towns of Brookhaven, Riverhead, and Southampton, as well as two villages in Suffolk County. For protection and

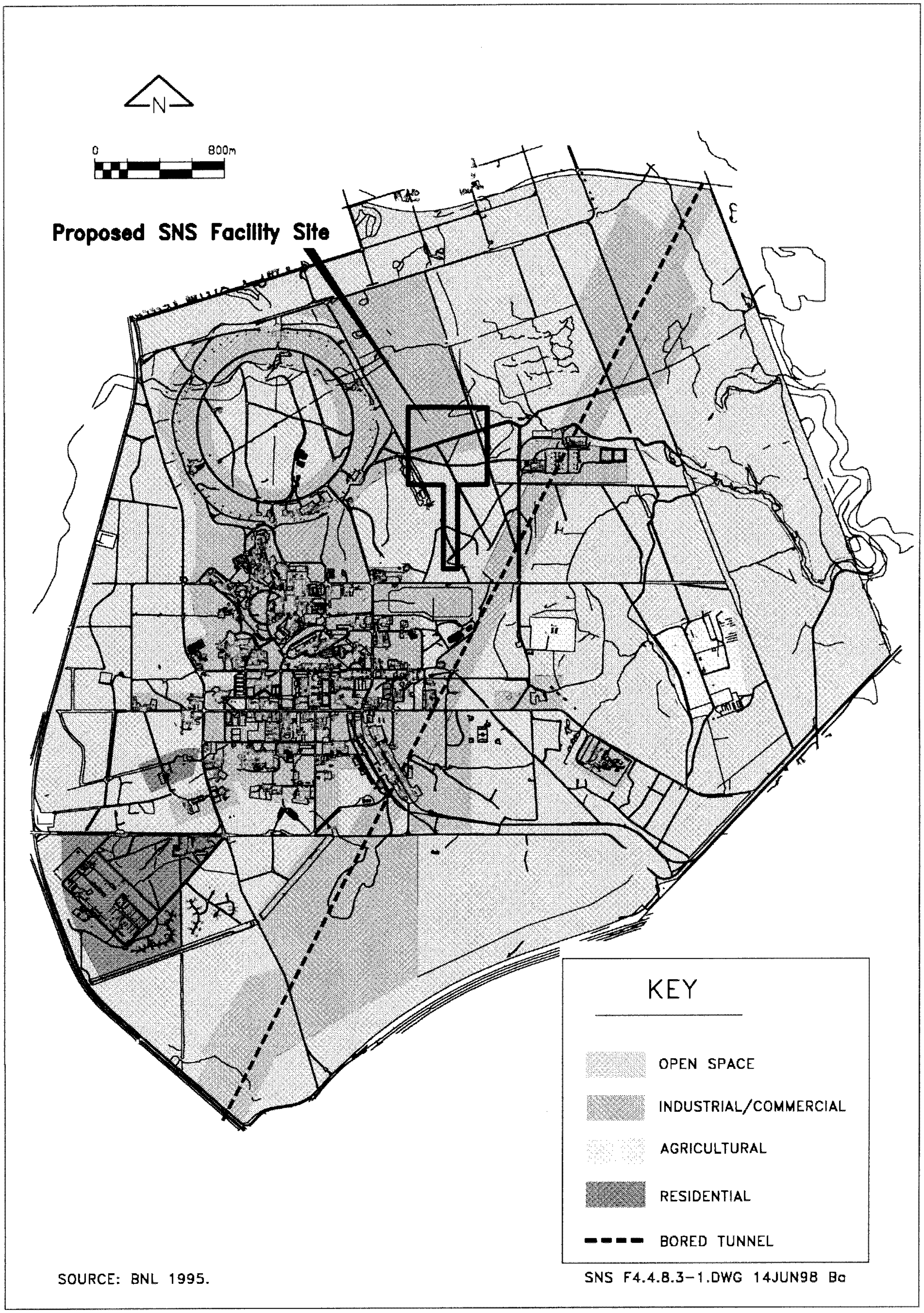


Figure 4.4.8.3-1. Map of land use zoning at BNL (Linear Accelerator Plan).

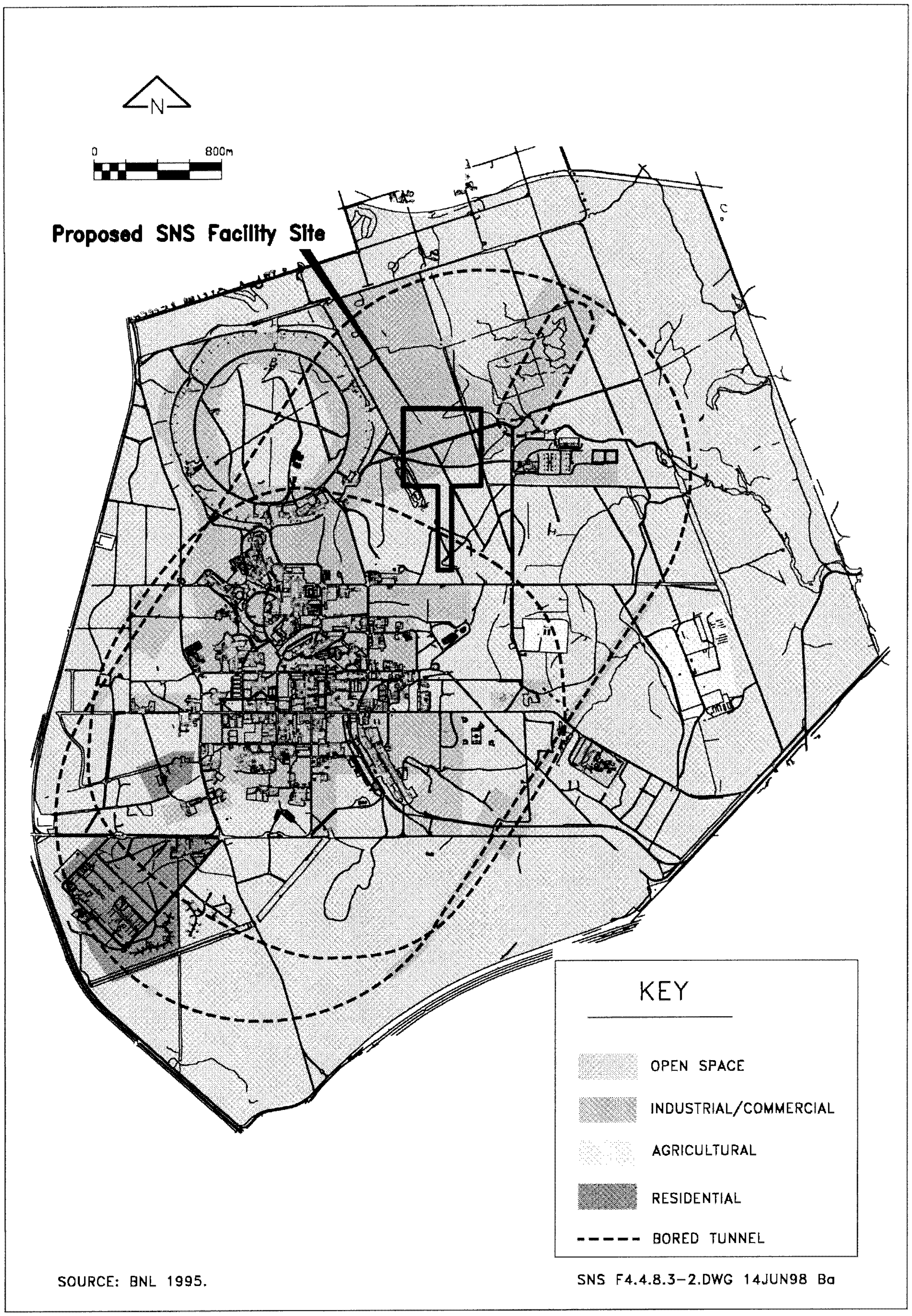


Figure 4.4.8.3-2. Map of land use zoning at BNL (Muon-Muon Collider Plan).

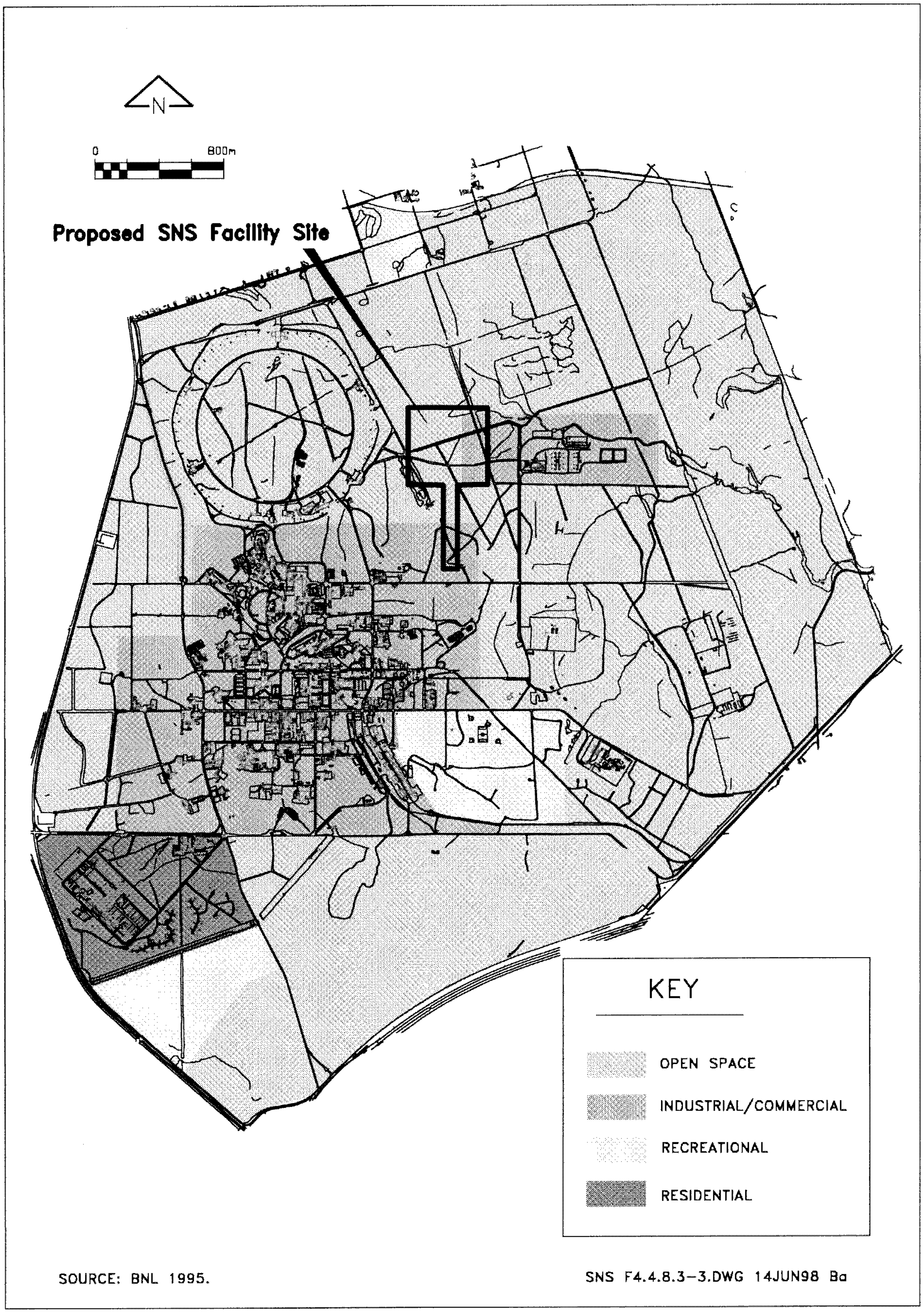


Figure 4.4.8.3-3. Map of end use zoning at BNL.

management purposes, the Central Pine Barrens Zone was subdivided into a Core Preservation Area and a Compatible Growth Area. The principal management goal for the Core Preservation Area is to preserve its natural state by limiting or prohibiting construction, development, and other activities. However, such activities are more possible within the Compatible Growth Area.

The Compatible Growth Area encompasses the central portion of BNL, where most of the laboratory's existing facilities are located. The Core Preservation Area encompasses 1,235 acres (500 ha) of BNL land on the north and south sides of the laboratory. The proposed SNS site and immediately adjacent land are located entirely within the Compatible Growth Area (BNL 1995: 1-2 to 1-3 and 7-2 to 7-3; Helms 1998: 4).

It is the position of DOE that the Long Island Pine Barrens Protection Act does not give the state of New York jurisdiction over the use of federal land at the laboratory. However, BNL has been providing technical support to the Pine Barrens Commission and has agreed to use the Long Island Pine Barrens Management Plan as a guide in site development and future land use planning (BNL 1995: 7-3).

A number of major parks, nature preserves, and recreational areas are located in the general vicinity of BNL. These locations are listed and described in Table 4.4.8.4-1.

4.4.8.5 Visual Resources

BNL is located on gently rolling land near the center of Long Island, New York. The area is mostly suburban in character. As a result, the broad area surrounding the laboratory is largely developed for residential and commercial purposes. In addition, large portions of laboratory land are developed. As a result, most views in the area contain a mixture of man-made and natural features. No established visual resources that include the proposed SNS site are known to exist in the vicinity of the laboratory.

4.4.9 RADIOLOGICAL AND CHEMICAL ENVIRONMENT

This section covers the radiological environment pathways and the chemical environment pathways associated with the site.

4.4.9.1 Radiological Environment

The principal sources of radiation at BNL include the HFBR, the Brookhaven Medical Research Reactor, and the Brookhaven Linear Accelerator Isotope Production Facility. Much smaller sources of radioactivity include Building 801 and the Alternating Gradient Synchrotron Facility.

4.4.9.1.1 Air

On a weekly basis, BNL collects air samples from six stations around the site and analyzes them for radioactive content. Results from air monitoring in 1995 indicate that the maximum tritium concentration recorded in a single event was 78 pCi/m^3 at the northeast section of the laboratory. Annual gross alpha results ranged from <0.01 to 0.03 pCi/m^3 while gross beta results ranged from 0.02 to 0.07 pCi/m^3.

In 1995, the EDE to the maximally exposed offsite individual adjacent to the north-northeast boundary was estimated to be 0.06 mrem. Approximately 94 percent of this dose is attributed to ^{41}Ar released from the Brookhaven

Table 4.4.8.4-1. Major parks, preserves, and recreational areas in the vicinity of BNL.

Facility	Direction from BNL[a]	Distance (mi/km)	Description and Uses
Peconic River	E	0-12.4/0-20	New York State Scenic and Recreational River. Fishing and canoeing.
Brookhaven State Park	N	0.3/0.5	Undeveloped state park. Hunting and hiking. Hiking trail along east boundary of BNL.
Rocky Point State Park	NW	1.9/3	Hunting, horseback riding, hiking, mountain biking.
Calverton Naval Weapons Plant	E-NE	0.3/0.5	Property being transferred to local government. Undeveloped portions used for hunting, hiking, fishing, horseback riding, and mountain biking.
Wilwood State Park	NE	5.6/9	State park developed for camping, swimming, and hiking.
Cathedral Pines County Park	W	1.2/2	County park used for hiking and mountain biking.
Carmens River	W	1.9/3	New York Scenic and Recreational River.
South Haven County Park (Carmens River)	W-SW	1.2/2	County park used for fishing, canoeing, hiking, picnicking, and skeet shooting.
Wertheim National Wildlife Refuge	SW	3.1/5	Protected area along the southern portion of the Carmens River to its discharge into Bellport Bay. Protection of wildlife and canoeing.
Randall Road Hunting Station	NW	0.6/1	Small state conservation area and checking station for hunters.

[a]NE- northeast, SE- southeast, SW- southwest, NW- northwest.
Source: Helms 1998.

Medical Research Reactor. By comparison, 0.06 mrem is well below the EPA airborne dose limit of 10 mrem per year. The collective dose to the population within a 50 mi (80 km) radius of BNL was estimated to be 3.2 person-rem.

4.4.9.1.2 Water

In early 1997 sampling in the vicinity of the HFBR identified tritium in the groundwater, with levels exceeding 600,000 pCi/L. Subsequent investigations narrowed the source of groundwater contamination to a leak in the reactor's spent fuel pool and determined that the plume extended a distance of 1200 m (4000 ft) south of the HFBR at a depth of 6–15 m (20–50 ft) below the ground surface. The contaminated plume front was located at approximately 760 m (2500 ft) from the site boundary, advancing at approximately 1 ft per day. In May 1997 BNL installed a pump-and-recharge system as an interim measure to ensure that tritium above the EPA drinking water standard (20,000 pCi/L) will not leave the BNL site boundary. A permanent remedy for the tritium plume is currently undergoing regulatory review with extensive community involvement (BNL 1998).

Monitoring of the surface water for the Peconic River watershed is performed at two stations within BNL, four stations downstream of BNL, and one station on the Carmens River for a reference location. With the following exceptions, radiological constituents in 1995 were either not detectable or at ambient levels. The ^{137}Cs levels within BNL (max 1.18 pCi/L and avg. 0.87 pCi/L at Station HM located interior to BNL) were slightly greater than ambient levels but consistent with the outfall at the STP and far below the DOE DCG of 3,000 pCi/L. The principal radionuclide detected at the STP Peconic River Outfall was tritium. The total annual release of tritium to the Peconic River in 1995 was 2.7 Ci, and the average annual tritium concentration was 2,960 pCi/L (compared to NYSDWS 20,000 pCi/L). Because the Peconic River is not used either as a drinking water supply or for irrigation, its waters do not constitute a direct pathway for the ingestion of radioactive material.

Potable and process groundwater supply wells were sampled for gross alpha and beta activity, tritium, and gamma-emitting radionuclides in 1995. Radioactivity was typical of regional water samples. Tritium was not observed above the minimum detection limit in any of the wells and gamma emitters were not detected in all the wells but one (Well No. 4 contained gamma activity levels close to the detection limit, making the results inconclusive).

BNL collects groundwater from 207 monitoring wells and performs analysis for radioactive constituents. Data from private wells adjacent to BNL were used to estimate the potential maximum EDE to an individual from water ingestion. Tritium was the only radionuclide detected in the wells. Maximum tritium concentration observed in a private well was 2,520 pCi/L, roughly eight times less than the 20,000 pCi/L limit established by the EPA. The corresponding dose to that maximally exposed individual is 0.1 mrem. Safe Drinking Water Act Standards restrict the annual dose limit to 4 mrem per year for the drinking water pathway.

Approximately five groundwater monitoring wells are within the immediate vicinity of BNL's preferred proposed SNS site. Data from these wells indicate that most of the wells are below the detection limit for all measured radionuclides. One well exhibits very slightly elevated ^{137}Cs and ^{90}Sr, which are 4.30 pCi/L and 1.49 pCi/L, respectively. To the east of the preferred site, wells at the STP exhibit slightly elevated levels of tritium, ^{137}Cs, and ^{90}Sr, primarily due to liquid effluents processed at the STP both past and present.

4.4.9.1.3 Soils

Soil samples were collected from offsite locations as part of the Soil and Vegetative Sampling Program and analyzed for radioactive content. Soil samples were collected from local farms situated adjacent to BNL. Sampling data from 1995 indicate that all radionuclides detected were of natural origin. No nuclides attributable to laboratory operations were detected.

4.4.9.1.4 Ambient Gamma Radiation

On a quarterly basis, BNL measures external gamma radiation levels at 24 onsite locations and 24 locations offsite. The average annual onsite integrated dose for 1995 was approximately 70 mrem; the offsite integrated dose was approximately 65 mrem.

4.4.9.2 Chemical Environment

This section describes the levels of nonradiological contaminants in air and water at BNL.

4.4.9.2.1 Air

Nonradioactive air emissions at BNL are typically from minor sources such as welding, degreasing, sandblasting, painting, and parts cleaning. Boilers at the Central Steam Facility (CSF) produce a majority of the nonradioactive air emissions at BNL. The CSF contains four boilers that are monitored for opacity, O_2, and CO_2. Emissions data are reported quarterly to the NYSDEC but are not included in the BNL Site Environmental Report.

4.4.9.2.2 Water Pathway

Water-quality analyses conducted on groundwater samples collected site-wide generally show compliance with New York State Ambient Water Quality Standards (NYS AWQS). However, metals and VOCs in groundwater exceed the NYS AWQS in a number of areas across the site. In some cases high iron levels reflect natural ambient levels in the subsurface aquifer, but in the vicinity of the Current Landfill, high iron and sodium levels are associated with materials disposed there. VOCs were detected above NYS AWQS at several locations on site, as well as across the southern boundary in an industrial park area (Schroeder 1998).

The offsite portion of the VOC contaminant plume is composed primarily of carbon tetrachloride, a solvent once widely used by BNL and in industry for degreasing. The solvent has been detected in on- and off-site monitoring wells at a depth of 55–90 m (180–300 ft) in concentrations as high as 5,100 parts per billion (ppb), exceeding the EPA drinking water standard of 5 ppb. A pump-and-treat system constructed in 1997 is currently cleaning up the on-site portion of the plume and preventing further offsite migration. An in-well air stripping system was funded in 1997 for treatment of the off-site plume.

Although a 1995 residential well sampling program in the area beyond the southern boundary showed no contamination from BNL above drinking water standards, DOE has offered area home and business owners free connections to the public water supply as a precautionary measure. Through 1997, approximately 800 private owners have been connected to the public water supply at DOE expense.

Surface waters were collected from the Peconic River and from the Carmens River as an offsite control location. All water quality parameters, except pH, were within State Pollution Elimination Discharge System discharge standards or New York State AWQS. Low pH may be attributed to natural conditions of groundwater recharge to the stream or stormwater runoff. All metal concentrations were consistent with historical data and the background levels at Carmens River Station were (except for iron) below the State Pollutant Discharge Elimination System effluent limits or appropriate AWQS. With the exception of a single chloroform concentration of 2.3 g/L (detection limit=2 g/L), all surface water measurements for VOCs were not detectable.

4.4.9.2.3. Soil

Soils are not monitored for nonradiological contaminants at BNL.

4.4.10 SUPPORT FACILITIES AND INFRASTRUCTURE

The Support Facilities and Infrastructure section characterizes the local vehicular transportation routes around the proposed SNS site. The existing utilities that are available to provide needed services to support the proposed SNS are also described.

4.4.10.1 Transportation

BNL is located on Long Island, Suffolk County, in the state of New York. Figure 4.4.10.1-1 gives the location of the proposed SNS facility site and the transportation routes surrounding the site.

There are three primary roads that border BNL: (1) the Long Island Expressway (I-495), a four-lane divided highway that runs east-west and borders BNL on the south; (2) the William Floyd Parkway, a four-lane divided highway that runs north-south and borders BNL to the east; and (3) Route 25, a four-lane divided highway that runs north-south and borders BNL to the north.

In 1990, a transportation master plan was completed for BNL that evaluated traffic circulation impacts for a predicted future site population of 3,800 employees. At that time, the number of employees was approximately 3,400. The results of that report indicated that the transportation infrastructure in and around BNL could adequately service the predicted site workforce of 3,800. In 1995, a BNL traffic study indicated that approximately 2,500 vehicles per day enter and exit BNL.

4.4.10.2 Utilities

This section provides a description of the utility infrastructure at BNL. The following is based upon existing documentation and discussions with select BNL staff.

4.4.10.2.1 Electrical Service

BNL purchases electric power from the New York Power Authority and the Long Island Lighting Company (LILCO). Power enters BNL via a 69-kV transmission line at a substation located at the southeast corner of the site. BNL has two main electrical substations that step down the power from 69 kV to 13.8 kV. The vast majority of electrical distribution at BNL is via underground lines; however, the RHIC and STP are fed via overhead distribution lines. BNL's present electrical demand is 52 MW but is expected to increase to 80 MW by the year 2000.

4.4.10.2.2 Steam

Steam originates for BNL operations onsite from the CSF. The CSF is located southwest of the BNL preferred location. The CSF consists of four boilers that have a combined capacity of 475,000 lb of steam per hour at 125 psig. The steam is distributed via 11 mi (17.6 km) of pipeline to various buildings, facilities, and laboratories and is used to power steam generators when needed. The present steam load at BNL peaks at 170,000 lb/hr.

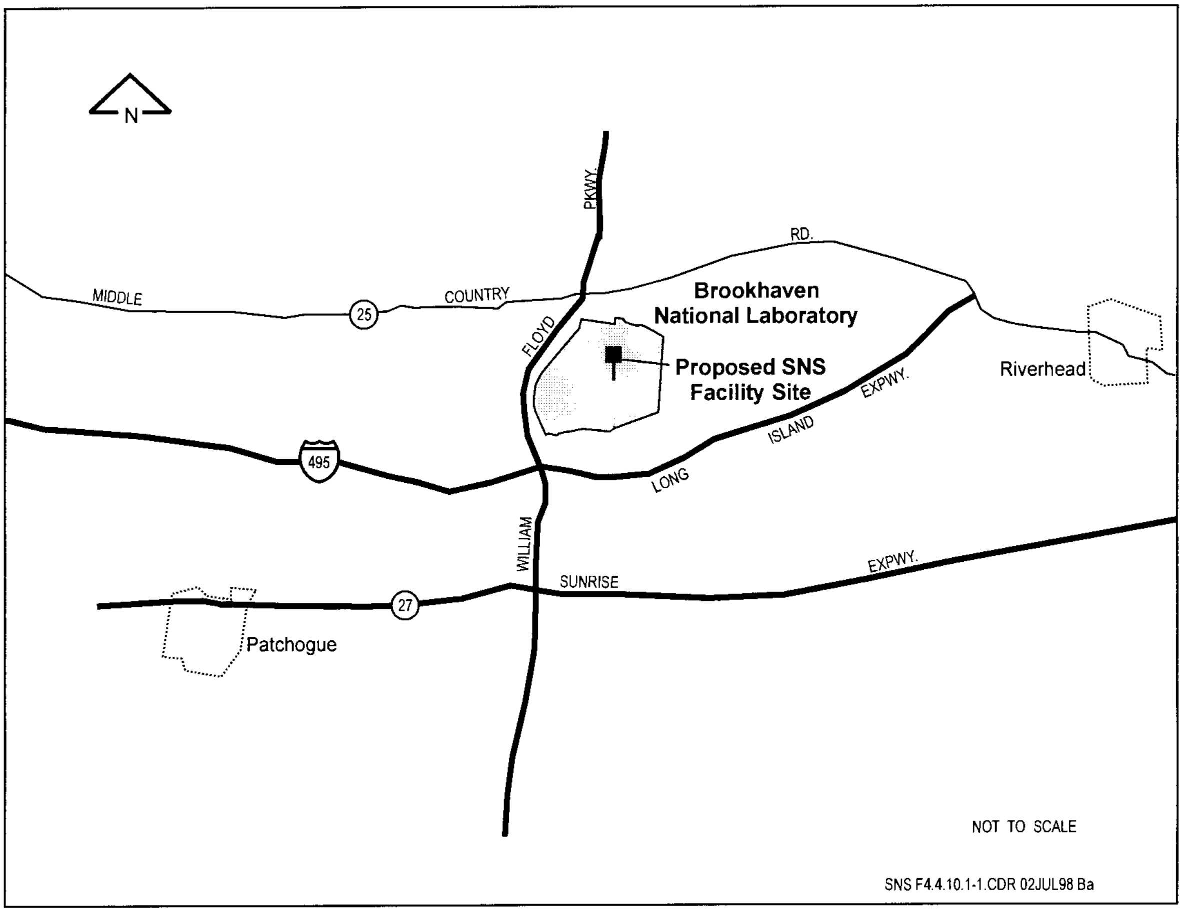


Figure 4.4.10.1-1. Transportation routes at BNL and surrounding areas.

4.4.10.2.3 Natural Gas

Natural gas is purchased from LILCO and is piped to BNL from an existing main located near the electrical substation at the southeast corner of the site. Natural gas is distributed exclusively to the CSF for steam production. The capacity of this line is 240,000 ft^3/hr (73,152 m^3/hr). BNL's present usage peaks at approximately 200,000 ft^3/hr (60,960 m^3/hr). The existing gas line is located at the CSF, approximately 4,000 ft (1,219 m) from the proposed SNS location.

4.4.10.2.4 Water Service

BNL obtains its general water supply from six onsite wells. The total pumping capacity of the wells is approximately 7,200 gpm (27,255 lpm). Currently, three of the domestic water wells are in the area of the proposed SNS location, and each is capable of producing 1,200 gpm (4,542 lpm). The average daily water usage at BNL is approximately 1 mgpd (3.8 million lpd). Water is stored onsite in three storage tanks with one million, 400,000, and 300,000 gal (14.3 million, 1.5 million, 1.1 million L) capacity, respectively. Only one of the supply wells is used for the site's water needs. BNL operates a 4.5 mgpd (17 million lpd) water treatment plant located less than 1 mi (1.6 km) west of the CSF.

4.4.10.2.5 Sanitary Waste Treatment

The BNL STP is located in the eastern portion of the site and directly east of the preferred site for the proposed SNS location. The plant receives all sanitary wastewater from the laboratory for processing before discharge to the Peconic River. The plant was renovated in 1997 to upgrade its hydraulic capacity to 3 mgpd (11.4 million lpd). Currently, the average daily volume of waste flow is less than 1 mgpd (3.8 million lpd).

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CHAPTER 5: ENVIRONMENTAL CONSEQUENCES

The U.S. Department of Energy (DOE) has assessed the effects from constructing and operating the proposed Spallation Neutron Source (SNS) on the environment at each of the four alternative sites (see Chapters 3 and 4). The potential effects described in this chapter are in addition to those that exist from other operations at each of the potential sites. DOE assessed these effects by analyzing the proposed action at each of the four alternative sites; assessing the actions that could have effects; identifying the nature of these effects; and quantifying (if possible) the magnitude of the effects.

The potential environmental impacts that could result from implementing the proposed action are described in this chapter. The proposed action could be implemented through any one of the four major siting alternatives: Oak Ridge National Laboratory (ORNL) site (Preferred Alternative), Los Alamos National Laboratory (LANL) site, Argonne National Laboratory (ANL) site, and Brookhaven National Laboratory (BNL) site. Impacts that could result from the No-Action Alternative are also described. All impacts from these alternatives are described in terms of the various aspects of the affected environment that would be expected to change over time as a result of their implementation. The impacts from the No-Action Alternative are those that would result from maintaining the status quo with respect to neutron sources. The No-Action Alternative impacts provide a basis to which the impacts expected from the other alternatives can be compared.

5.1 METHODOLOGY

The environmental impact assessment methodologies discussed in this section address the full range of issue areas pertinent to the sites considered in the Environmental Impact Statement (EIS). These resource areas are land resources, air quality and noise, water resources, geology and soils, biotic resources, cultural resources, socioeconomics, human health, support facilities, and waste management. Each of the pertinent issue area methodologies is presented in detail in the following subsections.

5.1.1 GEOLOGY AND SOILS

The impacts assessments for geology and soils identify resources that may be affected by the construction and operation of the SNS and the presence of natural conditions that may affect the integrity and safety of the project. Geological resources include mineral and energy resources (coal, oil, and mineral reserves); unique geologic features; geologic hazards (earthquakes, faults, volcanoes, landslides, subsidence, and karst development); and soil resources. Mineral and energy resources are evaluated from historical activities and accounts of past production to assess the potential for future exploitation. Geologic features would identify unique or scenic topographic features or rock units that may contain mineral or energy resources. Earthquake potential is evaluated on the basis of past events and the locations of capable faults. Areas of past mass movement and conditions favorable to mass movement, such as excessive slopes and soils susceptible to liquefaction, are identified. The evaluation of soil resources includes natural earth materials, prime farmland, and erosion control.

The impacts assessments for each alternative involve locating geologic and soil features of concern. A quantitative estimate of radionuclides accumulated in the soil mass during operations of the SNS is conducted to determine levels of radioactivity in the subsurface. These levels would not be expected to vary significantly due to site-specific conditions; however, the fate and transport of radionuclides is greatly affected by the natural environment at each alternative site. A study of transport of nuclides and exposure potential is performed for the ORNL site and used as a basis for qualitative comparison to the alternative sites. Impacts are identified if the proposed site at each alternative is located within any unique geologic feature that would be subjected to irreversible physical disturbance by the project. Potential operational activities conducted in areas prone to geologic or natural hazards are assessed and presented. The geology and soils impacts are discussed qualitatively for each alternative, and mitigation measures to reduce impacts from geology and soil resources are identified.

5.1.2 WATER RESOURCES

The assessment of potential impacts to water resources includes surface water bodies, floodplains, and groundwater resources and quality. The impacts assessment includes the evaluation of water availability, water quality, drainage channel alterations, and flooding potential.

Surface waters include creeks, streams, rivers, and lakes; they are described in terms of general flow characteristics and the affected environment of each water body. Construction impacts are evaluated in relation to erosion control and floodplains encroachment. Emphasis is placed on the alteration of water bodies potentially impacted during the operational phase of the proposed SNS by increased flow within the watershed. Surface water quality is compared to existing baseline conditions and the type, rate, and concentration of potential discharge constituents. Environmental consequences are related to construction impacts in the watersheds, increased discharge to drainage channels, and other parameters with the potential to further degrade existing water quality in violation of existing National Pollution Discharge Elimination System (NPDES) permit limits.

Floodplains include any lowlands that border a stream and encompass areas that may be covered by the stream’s overflow during flood stages. Any facility within a 100-year floodplain is considered a critical action.

Groundwater includes water that occurs below the water table in saturated, unconsolidated regolith and soil or in fractures and porous bedrock. Aquifers are saturated strata containing groundwater resources. Availability of groundwater varies widely among the siting alternatives because it is a function of both hydraulic characteristics of the aquifer and the competition in groundwater development and use by other consumers. The potential effects to groundwater availability are assessed for each alternative by evaluating whether the proposed project would increase groundwater withdrawal in an area, could potentially decrease groundwater levels in an area causing substantial depletion, or could exceed available supply limits. Potential effects on groundwater quality are associated with radiological contamination over the operational life of the SNS. The potential for contaminant migration to potable aquifers and other water sources is assessed and compared to federal and Nuclear Regulatory Commission (NRC) standards. Parameters with the potential to further degrade existing groundwater quality are identified for each alternative.

5.1.3 CLIMATOLOGY AND AIR QUALITY

The air quality assessment evaluates the environmental consequences of criteria pollutants that could be emitted during construction or operational activities at the four proposed SNS sites. Air quality impacts are evaluated within the context of the Clean Air Act as amended, the Environmental Protection Agency's (EPA's) National Primary and Secondary Ambient Air Quality Standards (40 CFR 50), and state-proposed or state-adopted standards and guidelines. Air quality concentrations from modeling proposed site emission rates are used to determine those effects of pollutants at each site.

Air quality impacts during construction are not strictly quantified, but fugitive dust and construction vehicle emissions are predicted to be minimal with temporary elevations of levels comparable to local construction and land fill operations.

The primary nonradiological airborne release during operations at the proposed SNS would be combustion products derived from the use of natural gas. Criteria pollutant emission rates for ten small boilers are derived from EPA's "Emission Factors for Stationary Sources" (AP-42). EPA's Screen 3 model is then employed to calculate the SNS impact to air quality by comparing projected ambient concentrations from calculated emissions against the National Ambient Air Quality Standards (NAAQS). Conversion factors are applied to predict concentrations for longer periods corresponding to NAAQS parameters. Background (baseline) concentrations (based upon maximum ambient-monitored concentrations at nearby locations to each site) were also added to the model projected maximums before final comparison to the NAAQS. Air quality effects of periodic discharges from diesel backup generators are stated to be negligible.

5.1.4 NOISE

The onsite and offsite acoustical environments may be impacted during facility construction and operation. General construction noise sources that may affect nearby receptors were taken from the reference Golden et al, 1980. This source provides noise levels anticipated at varying distances (up to 400 ft) from the construction activity. Since the nearest public accommodation is more than 400 ft from any construction, these values were used as conservative baselines for expected noise levels during construction. These noise levels are then compared to noise levels commonly encountered by the general public as taken from Harris et al, 1992.

Operation of the SNS would generate some noise, caused particularly by site traffic and cooling towers. In general, sound levels are stated to be characteristic of a light industrial setting. Effects upon residential areas are attenuated by the distance from the SNS and by a forested buffer zone. Onsite, the level of noise from the SNS is stated to be typical of accelerator facilities, and any effects are stated to be negligible when compared to ambient levels.

5.1.5 Ecological Resources

The assessment of potential impacts to ecological resources is performed for terrestrial resources, wetlands, aquatic resources, and threatened and endangered species. Potential impacts are assessed by evaluating changes to the baseline environment at each of the potential sites (no action) that could result from construction and operation of the SNS. The baseline conditions at the sites are descriptive and qualitative in nature. Assessing the potential impacts resulting from construction and operation of the SNS involves determining the amount of habitat lost or disturbed. Mitigation and monitoring strategies are discussed as appropriate.

5.1.5.1. Terrestrial Resources

Potential impacts to terrestrial resources include loss and disturbance of wildlife and wildlife habitat. Two important considerations in assessing the potential effects on habitat are the presence and regional importance of affected habitats and the size of the habitat area temporarily or permanently disturbed.

Potential impacts on terrestrial plant communities resulting from project activities are evaluated by comparing regional vegetation information to proposed land requirements for construction and operation of the SNS. Impacts to wildlife are based on plant community loss, which is closely related to wildlife habitat. The loss of important or sensitive species or habitats is more significant than the loss of species or habitats that are regionally abundant. Evaluation of the effects of construction and operation of the SNS on terrestrial resources involves looking at the disturbance, displacement, and loss of wildlife and wildlife habitat in the vicinity of the alternative sites for the SNS as well as the surrounding area.

5.1.5.2. Wetlands

Potential effects on wetlands caused by construction of the SNS include encroachment on the wetland and degradation of the wetland caused by activities outside of the wetland, such as soil erosion, siltation, and sedimentation. Operational effects may occur from effluents released from the SNS. The assessment of potential effects on wetlands includes determining whether construction of the SNS would encroach on an existing wetland and evaluating the potential effects from increased runoff of water and effluents released from the SNS during operations.

5.1.5.3. Aquatic Resources

Effects to aquatic resources depend on the nature of the water body and the aquatic life present. Potential effects due to habitat loss, sedimentation, increased flows, and introduction of waste heat are discussed in a qualitative manner for the aquatic resources at each of the alternative sites.

5.1.5.4. Threatened and Endangered Species

Information on threatened and endangered species at each of the alternate sites comes from informal consultation with the U.S. Fish and Wildlife Service, state agencies, and surveillance surveys conducted at each site (See Sections 4.1.5.4, 4.2.5.4, 4.3.5.4, and 4.4.5.4). The site-specific surveillance surveys were done to obtain an initial indication of whether protected species were present at each site. Effects are assessed by determining if construction of the SNS would disrupt existing threatened or endangered species or encroach on habitat critical for the survival of a protected species.

5.1.6 SOCIOECONOMIC AND DEMOGRAPHIC ENVIRONMENT

Socioeconomic impact analysis assesses the environmental consequences of demographic and economic changes resulting from the implementation of the SNS at each of the alternative sites. Increasing the level of activity at the four alternative sites could potentially burden existing community services and create additional demands on available housing stock. The primary determinants of community impacts are changes in the economic base and demographic composition usually associated with the in-migration of new workers. Assuming that total employment would rise from a proposed activity and that some of this increase could be associated with in-migration, the demand for local services could rise. The new workers and their families would require public services (for example, schools and health care) and, thus, create conditions for an expansion of the economic base of the region. Whether this occurs would depend in part on the degree of excess capacity that may already exist. Potential impacts could occur in regions that cannot expand to accommodate new population growth if the demands of this growth are rapid or excessive.

Socioeconomic impacts from new workers needed to construct the SNS and for the operational phase are assessed. The study focuses on the potential effects of additional workers on housing availability and community services, including health care services, education, and public safety. Potential socioeconomic effects are assessed for the geographic region-of-influence (ROI) that would be most affected. The ROI includes those cities and counties where 90 percent or more of the current site workers reside.

The proposed project would require additional workers at any of the alternative site's ROI during construction and operations phases. In addition to jobs created directly by the proposed SNS, other job opportunities would be indirectly created within the ROI because of the increased spending of money. This money would be respent locally as jobs are created and business activity increases. The "multiplied" economic effect of this "respending" is estimated using the IMPLAN input-output model developed by the U.S. Forest Service, the Bureau of Land Management, and the University of Minnesota. Specifically, ROI estimates are made for employment, indirect business taxes, personal income, and total economic output. For each of these industry indicators, impacts are generated for direct effects, indirect effects, and induced effects. Direct effects are associated with the construction and operation of the facilities, but they also include the regional jobs necessary to support regional purchases of supplies and equipment. Indirect effects measure the increases in interindustry purchases (businesses buying more from other businesses), and induced effects reflect changes in household spending as regional income increases.

5.1.6.1 Environmental Justice Assessment

The environmental justice analysis focuses on potential disproportionately high and adverse human health or environmental effects from proposed alternatives to minority and low-income populations. The assessment is pursuant to Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, dated February 16, 1994, which directs federal agencies to incorporate environmental justice as part of their missions.

The approach used to address the potential for environmental justice impacts is based on data developed for the *Waste Management Programmatic EIS* (DOE 1997a). Minority and low-income populations residing within 50 mi (80 km) of DOE sites are identified and mapped. The 50-mi (80-km) radius around the site is consistent with the 50-mi (80-km) radius used to assess human health for all populations around the site. Data on geographic distribution of low-income and minority populations and prevailing wind conditions are used to assess whether toxic/hazardous pollutants and radiological releases from the proposed action would be emitted disproportionately in the direction of these populations.

For purposes of this analysis, a minority population consists of any census tract within 50 mi (80 km) of the SNS site with a minority population proportion greater than the national average of 24.4 percent. Minorities include persons classified by the U.S. Bureau of the Census as Negro/Black/African-American, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, or other nonwhite, based on self-classification by the people according to the race with which they most closely identify. To avoid double-counting minority Hispanic persons (Hispanics can be of any race), only white Hispanics were included in the tabulation of racially based minorities. Nonwhite Hispanics had already been counted under their respective minority racial classification (for instance, Black, American Indian). A low-income population refers to U.S. Census Bureau data definitions of individuals living below the poverty line. For purposes of this analysis, a low-income population consists of any census tract within 50 mi (80 km) of the SNS site with a low-income population proportion greater than the national average of 13.1 percent.

5.1.7 CULTURAL RESOURCES

The assessment of potential impacts on cultural resources involves an evaluation of the projected effects of the proposed action, through the four siting alternatives, and the No-Action Alternative on prehistoric resources, historic resources, and traditional cultural properties (TCPs). A description of the baseline cultural resources environment at each of the four alternative sites for the proposed action is developed. Each description is based on the results of surveys and studies designed to identify cultural resources on and in the vicinity of these sites. The potential impacts are assessed by comparing the existing, baseline cultural resources environment to known, location-specific disturbances of this environment that would occur under the proposed action and the No-Action Alternative. Information obtained through consultations with the State Historic Preservation Officers (SHPOs) in Tennessee, New Mexico, Illinois, and New York is used to support the identification of cultural resources, their description, and the assessments of potential impacts on them.

5.1.7.1 Prehistoric Resources

Prehistoric resources in the U.S. consist of the significant physical remains of human activities that predate written records. They include, but are not limited to, sites containing stone tools, pottery, and the remains of ancient structures and hearths. To be identified as a prehistoric resource, such sites must be listed on, or eligible for listing on, the National Register of Historic Places (NRHP). The federal laws that protect such resources include the Archaeological Resources Protection Act (ARPA) and the National Historic Preservation Act (NHPA).

Archaeological surveys and studies are used to provide a baseline description of the prehistoric remains located on and in the vicinity of the four alternative SNS sites. Those remains that are listed on or eligible for listing on the NRHP are identified. These baseline descriptions of the existing prehistoric resources environment at each alternative site are provided in Sections 4.1.7.1, 4.2.7.1, 4.3.7.1, and 4.4.7.1.

The EIS assesses how existing prehistoric resources on and in the vicinity of the four alternative SNS sites would be affected by implementation of the proposed action and the No-Action Alternative. This is done by closely comparing the locations of known prehistoric resources to the types and degrees of ground surface and soil disturbance that would occur from various aspects of the proposed action and the No-Action Alternative. As a result of such comparisons, a qualitative evaluation of potential damage or effects on resources is generated. Activities under the proposed action that would have the ability to remove surface features and disturb archaeological materials would typically include land clearing and excavation associated with construction of the SNS. Because the four alternative sites would be entirely cleared and excavated at an early point during construction of the SNS, any prehistoric resources on and adjacent to the four alternative sites would be susceptible to disturbance or destruction during this stage of the proposed action. Subsequent operation of the SNS would not be expected to affect any prehistoric resources that have already been destroyed by construction. Operation of the SNS would not involve the generation of intense ground vibrations or airborne shock waves that could affect prehistoric resources beyond the SNS site boundaries. The process of assessing potential effects includes the identification of measures to mitigate these effects.

If the proposed action, as implemented through the siting alternatives, or No-Action Alternative would have adverse effects on one or more prehistoric resources, DOE would consult with the SHPO in the appropriate state to seek ways of avoiding or reducing these effects. As required by the federal regulations in 36 CFR 800.5(e)(1)(iii), the Advisory Council on Historic Preservation and other interested persons would also be afforded an opportunity to participate in these required consultations.

The identification of potential mitigation measures in the EIS is based on the characteristics of the resources, their locations, and the nature of the anticipated effects. Such measures include the recovery of archaeological data through excavations, recording of architectural information, or the avoidance of effects by relocating a proposed site or activity. Typically, such measures must be taken prior to implementation of a proposed action or alternative.

Should any prehistoric resources be inadvertently discovered during construction of the proposed SNS, construction activities in the immediate vicinity of the resources would cease until their significance and ultimate disposition is determined in consultation with the appropriate SHPO, Indian tribes with the closest known cultural affiliation, and the Advisory Council on Historic Preservation. For purposes of compliance with Section 3(d) of the Native American Graves Protection and Repatriation Act (NAGPRA), inadvertent discovery of human remains and funerary objects (associated and unassociated) would result in the cessation of construction activities, protection of the discovered items, notice of the discovery sent to the Indian tribes with the closest know cultural affiliation, and direction asked for treatment and disposition of the human remains or funerary objects. The 30-day delay period following official certification that notification of the accidental discovery has been received by the agency or tribe would be followed.

5.1.7.2 Historic Resources

Historic resources are the significant physical remains of human activities that post-date written records in the U.S. They include, but are not limited to, historic archaeological sites, residential structures, commercial structures, and trails. To be identified as a historic resource, such remains must be listed on, or eligible for listing on, the NRHP. The federal laws that protect such resources include ARPA and the NHPA. In the U.S., historic cultural resources date to the Historic Period, which spans the time from A.D. 1492 to the present day.

Archaeological site survey reports, historic site survey reports, and reports on historic site excavations are used to provide a baseline description of the historic remains located on and in the vicinity of the four alternative SNS sites. Those remains that are listed on or eligible for listing on the NRHP are identified. These descriptions of the historic cultural resources environment at each alternative site are provided in Sections 4.1.7.2, 4.2.7.2, 4.3.7.2, and 4.4.7.2.

The EIS assesses how historic resources on and in the vicinity of the four alternative SNS sites would be affected by implementation of the proposed action and the No-Action Alternative. This is done by closely comparing the locations of known historic resources to the types and degrees of ground surface and soil disturbance that would occur at these locations as a result of the proposed action and the No-Action Alternative. From such comparisons, a qualitative evaluation of potential damage or effects on resources is generated. Activities under the proposed action that would have the ability to remove surface structures and disturb historic archaeological materials would typically include land clearing and excavation associated with construction of the SNS. Because the four alternative sites would be entirely cleared and excavated at an early point during construction of the SNS, any historic resources on and adjacent to the four alternative sites would be susceptible to disturbance or destruction during this stage of the proposed action. Subsequent operation of the SNS would not be expected to affect any historic resources that have already been destroyed by construction. Operation of the SNS would not involve the generation of ground vibrations or airborne shock waves that could affect historic resources beyond the SNS site boundaries.

If the proposed action, as implemented through the siting alternatives, or No-Action Alternative would have adverse effects on one or more historic resources, DOE would consult with the SHPO in the appropriate state to seek ways of avoiding or reducing these effects. As required by the federal regulations in 36 CFR 800.5(e)(1)(iii), the Advisory Council on Historic Preservation and other interested persons would also be afforded an opportunity to participate in these required consultations.

The identification of potential mitigation measures in the EIS is based on the characteristics of the resources, their locations, and the nature of the anticipated effects. Such measures include the recovery of archaeological data through excavations, recording of information on historic structures and features, or the avoidance of effects by relocating a proposed site or activity. Typically, such measures must be taken prior to implementation of a proposed action or alternative.

The inadvertent discovery of historic resources during construction of the proposed SNS would be handled in the manner described in Section 5.1.7.1.

5.1.7.3 Traditional Cultural Properties

A TCP is a significant place or object associated with the historical and cultural practices or beliefs of a living community. It is rooted in the community's history and is important for maintaining the continuing cultural identity of the community. A TCP may include a prehistoric or historic archaeological site, natural resource, traditional use area, shrine, sacred place, trail, spring, river, traditional hunting area, cemetery or burial site, or rock art. In addition, it may include a rural community or urban neighborhood with a unique cultural tradition and identity. The term is not limited to ethnic minority groups. All Americans have properties to which they ascribe traditional cultural value.

TCPs are protected under the American Indian Religious Freedom Act and NAGPRA. These laws and their implementing regulations establish procedures for the identification and protection of TCPs. Sites that are sacred to American Indians and access to these sites by Indian religious practitioners are protected under Executive Order 13007. (Refer to Section 6.1.8).

Existing reports of consultations with Native American tribal groups and Hispanic groups are used, when possible, to identify and locate TCPs on and in the vicinity of the four alternative SNS sites. If the site at LANL is selected for construction of the SNS, additional consultations with tribal and Hispanic groups are planned to identify other specific TCPs on the SNS site. Descriptions of the TCP environment at each alternative site are provided in Sections 4.1.7.3, 4.2.7.3, 4.3.7.3, and 4.4.7.3.

The same basic methodological approach used to assess the effects of the proposed action and No-Action Alternative on prehistoric and historic resources is used to assess their effects on TCPs. DOE plans to develop and implement mitigation measures in close consultation with those tribal and Hispanic groups that ascribe traditional cultural value to the affected TCPs.

5.1.8 LAND USE

The land use analysis assesses the potential effects construction and operation of the SNS would have on land use patterns on and in the vicinity of the four alternative sites for the proposed action. In addition, the potential effects of the No-Action Alternative on land use are also assessed.

Descriptions of the past, current, and planned future land use environments of the four alternative SNS sites are developed using a variety of information sources. These include data calls, facility site development plans, land use plans, reports on stakeholder land use recommendations to DOE, technical reports, and aerial photographs. These descriptions of the affected land use environment provide a baseline framework for assessing the effects of the proposed action on land use at the four alternative SNS sites. The descriptions are presented in Sections 4.1.8, 4.2.8, 4.3.8, and 4.4.8.

A qualitative approach is used to assess the extent and magnitude of potential effects on land use patterns that would result from implementing the proposed action on each alternative site and from implementing the No-Action Alternative. This is done by comparing current land uses and land use plans to anticipated changes in land use that would occur as a result of implementing the proposed action and the No-Action Alternative. The land use analysis assesses the following: effects on land use outside laboratory boundaries and throughout most laboratory land; effects on undeveloped land; effects on the current use of SNS site land; effects on the use of laboratory land for research purposes; effects involving the zoning of SNS site land for future use; effects on the future use of SNS site land and land adjacent to it; and effects on the use of land for parks, nature preserves, and recreation.

Potential effects on visual resources are assessed qualitatively using the degree of visual contrast between activities under the proposed action and No-Action Alternatives and the existing landscape character as seen from viewpoints accessible to the public. The sensitivity levels of viewpoints and visibility of the SNS sites to the public are taken into consideration in the assessments.

5.1.9 HUMAN HEALTH

The assessment of impacts to workers and the public for radiological and toxic material releases considers both normal operations and facility accident conditions. Doses and consequences are calculated in a parallel manner for all alternatives to provide quantifiable indicators for comparison between the alternatives. The steps in evaluating quantifiable consequences follows:

- Identify and quantify emissions (source terms);
- Identify and select human exposure pathways;
- Analyze transport of contaminants through each exposure pathway;
- Calculate dose to individual, group, or population;
- Quantify consequences in terms of excess latent cancer fatalities (LCFs); and
- Discuss and evaluate consequences.

The emission of radioactive and toxic materials and the human exposure pathways are generic for the SNS and are independent of the specific proposed site. The analysis of material transport from the SNS to the potentially exposed individual(s) and the calculation of resulting concentrations and doses use site-dependent factors such as recent meteorology, actual population distributions, and the proposed facility location with respect to the site boundary. Site-specific doses are then converted to the projected number of incremental or excess fatal cancers using dose-to-risk conversion factors (DOE 1993b). A discussion of the methods and assumptions used in each of these steps is provided below. Additional details of emission identification and calculations of atmospheric dispersion and doses are provided in Appendix F.

5.1.9.1 Radioactive Emissions

Radioactivity would not be discharged from the proposed SNS to surface water under normal conditions of operation. Liquid low-level waste (LLLW) and process waste would be collected and transported by tanker truck to existing waste processing facilities. Radioactive emissions to the atmosphere from the proposed SNS would consist of releases from two stacks—the Tunnel Confinement Exhaust Stack and the Target Building Exhaust Stack. The locations of these stacks are shown in Figure 3.2.1.5-1.

Annual emissions from these systems are summarized in Table 3.2.3.5-1 for power levels of both 1 MW and 4 MW. A detailed list of radionuclide emissions used for dose calculations is provided in Table F-1 of Appendix F. Assumptions on facility design for upgrade from 1 MW to 4 MW result in a linear scaling of off-gases from the cooling system and the target. Off-gases from the beam stops and exhausts from the various tunnels through the Tunnel Confinement Exhaust do not scale linearly due to specifics of the proposed upgrade design.

5.1.9.2 Exposure Pathways

Routine airborne emissions of radionuclides result in internal exposures of onsite workers by way of inhalation and external exposures via immersion in the plume of released radionuclides and from radionuclides deposited on the ground surface. The offsite public could be exposed through these same pathways as the workers and could receive additional internal exposures by way of a series of ingestion pathways initiated by the deposition of radionuclides on the ground surface and leafy surfaces in pasture lands and gardens. These radionuclides are then taken up directly through ingestion of contaminated vegetation or indirectly through ingestion of meat or dairy products from animals that had ingested the vegetation.

Many of the mercury radionuclides produced in the target and emitted from the Target Building Exhaust Stack decay through a series of radioactive progeny called a decay chain. The half-lives of the various members of a decay chain cause individual members of the chain to be more or less important in the various exposure pathways. Radionuclides with a short half-life are a more significant hazard for inhalation, an exposure that occurs within minutes or hours of release; but a radionuclide with a long half-life could be important for ingestion, which would occur within days to months following the release.

5.1.9.3 Calculation of Atmospheric Dispersion and Doses

A number of computer codes are available that can account for dispersion, deposition, and radioactive decay of radionuclides released to the environment. Codes such as GENII and MACCS are comprehensive codes that model atmospheric dispersion and calculate doses in a single evaluation. CAP88-PC is a widely used code that performs such calculations for continuous releases such as SNS normal emissions. However, these codes could not be used in this analysis because of the unique radionuclide products activated in the mercury target of the SNS. The activated mercury products and members of the associated decay chains were not included in the databases of these codes, their decay and in-growth during dispersion could not be modeled, conversion factors from environmental concentration to individual dose were not available, or the source code did not enable additional radionuclides to be added to the analysis.

For normal conditions of continuous low-magnitude emissions, a set of Microsoft Excel97 spreadsheet and Visual Basic macros were developed to implement the methodology used in CAP88-PC and allow the evaluation of the unique SNS radionuclides. This methodology is described in the code user guide (EPA 402-B-92-001 – EPA, 1992). The documentation for AIRDOS-EPA (Moore 1979), a mainframe predecessor of CAP88-PC, contains additional detail and a source code listing. Details of the implementation of the methodology are discussed in Appendix F.

This methodology uses a Gaussian plume model to calculate sector-averaged depleted ground-level concentrations in air and ground deposition rates of radionuclides. The depletion mechanisms considered are radioactive decay and ingrowth, precipitation scavenging, and dry deposition. Buildup of radionuclides deposited on the ground and on plant surfaces are also considered. Concentrations in vegetation, beef, and milk consumed by humans are calculated using soil-to-plant, animal feed-to-milk, and animal feed-to-beef transfer factors. Intake of radionuclides by humans is calculated based on agricultural production data for the appropriate state and consumption rates of leafy vegetables, produce, milk, and beef.

For short-term releases occurring in accidents, atmospheric dispersion calculations were performed using PAVAN, a public-domain compiled program used by the NRC to calculate ground-level normalized atmospheric dispersion factors for short-term releases at ground level and at elevation (PNL 1982). PAVAN uses site-specific annual wind patterns to determine short-term or averaged dispersion in 22.5^{o} sectors surrounding the site.

The computer spreadsheets developed to estimate dose from airborne emissions incorporated the atmospheric dispersion from the codes, the duration and source terms for the individual release scenario (normal operations or accident), site-specific data on population distribution of onsite workers and offsite public, and radionuclide-specific dose conversion factors (DCFs) to convert environmental concentration to individual dose. Population effects are calculated using actual population distributions within 80 km (50 mi) of each release site. These spreadsheets perform rigorous decay calculations for all radionuclide chains for the proposed SNS and calculate the dose to workers and the public from inhalation and immersion. The analysis also includes the estimated contribution of dose from radionuclides deposited on the ground and from ingestion as discussed in Appendix F (Section F.5.3).

Most radiological dose assessments use DCFs published by the U.S. EPA in Federal Guidance Report No. 12 (Eckerman and Ryman 1993). However, these published and accepted DCFs do not include data for all of the mercury and iodine radionuclides or their decay products that are anticipated in SNS emissions. At DOE request, staff at ORNL, who produced the published data, developed DCFs for inhalation, ingestion, immersion, and ground plane exposure to isotopes of mercury, iodine, and their decay products (Eckerman 1998a, Eckerman 1998b). The discussion in Appendix F provides more detail of, and the basis for, the use of the various DCFs in this dose calculation.

5.1.9.4 Quantification of Radiological Consequences

DOE uses the linear dose response, no threshold model to compute the potential risk of radiological exposures for each alternative considered in an EIS (DOE 1993b). This model estimates excess LCFs using dose-to-risk conversion factors recommended by the International Commission on Radiation Protection (ICRP) (ICRP 1991). For low-dose, low-dose rate exposures (< 20 rad, < 10 rad/hr), ICRP recommends factors of 0.0004 LCF per person-rem for workers and 0.0005 LCF per person-rem for the public. The higher risk factor for the public reflects the presence of children in the public who are not present in the workforce.

This method of quantifying effects is a conservative assumption of biological response to radiation dose. To compare potential impacts, dose-to-risk conversion factors are applied as if any radiation exposure, no matter how small, involves some potential risk. While the human body has the ability to repair cell damage caused by radiation and other agents, the present state of scientific knowledge does not allow the threshold at which radiation dose would lead to the development of a fatal cancer to be determined with any certainty. Accordingly, DOE conservative estimates provide an assurance that the potential effects will not be underestimated, while accepting that assumptions may lead to an overestimate of potential consequences.

5.1.9.5 Toxic Material Emissions and Consequences

The only toxic material that would be emitted from the proposed SNS during normal operations is elemental mercury vapor. Lead would be used for radiation shielding in the target areas and other areas of the proposed SNS, but it is not volatile at the temperatures to which it would be subjected. Elemental mercury vapor would be present in the gases released from the Target Building Exhaust Stack from two sources: off-gassing from the target and in air from the target cell ventilation system due to evaporation of small droplets assumed to be adhering to the cell drain surfaces. Exposures of individual workers to mercury vapors are evaluated by comparing calculated concentrations to limits promulgated by the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH). For continuous or unlimited duration exposure of the general public, the EPA has established a Reference Concentration (RfC) intended to prevent the occurrence of observable detrimental effects.

5.1.9.6 Accident Conditions

During operation of the proposed SNS, it is possible that equipment failures, human errors, or natural phenomena would result in the release of radiation, radioactive materials, or toxic materials. Such releases could have potential adverse effects on the health of workers and the public. The significance of these potential effects is evaluated in terms of probability that a given accidental release would occur and the consequences of the release if it does occur.

5.1.9.6.1 Accident Scenarios

DOE has analyzed a wide range of potential hazards associated with operation of the proposed SNS and, based on this analysis, has selected bounding accidents. For each of the bounding accidents, the frequency of occurrence and source terms has been estimated. A source term specifies the quantity or activity of material released and duration of the release. The accident analysis is included as Appendix A of this EIS.

Accident frequencies are described using the terms "anticipated," "unlikely," "extremely unlikely," and "beyond extremely unlikely." These terms and their corresponding ranges of frequencies of occurrence are defined in Table 5.1.9.6.1-1. Some accidents are described as "beyond design basis." Such accidents usually have frequencies of occurrence less than 1×10^{-6}/yr. Table F-2 (refer to Appendix F), summarizes information about the accidents described in detail in Appendix A.

5.1.9.6.2 Direct Radiation in Accidents

Accidents involving exposure to direct radiation are not specifically addressed in Appendix A. Very high levels of radiation would exist in the linac tunnel, ring tunnel(s), high-energy beam transport tunnels, and target areas when the particle beam is present, but they would rapidly decrease immediately after the beam is shut off. A combination of administrative controls, written procedures and training, and design features would be used to prevent exposures to high levels of direct radiation in accordance with the requirements of 10 CFR 835 Subpart F, "Entry Control Program." DOE's Shielding Design Policy for the proposed SNS is such that for the worst-case design-basis accident, the dose to the maximum exposed individual in an uncontrolled area would be limited to 1 rem and for a worker in a controlled area would be limited to 25 rem.

5.1.9.6.3 Radioactive Materials Accidents

The consequences of accidents resulting in the release of radioactive materials have been evaluated using the same methods and site-specific data used to evaluate the effects of normal operations. These methods and data are discussed in detail in Appendix F. Exposures that would result from the release of radioactive materials during credible and beyond design-

Table 5.1.9.6.1-1 Accident frequency categories

Category	Description	Annual Frequency of Occurrence (yr^{-1})
Anticipated	May occur several times during the lifetime of the facility	1 to 10^{-2}
Unlikely	Not anticipated to occur at some time during the lifetime of the facility (includes accidents initiated by Uniform Building Code-level earthquake, 100-year floods, maximum wind gust, etc.)	10^{-2} to 10^{-4}
Extremely Unlikely	Probably will not occur during the lifetime of the facility (includes design basis accidents)	10^{-4} to 10^{-6}
Beyond Extremely Unlikely	Not credible during the lifetime of the facility (beyond design basis accidents)	$<10^{-6}$

basis accidents at the proposed SNS are low-dose, and low-dose rate events. Accordingly, the same dose-to-risk conversion factors of 0.0005 LCF per person-rem for exposures of the public and 0.0004 LCF per person-rem for workers used to estimate effects of normal operations have been used to estimate accident consequences.

5.1.9.7 Consequence Evaluation

For each location, doses to the maximum exposed individual, both the uninvolved worker and the member of the public, and the population dose are estimated using site-specific population distributions. Doses are converted to consequences expressed as excess LCFs, using factors recommended by the ICRP.

5.1.9.7.1 Releases in Routine Operations

The proposed SNS would be operated so that radiation dose to workers and the public from radiation and radioactive emissions in routine operations would not exceed applicable regulatory limits. The Shielding Design Policy for the Proposed SNS (ORNL 1997a) was developed to ensure compliance with the requirements of Title 10 CFR Part 835, *Occupational Radiation Protection*, and DOE Order 5400.5, *Radiation Protection of the Public and the Environment*. Further, adherence to the as low as reasonably achievable (ALARA) program requirements will ensure that operations are conducted in a manner to maintain the exposures far below these regulatory limits. Consequences to the uninvolved onsite worker and to the offsite population resulting from routine emissions of radioactivity and mercury have been quantified as discussed above. The numerical results are presented in individual sections addressing each alternative site.

5.1.9.7.2 Accidental Releases

The evaluation of accidents is based on the potential exposures of uninvolved workers and the public to airborne radioactivity during the period of uncontrolled release. These exposures are limited to dose from inhalation and immersion. This EIS presents an analysis of risk based on a conceptual design, one of the earliest stages of the design process. As a result, the mitigating effects of many systems and design features that would reduce the likelihood and/or the consequences of postulated accidents have not been incorporated or have been assumed to function at reduced efficiency.

In the quantification of consequences, an LCF estimate of 1.0 or greater does not mean that a fatality will necessarily occur. Instead, the calculation of estimated LCFs provides a numerical value to compare whether impacts to human health could be greater for one alternative than for another. The magnitude of LCFs are calculated based on the assumption that a release has occurred; the probability that the LCFs will appear depends on the probability of the radionuclide release. At this stage of design, releases during normal operations and the probability of an accident occurring cannot be separately evaluated by alternative. Probabilities or accidental frequencies are provided in Appendix A.

5.1.10 SUPPORT FACILITIES AND INFRASTRUCTURE

The following sections present the methods used to evaluate the potential effects on transportation and utilities for the proposed construction and operation of the SNS.

5.1.10.1 Transportation

The transportation impact analysis examines the predicted increases in traffic on roads in proximity to the alternative SNS sites versus the baseline average daily traffic those same roads currently handle. The primary determinants of transportation effects are changes in traffic at peak use times (rush hr) that diminish the level of service (LOS) for those traveling on the road. The analysis of traffic effects also includes accounting for the non-passenger vehicles (i.e., trucks, heavy equipment) associated with both construction and operational phases at each of the four proposed SNS sites.

Based on the design of the proposed action (as described in Section 3.2), assumptions are made regarding the number of vehicles that would travel to the proposed SNS location for the construction and operational phases. Specific-ally, site employees are assumed to drive a maximum of 466 passenger vehicles to the site during peak year construction (2002) at each of the four alternative sites. Construction vehicles account for an additional seven trucks per workday of the 5-year construction period. Service vehicles are assumed to add an additional three trucks per day during both the construction and operational phases of the proposed SNS. Three hundred and two passenger vehicles are assumed to support SNS operations at its maximum (4 MW) operating power. Using the maximum construction-year number of employees and the maximum operations number of employees for the analysis provides the most conservative analysis (worst case) of the potential effects on transportation.

Baseline average daily traffic data are compiled from site-specific traffic analyses or from recent local traffic counts. The predicted change in traffic is based on the number of employees currently traveling to the respective sites, added to the incremental increase in traffic attributable to the SNS construction and operational activities, minus a factor for carpooling. This increase in traffic volume to the site, added to the total number of vehicles currently utilizing the same access roads, provides the basis for analyzing the changes in service.

5.1.10.2 Utilities

Basic utility services are necessary for construction and operation of the proposed SNS and are evaluated to examine the accessibility and available capacity to service the SNS at each of the locations considered. The design requirements for utility services (electrical, steam, natural gas, water, and sanitary waste treatment) would be the same at each of the four sites and provide a consistent basis of comparison for the site-specific analysis. The site-specific information to support the utilities analysis (accessibility and capacity) is developed by phone interviews with individuals at each of the alternative sites being considered. This information is then used to assess the effects from providing the required services to the proposed SNS. Where possible, these services are assumed to extend from the points where existing sources of sufficient quantity make their nearest approaches to the SNS site.

5.1.11 WASTE MANAGEMENT

The analysis for waste management evaluates impacts of the proposed action on the existing and projected waste management activities at the alternative sites against the No-Action Alternative at that site. The assessment addresses the waste types and waste capacities from the various waste management facilities at each site and compares them with the No-Action Alternative.

The EIS assesses the environmental effects associated with waste management for construction and operation of the proposed action. The following categories of waste are analyzed: hazardous, low-level, mixed, and sanitary. Design capacity, site waste projections, SNS waste operations projections, and remaining site capacity data are reviewed for all waste facilities at each of the four alternative sites. Based upon this information, the potential effects the proposed action would have on the existing waste management facilities, and hence the overall site, are assessed. Effects are assessed if the current waste management facilities at each alternative site are not adequate for accommodating the waste that would be generated by the proposed SNS. The waste management information provided for this assessment is based on figures and estimates obtained from current waste management documentation and information provided by waste management subject matter experts from each site.

5.2 OAK RIDGE NATIONAL LABORATORY

This section describes the potential environmental impacts or changes that would be expected to occur at ORNL if the proposed action were to be implemented. Included in the discussion of this section are the impacts to the physical environment; the ecological and biological resources; the existing social and demographic environment; the cultural, land, and infrastructure resources; and public/worker health.

5.2.1 GEOLOGY AND SOILS

Effects on the geology and soils from construction and operation of the proposed SNS on the proposed Chestnut Ridge site at DOE's Oak Ridge Reservation (ORR) are described in the following sections.

5.2.1.1 Site Stability

Survey data accumulated to date indicate that no effects would occur from the construction or operation of the proposed SNS at the Chestnut Ridge site. Results from a preliminary geotechnical investigation (LAW 1997) have not encountered soil stability problems at the site. Soil borings have determined that depth to bedrock is highly variable and in excess of 100 ft (30 m) deep. Karst voids in the bedrock may occur at depth. More detailed boring and geophysical surveys are planned in the future to fully characterized the subsurface nature of the site. It should be noted, however, that the conceptual design proposes to construct the SNS foundation with a floating slab design supported by the soil column. Foundation designs would account for specific loading factors for each component of the facility to achieve acceptable levels of differential settling between accelerator components. If the final design requires heavily loaded structures that are extremely sensitive to differential settlement, mitigation measures may include the removal of soil and replacement with a less compressible medium (for example, flowable fill or crushed stone). In extreme cases, foundation supports could be installed by driving piles or drilling piers to solid rock at depth. No effects are anticipated from site stability.

5.2.1.2 Seismic Risk

Components of the proposed SNS would be designed and constructed to withstand the magnitude of earthquake shocks that are considered likely to occur in this area. In 1989, DOE issued Order 6430.1A to be used for seismic design of new facilities and the evaluation of existing facilities. Because of the many uncertainties about seismicity of the central and eastern U.S., new efforts to evaluate seismicity were undertaken by the Electric Power Research Institute and Lawrence Livermore National Laboratory (sponsored by the NRC). Based on those facilities' studies, additional studies by Lockheed Martin Energy Systems (LMES), specifications required under new DOE orders, and other advances in the art of evaluating seismic hazards, revised assessments to support the design of new facilities and the evaluation of existing facilities were conducted (Beavers 1995). This assessment resulted in new seismic criteria for DOE-Oak Ridge Operations (DOE-ORO). Table 5.2.1.2-1 presents estimated peak ground acceleration (PGA) at locations with greater than 30 ft (10 m) of soil cover (as would be the case with the proposed SNS at Chestnut Ridge).

Buildings and components of the proposed SNS would be designed to withstand corresponding earthquake levels without sustaining serious damage. As such, predictable seismicity for the proposed Chestnut Ridge site would have no effect on the construction, operation, or retirement of the proposed SNS.

5.2.1.3 Soils

Excavations required for construction of the proposed SNS would disturb the native soils. Excavated soils would be stockpiled according to soil type and horizon. If the excavated soils possess the proper characteristics, they would be used to construct the shielding berm. Otherwise, the soils would be placed in the spoils area (refer to Section 3.2.5.2). Topsoil removed during excavation would be used for grading and

Table 5.2.1.2-1. Seismic design criteria for ORR.

Return Period (years)	Mean PGA[a] — New Site-Specific Criteria [depth of soil > 10 ft (3 m)]	
	Horizontal	Vertical
0	0.00	0.00
500	0.15	0.10
1,000	0.20	0.13
2,000	0.30	0.20
10,000	NA	NA

[a] Beavers 1995.
NA - Not available.

landscaping of the site at the finish of construction.

Construction of the SNS would require grading of the site and removal of vegetative cover. As a result, the potential exists for soil erosion and stream siltation especially during periodic storm events. Best management practices would be followed to minimize the impacts of erosion during construction activities. Section 3.2.2.3, Site Preparation, discusses the elements (retention basin, silt fences, temporary storm water drainages, etc.) that would follow an erosion control plan to prevent erosion and siltation of White Oak Creek (WOC).

Operation of the proposed SNS would affect soils used for shielding surrounding the linac tunnel. The proposed SNS would produce particles that would diffuse outward from the center of the beam within the linac tunnel and would interact with any physical matter, producing a series of nuclear cascades. This reaction is termed neutron activation, whereby the soils would become radioactive. Analyses show that activation products would be concentrated toward the last 65.6 ft (20 m) of the linac tunnel nearest the target structure and that 99.9 percent of the radionuclides in the activation zone would be contained within the first 4 m of soil surrounding the tunnel. The radionuclides created within the soil and in pore waters within the matrix of the soil would then be subject to leaching and transport via groundwater movement. An assessment of radionuclide activities or concentrations at a boundary 32.8 ft (10 m) from the tunnel was made for a 10-year period after closure. It is estimated that if the activation were spread uniformly over the full length of the linac tunnel, 309,000 Ci would be contained within the soil (see Section 5.2.2.3). The primary effects due to activation of the soil would be its effect on groundwater (refer to Section 5.2.2.3 for groundwater impacts) and the mitigation of a radioactive source term to close the facility at the end of its operational life. An evaluation of the activation products generated and transported in the subsurface was conducted to determine the effect on the environment (Dole 1998).

Multiple conservative assumptions were made in the study to ensure the protection of the environment. These assumptions were employed for the site-specific study at ORNL but would apply to the alternative sites in the qualitative comparison between site-alternatives. Several of the key conservative assumptions would overstate the potential for migration of the radionuclides:

- The facility operates continuously for 30 years—overestimating significant periods of time when the SNS linac is not operational and radionuclides are not generated.
- The entire soil volume surrounding the tunnel is subjected to the same level of neutron activation as the high-energy end of the linac—resulting in an overestimation by several factors in the volume of the activation products generated.
- Activation products remain within the berm and do not begin to move until the end of the facility's life, and all of the radionuclides are immediately available for diffusion and hydraulic transport—thereby overestimating

> **Neutron Activation** is the process of creating unstable radioisotopes or nuclides by the adsorption of neutrons into the nucleus of an atom.

the maximum starting concentrations and transport potential of radionuclides.

- Saturated flow continuously exists around the outer surface of the berm to carry contaminants to the water table—even though the linac tunnel will be located in the unsaturated soil horizon.
- The use of laboratory-measured diffusion coefficients to simulate real-world conditions provides a high estimate of diffusion and transport of radionuclides.

Even using very conservative assumptions, it is concluded that radioactive decay would eliminate any significant effects to human or ecological receptors because of the slow movement by the groundwater.

5.2.2 WATER RESOURCES

Effects on the water resources from the construction and operation of the proposed SNS located on the proposed Chestnut Ridge site at DOE's ORR are described in the following sections.

5.2.2.1 Surface Water

The effects on surface water resources from operation of the proposed SNS are discussed in this section. Best management practices would be employed to minimize any effects on surface water due to erosion and siltation during construction (see Section 5.2.1.3).

5.2.2.1.1 Water Supply

Melton Hill Lake is the primary water source for the City of Oak Ridge and DOE facilities. Potable water supplies would be delivered to the proposed SNS site by an existing 24-in. (61-cm) line from the Oak Ridge Water Plant. Currently, there is no estimate of the amount of water required for construction. However, it is expected that construction water requirements would be negligible compared to the available supply. Demands ranging from 800 to 1,600 gpm (3,028 to 6,057 lpm) would be required to support operations at the proposed SNS facility, which may be upgraded throughout its operational life from 1 MW to 4 MW. These demands could be met by the existing capacity of the system.

5.2.2.1.2 Discharge

Of the total water demands, conventional cooling tower usage would require 700 gpm (2,650 lpm) for a 4-MW facility. Roughly one-half of this volume [350 gpm (1,325 lpm)] would be needed to replenish water lost through evaporation, and one-half [350 gpm (1,325 lpm)] would be needed for make-up water to replace blowdown water discharges. Cooling tower usage is estimated at about 500 gpm (1,893 lpm) for a 2-MW facility. A continuous discharge or blowdown would be released into the retention basin on the proposed SNS site. This basin would be designed to allow sufficient residence time for the discharge to cool to ambient temperatures. If necessary, active cooling systems such as recirculating fountains may be employed. From the retention pond, the discharge would be piped to below the WOC weir located at the base of Chestnut Ridge before release in the WOC drainage system.

Base flow at the WOC weir has been gauged at 0.15 to 0.25 mgpd (0.57 to 0.95 million lpd) during the dry season and at 0.75 to 1.0 mgpd (2.84 to 3.8 million lpd) during the wet season (refer to Section 4.1.2.1). The addition of the proposed SNS discharge [0.36 to 0.50 mgpd (1.4 to 1.9 million lpd)] to WOC would increase the flow rate by roughly 50 percent in the wet season and by a factor of two or more during the dry season. Effects resulting from a 50 to 200 percent increase in flow would include increased stream velocity, channel size, erosion and sediment transport (at least until an equilibrium is reached), and possibly water parameter changes from ambient conditions.

Polyphosphonates for antiscaling and ozone as a biocide would be used in the cooling towers as is the common practice at other ORNL cooling towers. Discharge from the towers would be regulated to contain about four times the dissolved solids content of potable water (i.e., 1,000 to 1,200 mmhos conductivity).

Discharge by the proposed SNS into WOC would provide a net increase to the water budget of the Bethel Valley and Melton Valley watersheds. As such, it is possible that discharge by WOC into White Oak Lake could increase, which in turn might lead to an increase in flow over White Oak Dam. Because White Oak Lake acts as a reservoir for radionuclides in suspension and in solution, an increase of flow over the dam could effect the release of radionuclides. Assuming no loss by evapotranspiration and no infiltration or recharge to the intermediate and deep groundwater regimes, the maximum estimated discharge (at full loading for 4 MW) from the proposed SNS would increase the White Oak Dam flow by 2 to 4 percent during the wet weather season and by 10 to 15 percent during the dry weather season (Figure 5.2.2.1.2-1). Actual losses by infiltration and evapotranspiration would reduce the contribution by the proposed SNS over White Oak Dam by well over 50 percent of the maximum. In fact, the measure of any real contribution to actual flow over White Oak Dam would be lost in the noise of monthly variance in precipitation. Accordingly, the effect of the proposed SNS on radionuclide releases from ORNL is considered minimal.

5.2.2.2 Flood Potential and Floodplain Activities

The proposed SNS at ORNL does not lie within a floodplain or designated flood fringe area; therefore, flood potential of the site is negligible. Seasonal storm events may cause limited

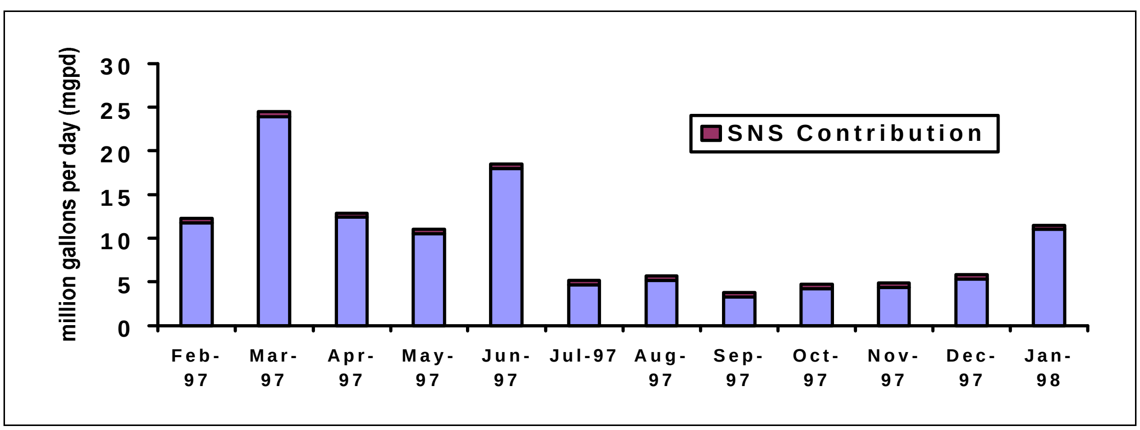

Figure 5.2.2.1.2-1. Proposed SNS contribution to flow over White Oak Dam.

flooding along Chestnut Ridge and portions of the proposed site when man-made storm drains and natural drainage channels exceed capacity. The effect would be localized and temporary.

5.2.2.3 Groundwater

The effects of proposed SNS construction and operations on groundwater are discussed in this section.

5.2.2.3.1 Resources

Construction and operation of the proposed SNS would have minimal to no effect on the intermediate and deep groundwater systems at the proposed Chestnut Ridge site, and no groundwater resources would be utilized by SNS construction or operations. Depth to groundwater observed during preliminary site characterization activities may be as deep as 100 ft (30.5 m), and the maximum planned excavation should not intersect the water table. If conduit flow of groundwater within the bedrock exists beneath Chestnut Ridge, the surface excavations required to construct the facility would not affect the flow capacity or yield from these zones. Also, the limited footprint of the proposed SNS would not materially affect the recharge by infiltration to the shallow groundwater zone or to the Knox aquifer underneath Chestnut Ridge. There could be increased recharge to the groundwater system if the proposed SNS retention pond is built above a karst system. If, during site characterization, a karst formation is identified at the location of the retention pond, appropriate measures would be taken.

5.2.2.3.2 Contamination

In addition to determining the types and quantities of radionuclides generated in the soil berm, an evaluation of transport of these contaminants under natural conditions was conducted. Figure 5.2.2.3.2-1 depicts the hydrologic cross section used to calculate the infiltration of precipitation from above and the flow of groundwater below the proposed site.

Assuming an arbitrary 32.8-ft (10-m) compliance boundary beyond the 72-ft (22-m) diameter of the berm, the cross section of the 3,143-ft (958-m) long proposed SNS tunnel system has an effective area of 450,577 ft^2 (41,860 m^2). With 15 in. (38.1 cm) of annual recharge at the ORNL site, a volume of 563,274 ft^3 (15,950 m^3) per year would infiltrate through the berm into the groundwater. With a 9.8-ft (3-m) thick mixing zone and groundwater velocity under this site at 2.9 m/yr, the annual horizontal contribution of groundwater under the proposed SNS tunnels is only 105,238 ft^3 (2,980 m^3). This brings the total annual water balance under the proposed SNS facility and its 32.8-ft (10-m) zones of influence to an annual turnover of 668,513 ft^3 (18,930 m^3) per year. The flow-through rate was combined with the calculation of migration rates of contaminants to the outer berm surface and was used to estimate concentrations of radionuclides in the groundwater. Using an assumed saturated hydraulic conductivity for the vadose zone of 1 m/yr (a conservative assumption compared to measurements approaching 0.2 m/yr), water carrying contaminants from the berm’s surface would reach the 32.8-ft (10-m) boundary zone in

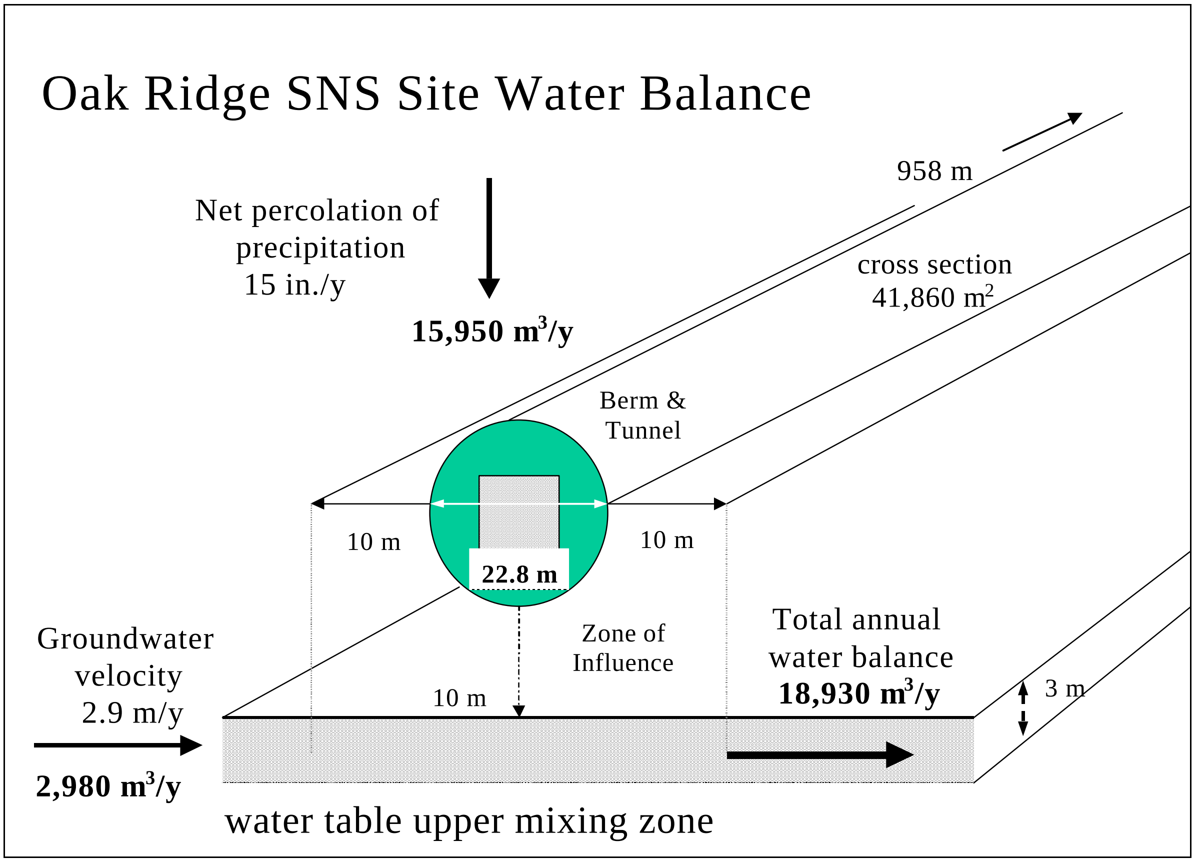

Figure 5.2.2.3.2-1. Hydrologic cross section of the proposed SNS site at ORNL.

only 10 years. During that time, a number of radionuclides in transport would decline in activity due to half-life decay. Table 5.2.2.3.2-1 displays the estimate of isotope activities at the 32.8-ft (10-m) boundary 10 years after closure of the facility.

Based on very conservative assumptions incorporated into this evaluation (see Section 5.2.1.3), only 3 (^{14}C, ^{22}Na, and ^{54}Mn) of 12 isotopes would have any potential for affecting groundwater quality within a 32.8-ft (10-m) zone of influence at the proposed SNS facility. In the case of ^{22}Na and ^{54}Mn, these isotopes have short half-lives of 2.6 years and 0.854 years, respectively. If less conservative but realistic retardation factors are applied to account for slowed contaminant migration through ORNL-type soils, then these isotopes would decay to below levels of concern before they might reach the 32.8-ft (10-m) boundary.

Lastly, the only nuclide of potential concern would be ^{14}C because of its mobility, long half-life, and high specific activity. If a realistic (i.e., not conservative) groundwater travel time is used and a retardation factor is applied, the decay in ^{14}C would still result in approximately a 22 percent reduction. This concentration would still be above drinking water limits, but it does not account for a corresponding natural dilution (5 to 208 times) due to the increase in travel time of 50 to 2080.

Table 5.2.2.3.2-1. Estimates of radionuclide concentrations in soils and water surrounding the proposed SNS.

Isotope	Half-Life (years)	Total Curies in berm at 0 - 4 m Over 958-m Length	Estimated[a] Soil Berm Activity (μCi/g)	Estimated[b] Groundwater Activity at 10 m (μCi/cc)	10 CFR 20 NRC Limits for Uncontrolled Releases (μCi/cc)
H-3	1.23E+01	2.278E-02	4.66E-08	6.85E-08	1.00E-03
Be-10	1.50E+06	1.976E-04	4.04E-10	4.23E-10	2.00E-05
C-14	5.73E+03	1.546E+02	3.16E-04	4.43E-04	3.00E-05
Na-22	2.60E+00	3.283E+02	6.72E-04	5.54E-05	6.00E-06
Al-26	7.15E+05	2.202E-01	4.50E-07	4.58E-08	6.00E-06
Cl-36	3.01E+05	8.593E-02	1.76E-07	4.54E-07	2.00E-05
Ar-39	2.69E+02	3.795E+02	7.76E-04	2.00E-03	NA
K-40	1.27E+09	2.684E-03	5.48E-09	6.50E-09	4.00E-06
Ca-41	1.03E+05	8.448E-01	1.73E-06	1.76E-07	6.00E-05
Mn-53	3.70E+06	1.639E-03	3.35E-09	3.14E-09	7.00E-04
Mn-54	8.54E-01	2.861E+05	5.85E-01	1.64E-04	3.00E-05
Fe-55	2.73E+00	2.202E+04	4.50E-02	1.09E-15	1.00E-04
	Total =	3.09E+05			

[a] Uniform distribution of isotopes over its entire length and diameter in the proposed SNS berm.
[b] Groundwater activities at a 32.8-ft (10-m) boundary 10 years after the end of 30 years of operations, assuming no retardation of the isotope migration by soils.
NA - Not available.

A very conservative treatment of many factors and assumptions is used in this evaluation. The net effect of this multiplication of conservative assumptions is to overestimate the potential concentrations in the groundwater below the proposed SNS site by a factor of between 25 to over 100 times. When the predictions show that the radionuclides are below 10 Code of Federal Regulations (CFR) 20 NRC Dose Limits for an individual member of the public, there is a very high confidence level that these limits would never be exceeded during the post-operation period of the proposed SNS facility. In summary, this assessment indicates that an exceedance of drinking water limits for an actual receptor under realistic conditions would be highly unlikely (even for ^{14}C). Mitigation measures would include routine monitoring of the groundwater to ensure that nuclide migration would not occur. In addition, modifications to the shield design of the proposed SNS would be incorporated to further protect against nuclide transport, including the placement of a crushed limestone interval covered by a geomembrane to protect and inhibit groundwater flow surrounding the tunnel. Thus, operation of the proposed SNS would have minimal to no effect on intermediate and deep groundwater systems on the ORR.

5.2.3 CLIMATOLOGY AND AIR QUALITY

Impacts on the climate and air quality from the construction and operation of the SNS located on the proposed Chestnut Ridge site at DOE's ORR are described in the following sections.

5.2.3.1 Climatology

Construction and operation of the proposed SNS would not affect regional or localized climates within the Oak Ridge area. Emissions from the proposed SNS facility may affect meteorological measurements, air indices, or measurements taken for research projects at the nearby Walker Branch Watershed. These impacts are discussed in Section 5.2.8.

5.2.3.2 Air Quality

Only negligible impacts would occur to nonradiological air quality. The nonradiological air quality assessment is presented in this section, while airborne radiological releases are evaluated under human health impacts (refer to Section 5.2.9). Construction activities would create temporary impacts from fugitive dust during the early construction phase of the project. This impact would be greatest during the clearing, contouring, and excavation stages but would decrease within a relatively short time period. In addition, fugitive dust would be most elevated during work hours (with an assumed 10-hr work day). While no estimates of suspended particulate matter have been prepared, PM_{10} measurements are predicted to be minimal when normalized for the standard 24-hr period. Moreover, the proposed SNS site is located in a remote section of the ORR several miles from the reservation boundary. Temporary elevation of particulate matter during excavation would contribute less impact to offsite receptors than operations at local construction sites or landfill operations.

The primary nonradiological airborne release during operations at the proposed SNS would be combustion products derived from the use of natural gas. Peak usage of natural gas would be during winter months at an approximate rate of 1,447 lb/hr. Emission rates for the maximum use of natural gas at 4-MW operations are estimated in Table 5.2.3.2-1. The projected emission levels would be well below those required for prevention of significant deterioration (PSD) review (i.e., this "minor source" would not be subject to the PSD permitting process).

The EPA Screen 3 Model (version 96043) was employed to calculate the impact of the proposed SNS to air quality by comparing projected ambient concentrations from

Table 5.2.3.2-1. Combustion products from natural-gas-fired boilers at the proposed SNS.

Combustion Products	Rate ($lb/10^{6}\ ft^{3}$)[a]	Total Load (lb/hr)[b]
SO_2	0.6	0.02
NO_x	100	3.49
CO	21	0.73
CO_2	1.2E+05	4184
Organic Compounds (total)	5.3	0.18
Particulate Matter (PM_{10})	12	0.42

[a] Emission factors from EPA AP42 for commercial boilers (rating: 0.3 to < 10^6 Btu/hr).
[b] Based on cumulative output of 10 boilers at the proposed SNS with total heat load of 34,870,000 Btu/hr.

calculated emissions against the NAAQS. A simple approach was undertaken for a screening-level assessment of the impacts. It was conservatively assumed that all emissions (from 10 stacks) would emanate from one stack (on the target building), and the simple elevated terrain (with maximum terrain height equal to stack top height) option was selected. The above emission rates were incorporated into the model to provide the calculated distance and maximum concentration (μg/m³) for a 1-hr average period. Conversion factors were applied to predict concentrations for longer periods corresponding to NAAQS parameters. Table 5.2.3.2-2 compares the projected ambient concentrations against the ambient air quality standards. Impacts to air quality at a 984-ft (300-m) site boundary from the burning of natural gas at the proposed SNS facility would be below all indicated limits. Adding maximum background concentrations to maximum projected impacts from the proposed SNS sources (a very conservative procedure since the two do not occur at the same location or time) also does not provide any violations of the NAAQS.

Five 200-kW diesel backup generators would be tested for short durations several times a year. Discharge from these generators is rated at 1,450 cfm at 910°F (487°C). Periodic discharges from these generator testings would not impact overall air quality, and impacts to air quality by the construction or operation of the proposed SNS would be negligible.

Table 5.2.3.2-2. Impact of natural gas combustion at the proposed SNS.

NAAQS Compound	Period[a]	Estimate (μg/m³) at 984 ft (300 m)	Maximum Concentration[b]	Assumed Background (μg/m³) (Table 4.1.3.3-1)	Background + 300 m Location (μg/m³)	NAAQS Limits (μg/m³)
Sulfur dioxide (SO_2)	Annual[c]	0.1	0.8	13.3	13.4	80
	24-hr	1.0	10.0	85.0	86.0	365
	3-hr	2.4	22.7	403.7	406.1	1,300
Carbon monoxide (CO)	8-hr	69.0	644	5,693	5,762	10,000
	1-hr	99.0	921	11,967	12,066	40,000
Nitrogen dioxide (NO_2)[d]	Annual[c]	16.0	147	28.6	44.6	100
Particulate (PM_{10})	Annual[c]	1.9	17.7	33.0	34.9	50
	24-hr	23.0	212.0	69.0	92.0	150

[a] Factors used to convert from 1-hr averages to long periods taken from EPA 1977. Annual averages based on conservative 0.1 factor.
[b] Concentration at 984 ft (300 m) estimated boundary and maximum concentration [occurring at 174 ft (53 m)] estimated by EPA – Screen 3 Model (version 96043). Maximum concentration location is expected to be "onsite."
[c] Annual concentrations reflect 33% estimated (conservative) annual usage factor.
[d] Estimated concentration in this table includes all NO_x compounds and not only NO_2 for NAAQS.

5.2.4 NOISE

Noise levels resulting from construction and operation of the proposed SNS within the affected environment are discussed in this section.

Noise levels would be elevated both during construction and during operation of the proposed SNS. Two types of noise may be emitted during the proposed SNS construction phase. Continuous moderate noise levels would be created during the period of construction activities. Earth-moving, transportation, and construction activities would produce peak noise levels as indicated in Table 3.2.2.12-1.

As Table 3.2.2.12-1 indicates, sound levels for a point source will decrease by 6 dBA for each doubling of distance [Department of Transportation (DOT) 1995]. Since the nearest public accommodations are considerably more than 400 ft (122 m) from the SNS site, the noise levels shown at 400 ft in Table 3.2.2.12-1 could serve as a very conservative estimate of peak noise levels anticipated offsite during construction. Comparison of the maximum 400-ft noise level of 84 dBA from this table to common sound levels shown in Figure 5.2.4-1 indicates that this maximum would be no greater than a “noisy urban” atmosphere or a household food blender. General construction noise levels of 55 to 77 dBA would be typical of a “commercial area” or normal speech. Thus, offsite construction sound levels should be typical of those most likely experienced by the general public.

Site traffic would contribute to elevated noise levels, but the incremental increase for the region would be insignificant, and site-specific levels would be elevated primarily during shift change. Moreover, traffic noise would not be a problem for people who live more than 100 to 200 ft (30 to 60 m) from lightly traveled roads (DOT 1995).

5.2.5 ECOLOGICAL RESOURCES

The effects of proposed SNS construction and operations on ecological resources are discussed in this section.

5.2.5.1 Terrestrial Resources

Preparation of the proposed SNS site for construction would result in clearing the existing vegetation, which is primarily mixed hardwood forest and pine plantations, from 110 acres (45 ha) of ORR land on Chestnut Ridge. The entire area of the proposed site would be cleared during the first year of construction. The timber harvested during site preparation would be sold. Areas that are not immediately required for the construction of facilities would be planted with grasses to minimize erosion.

Removal of vegetation would increase forest fragmentation; however, the area around the proposed SNS site would remain forested. In addition, current construction plans call for a minimum of forest clearing, which would reduce the fragmentation effects of the clear cutting. The specific locations of utility corridors are not known at this time; however, they would be constructed in existing rights-of-way whenever possible to reduce the area of land disturbance. The 161-kV electrical transmission line that would provide power to the proposed SNS is located less than 3,000 ft (914.4 m) west of the site, and the existing water main passes through the eastern end of the site. Other utilities, such

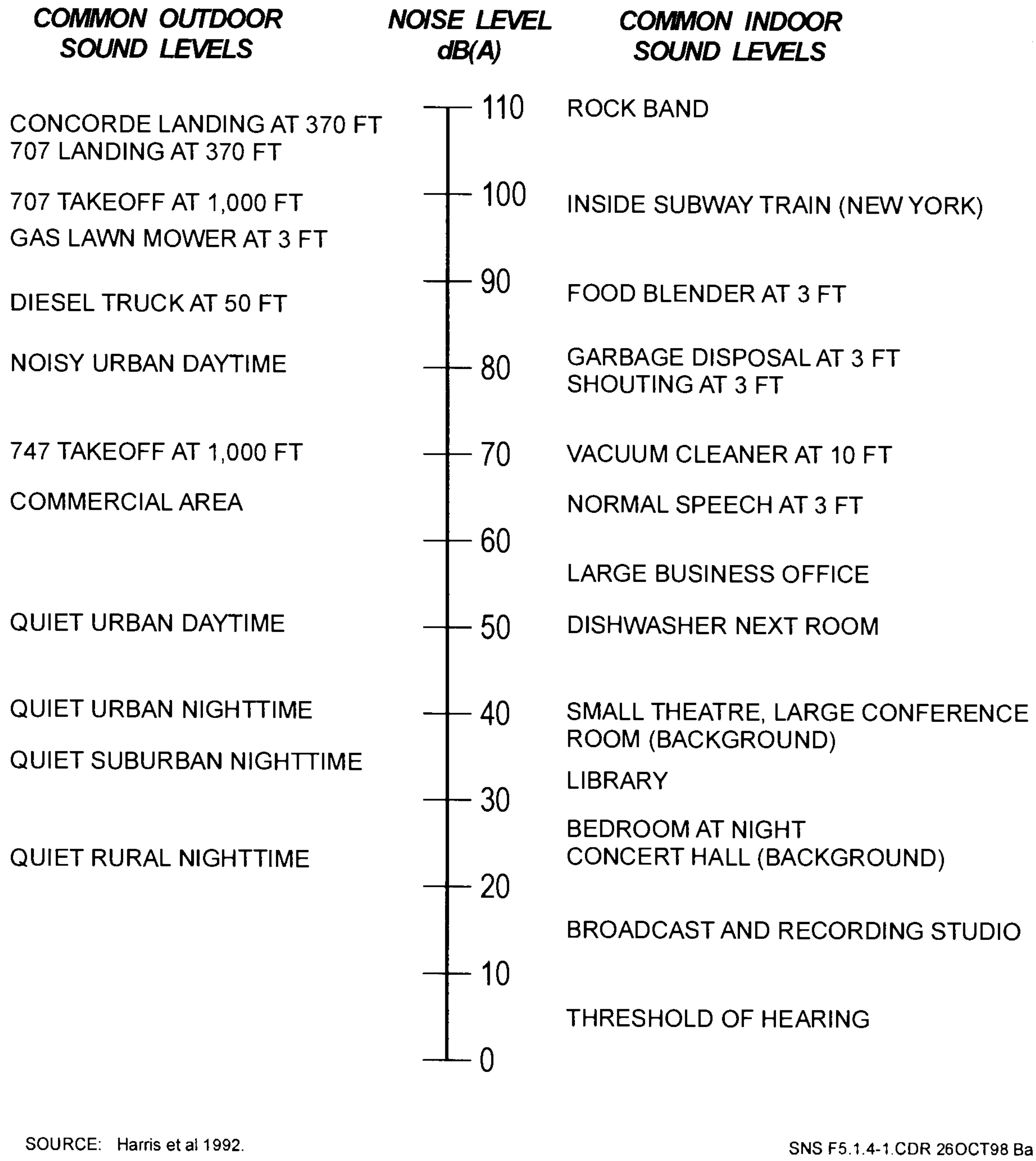

Figure 5.2.4-1. Common sound levels.

as natural gas and telephone service, would be brought into the site along Chestnut Ridge Road.

The general vegetation cover on the ORR is approximately 80 percent forest (LMES 1996). Although movement of wildlife across the proposed site would be slightly disrupted, there would still be a continuously forested path across Chestnut Ridge. The 110-acre (45-ha) site represents less than one-half percent of the total forested area on the ORR.

Clearing operations for construction of the SNS may cause the direct loss of small animals. Also, wildlife would be displaced from cleared areas and the surrounding habitat. Large mammals would be mostly excluded from controlled areas by access control fences. While additional forest-edge habitat would be created, cleared land would represent long-term loss of habitat.

Construction and operation activities and the associated noise and human presence would disturb wildlife occupying areas adjacent to the proposed site. This could result in emigration of some sensitive species from the surrounding area, although many of the species would adjust to the disturbance. To help minimize disturbance to wildlife, construction machinery would be kept in proper operating condition, and workers would be prevented from entering undisturbed areas delineated before construction.

In summary, the potential effect of the proposed vegetation removal on terrestrial wildlife would be minimal.

The proposed SNS would operate on land where natural features have been largely removed or altered by construction activities. Consequently, proposed SNS operations would have a minimal effect on terrestrial resources at this location and in immediately adjacent areas.

5.2.5.2 Wetlands

Eight wetland areas are located in and around the proposed SNS site. The sediment retention basin for the proposed SNS cooling water may encroach on the most northern portion of wetland WONT1-1. Proper construction techniques, including erosion control, would serve to minimize impacts to the area.

Wetland area WOM16 covers approximately 1.6 acres (0.65 ha), which makes it the largest of the three wetlands in this area. It contains two plant species, *Carex leptalea* and *Bartonia paniculatum*, that are uncommon in East Tennessee. During construction of the proposed SNS, this wetland would be potentially affected by increased runoff and siltation. Appropriate mitigation measures, including control of runoff and use of silt fences, would be incorporated to minimize these effects. However, because of its close proximity to the access road, this wetland would continue to receive increased runoff during rain events. The natural drainage flow in this area

> Federal policy on wetland protection is contained in Executive Order 11990. In addition, 10 CFR 1022 describes DOE's implementation of this Executive Order. This order requires federal agencies to identify potential impacts to wetlands resulting from the proposed activities and to minimize these impacts. Where impacts cannot be avoided, action must be taken to mitigate the damage by repairing the damage or replacing the wetlands with an equal or greater amount of man-made wetland as much like the original wetland as possible. The current DOE policy is for no net decrease in the amount of wetlands as a result of DOE activities.

Wetlands Function: Wetlands perform several functions within an ecosystem, including groundwater recharge and discharge, flood flow alteration, sediment stabilization, nutrient removal and transformation, sediment and toxicant retention, production export, and provision of wildlife and aquatic species habitat. Not all functions will be performed in every wetland. The factors that affect wetland functions are numerous and include geographic and topographic location; wetland position in the watershed; and physical, chemical, and biological characteristics of the wetland.

Wetland functions, as described by Adamus et al. (1991), that could be present in headwater wetlands include the following:

Flood flow alteration. The process by which peak flows from runoff, surface flow, and precipitation enter a wetland and are stored or delayed from their downstream movement.

Nutrient removal and transformation. The storage of nutrients (primarily nitrogen and phosphorus) within the sediment or plant substrate, the transformation of inorganic nutrients to their inorganic forms, and the transformation and removal of nitrogen (Adamus et al. 1991).

Sediment and toxicant retention: The process by which suspended solids and adsorbed contaminants are retained and deposited in a wetland.

Production export: The flushing of organic material from the wetland to downstream or adjacent waters.

Wildlife diversity: All wildlife species that are wetland dependant or that may use wetlands on a daily, seasonal, or intermittent basis.

would be to the south along Chestnut Ridge Road. This drainage pattern could minimize the amount of runoff from the road that actually enters WOM16.

Wetland areas WOM14 and WOM15 are located adjacent to WOC and Chestnut Ridge Road and have a combined area of 0.12 acres (0.05 ha). The upgrade of Chestnut Ridge Road and the laying of utility lines along this road would encroach on these areas and probably destroy them. Because of the proximity of wetland area WOM16, relocating this portion of the road to avoid the two wetland areas would not be a viable mitigation. The functions provided by these two wetland areas are limited by their small size. A thorough wetland functional assessment has not been made. However, the primary function of these wetland areas, based on professional judgement, would include the provision of wildlife habitat, including amphibian breeding habitat, nutrient transformation, and organic material production and export (Rosensteel et al. 1997). Mitigation measures that would be considered include creation of a new wetland area along the stream channel of one of the tributaries of WOC or enlarging an existing wetland. DOE would consult with the U.S. Army Corp of Engineers (USACOE) and the State of Tennessee to finalize the mitigation plan prior to the start of construction.

Effects to the remaining four wetland areas (BCST2-1, WOM17, WOM18, and WONT2-1) would be minimal. These wetlands are not in areas that would be disturbed by construction of the proposed SNS. Proper control of runoff, especially during site preparation, would minimize effects on these wetland areas.

All runoff and water discharges would be directed to the sediment retention basin during operations at the proposed SNS. The outflow from this basin would not be channeled into the upper reaches of WOC (see Section 5.2.5.3), so no effects on wetlands in this area would be expected.

5.2.5.3 Aquatic Resources

The proposed SNS site is located in the headwaters area of WOC. During land clearing for improvement of the access road and construction, there would be a potential for increased precipitation runoff and sediment loading in the creek. In addition, clear cutting of vegetation could expose the creek channel to increased solar radiation, which would increase the water temperature in the stream. Increasing the water temperature could disrupt the life cycle of cooler water fish, such as the banded sculpin and the blacknose dace. As a result, these species could be displaced by warmer water species migrating from the lower reaches of the creek.

DOE would establish a 100 to 200 ft (34 to 68 m) buffer zone around WOC. Trees within this buffer zone would not be cut, thus preserving the vegetative cover of the creek and avoiding increases in its water temperature. Runoff and erosion control measures, including silt fencing and preservation of native vegetation, would minimize the increased runoff and sediment load to the creek during construction. As a result of these measures, construction activities would have minimal effects on the aquatic resources in WOC.

No discharges from the proposed SNS to the headwaters of WOC would occur during operation of the proposed SNS. All surface runoff from the proposed SNS site would be directed to the sediment retention basin. Steam condensate and cooling tower blowdown water would also be released to this basin. The basin would discharge up to 350 gpm (1,325 lpm) of water through a standpipe, and the discharge would be piped offsite. The discharge pipe would empty into WOC, south of Bethel Valley Road near the intersection of WOC Road and Melton Valley Access Road. Thus, no impacts on aquatic resources in the headwaters of WOC would be expected from the proposed SNS operations.

The cooling tower blowdown water would be elevated in temperature and would contain biocides and antiscaling agents. The makeup water for the cooling towers would be obtained from the potable water supply for the proposed SNS site; therefore, the blowdown would contain chlorine. The blowdown would be dechlorinated prior to its release into the retention basin. As described in Chapter 3, the retention basin would be designed to reduce the temperature of the blowdown to the ambient temperature of WOC (refer to Section 5.2.2.1.2).

5.2.5.4 Threatened and Endangered Species

The results of the survey of the proposed SNS site verified the presence of two protected plant species at three locations in the immediate vicinity of the proposed SNS site (refer to Section 4.1.5.4). These species are pink lady’s slipper—a Tennessee endangered species due to commercial exploitation; and American ginseng—a threatened species in Tennessee. However, these plants are not located in areas expected to be heavily disturbed by construction or operation of the proposed SNS.

As stated in Section 4.1.5.4, the proposed SNS site encroaches on a NERP-designated Natural Area. This Natural Area, NA52, was established based on the presence of protected species and habitat that may be used by protected species. Approximately 20 percent of the 147 acres (59.5 ha) of NA52 overlap the proposed SNS site. The vegetation in this area would be cleared during construction.

The U.S. Fish and Wildlife Services, in response to DOE's informal consultation letter, submitted a list of federally listed or proposed endangered or threatened species that may occur in the project impact area (see Appendix C). However, no indications that these species occur at the ORNL site have been found to date.

A systematic survey of the potential habitat areas for protected species would be conducted prior to the start of land clearing for utility corridors, access roads, and construction. Because definitive identifications of many protected plants can be made only when they are flowering, this survey would extend over the spring, summer, and fall seasons to maximize the probability of finding these plants. If found in areas subject to disturbance, DOE would begin formal consultation with the USFWS and the State of Tennessee and implement an appropriate conservation plan to protect them during construction and operation of the proposed SNS. Possible conservation measures could include placing a fence around the habitat containing protected plants so the construction workers and equipment cannot cause damage, or transplanting the plants to areas of similar habitat. Overall, impacts on protected species by the proposed action are expected to be minimal.

5.2.6 SOCIOECONOMIC AND DEMOGRAPHIC ENVIRONMENT

The socioeconomic effects section identifies whether construction and operation of the proposed SNS and associated worker in-migration from outside the ROI may adversely affect regional services and infrastructure. It also presents an estimate of the financial effects (employment, income, taxes, and economic output) that would be generated locally in the form of worker salaries, indirect effects, and induced effects. Unless otherwise noted, economic effects are described in escalated-year dollars.

The ROI associated with the proposed SNS at the ORNL site includes Anderson, Knox, Loudon, and Roane Counties in Tennessee. This 1,436-mi^2 (3,719-km^2) region was selected because it is the region within which at least 90 percent of Oak Ridge workers currently reside. It is, therefore, the area within which the majority of socioeconomic impacts are expected to occur. Socioeconomic effects beyond the ROI area are generally expected to be minor.

The total local construction cost is estimated to be approximately $332 million (escalated dollars), and the peak construction year would be 2002, when 578 workers would be onsite (Brown 1998a). Of this total, about three-fourths (433 individuals) would likely be hired from the local area, and 144 would come from outside the ROI. An approximate average of 300 workers per year would be onsite, including all construction, management, engineering design personnel, and other technical and commissioning staff. Construction of the 1-MW proposed SNS is the bounding case for analysis of construction effects. If the SNS is upgraded to 4 MW, additional construction would occur, but this would be much less than the effects associated with the initial construction of the 1-MW SNS.

Operations of the proposed SNS at 1 MW would begin in the year 2006 with a staff of 250 persons. Later, if the proposed SNS is upgraded to 4 MW, 375 persons would be employed. The 4-MW case is used for this analysis as the bounding case. The effects of the 1-MW proposed SNS on the ROI would be similar but slightly less than the 4-MW case.

5.2.6.1 Demographic Characteristics

It is assumed that approximately 75 percent of all construction workers would come from the local area (Brown 1998a). Most of the construction workers would be general craft laborers, and the specialized technical components would be contracted out and fabricated in places not yet known. All locally hired construction workers would commute to the job site from existing residences and would not relocate closer to the site. The experience with other major construction projects has been that most in-migrating workers would temporarily move to the project area but would usually commute home periodically or on weekends. Generally, these individuals would not bring families to the ROI for the construction period. However, even if all of the in-migrating workers brought families into the area, the total (temporary) population increase would be less than 500 persons (including spouses and children) in the peak year. This would be a temporary increase in population of less than 0.01 percent and is, therefore, negligible.

People with the technical expertise needed to operate the proposed SNS currently reside in the ROI. However, it is also expected that some plant operators would come from outside the local area. It is assumed that about half of the 375-person operating workforce (for the bounding 4-MW case) would come from outside the area. It is further assumed that these households would be the same size as the national average because it is not known from where they would in-migrate. It is conservatively estimated that in 2006, the total population increase associated with operations would be about 600 individuals, including spouses and children. The facility operators would be "permanent" residents of the ROI, and little additional in-migration would occur in subsequent years. The population increase associated with construction and operations would represent approximately 0.01 percent of the local population and is, therefore, negligible.

5.2.6.2 Housing

With about 14,600 vacant dwelling units (refer to Section 4.1.6.2) in the four-county ROI, workers should be able to find apartments to rent or houses to purchase easily. This is especially true because of recent downsizing of DOE program operations on the ORR. The effects on housing would be minor.

5.2.6.3 Infrastructure

Potential effects on infrastructure are closely tied to population growth. Because the expected permanent in-migration would be only 600 individuals, impacts to infrastructure would be relatively minimal. There are 138 schools with an enrollment of over 75,000 students in the area. The addition of less than 300 children to the ROI would be a minor effect. Even if all

300 children attended schools in Knox County, the current teacher-student ratio of 1:19 would be unchanged. Also, effects would be minimal for police and fire protection, health care, and other services.

5.2.6.4 Local Economy

Design of the SNS would begin in 1999, and the first construction managers and workers would begin work in FY 2000. The majority of the construction would occur from FY 2001 through FY 2004, with the peak construction employment occurring in FY 2002. Testing of the SNS would be from FY 2003 through FY 2005. Operations are planned to begin by the end of FY 2005; FY 2006 would be the first full year of operations (see Figure 3.2.2-1).

Table 5.2.6.4-1 presents the results of the IMPLAN modeling for the period 1999 through 2006. Economic benefits in the form of jobs, wages, business taxes, and income would begin to accrue during the first year of the project in FY 1999. These economic benefits in the ROI would increase as construction and other associated project activities increase. Design and construction employment would be highest in FY 2002, and there would be an estimated 1,499 total (direct, indirect, and induced) new jobs created at ORNL. This trend would begin to diminish in FY 2003 as design and construction employment decreased and would continue to decrease until construction is completed in FY 2004. Facility operations would begin in FY 2005. Operations would reflect substantial regional spending for operator salaries, supplies, utilities, and administrative costs.

The SNS is planned to operate for 40 years. If the level of operation is the same as the 4-MW case measured in the first full year (FY 2006), it is estimated that facility operation would continue to support 1,704 direct, indirect, and induced jobs for each of the following years of operation. Other annual operations effects would include $68.7 million in local wages, $7.5 million in business taxes, $75.9 million in personal income, and $176.3 million in total output.

Construction of the facility would create new jobs and could potentially lower the region's total unemployment rate from about 3.2 percent to 3.0 percent. During operations, the unemployment rate would likely decrease further, although this would depend on whether construction workers and engineers (unemployed following project completion) stay in the ROI. The effects of operating the 1-MW proposed SNS would be similar but slightly lower.

5.2.6.5 Environmental Justice

As identified in Figures 4.1.6.5-1 and 4.1.6.5-2, minority populations and low-income populations reside within 50 mi (80 km) of the proposed SNS site. For environmental justice impacts to occur, there must be high and adverse human health or environmental effects that disproportionately affect minority populations or low-income populations.

The human health and safety analyses show that hazardous chemical and radiological releases from normal operations of the proposed SNS at 1-MW and 4-MW power levels would be within regulatory limits. Annual radiological doses are given in Section 5.2.9, and the data show that normal air emissions of the 1-MW proposed SNS would be negligible and would not result in adverse human health or environmental effects on the offsite public. Therefore, operation of the

Table 5.2.6.4-1. ORNL IMPLAN modeling results—construction and operations impacts.

	1999	2000	2001	2002	2003	2004	2005	2006
Employment								
Direct	80	168	387	460	320	213	29	744
Indirect	96	172	413	517	372	255	35	328
Induced	95	178	423	522	372	253	35	632
Total	271	518	1,223	1,499	1,064	722	99	1,704
Wages								
Direct	$5,393,195	$10,461,635	$25,209,789	$31,551,929	$22,870,276	$15,825,858	$2,214,385	$42,288,062
Indirect	$2,602,596	$4,789,126	$11,720,166	$14,947,307	$10,963,754	$7,675,011	$1,076,888	$10,192,999
Induced	$2,153,266	$4,093,319	$9,872,770	$12,431,138	$9,025,748	$6,255,302	$874,191	$16,185,791
Total	$10,149,057	$19,344,080	$46,822,724	$58,930,373	$42,859,777	$29,756,171	$4,165,464	$68,666,850
Business Tax								
Direct	$115,218	$237,187	$563,537	$691,797	$495,116	$338,324	$47,327	$2,147,003
Indirect	$521,081	$949,166	$2,314,978	$2,941,707	$2,148,064	$1,496,606	$208,816	$1,397,183
Induced	$531,318	$1,008,037	$2,431,249	$3,048,597	$2,208,599	$1,527,191	$212,926	$3,932,794
Total	$1,167,617	$2,194,390	$5,309,763	$6,682,100	$4,851,779	$3,362,121	$469,070	$7,476,980
Income								
Direct	$6,121,350	$11,835,876	$28,545,240	$35,765,984	$25,942,069	$17,962,928	$2,513,568	$44,391,954
Indirect	$3,012,179	$5,543,681	$13,576,165	$17,327,200	$12,718,333	$8,909,689	$1,250,971	$12,374,347
Induced	$2,545,442	$4,840,266	$11,701,405	$14,798,082	$10,681,986	$7,405,248	$1,035,187	$19,171,977
Total	$11,678,971	$22,219,822	$53,822,810	$67,801,266	$49,342,388	$34,277,864	$4,799,726	$75,938,279
Output								
Direct	$23,268,421	$43,760,128	$106,356,197	$134,502,188	$98,102,769	$68,290,104	$9,560,702	$92,847,043
Indirect	$7,305,926	$13,581,143	$33,109,038	$42,039,272	$30,745,296	$21,462,300	$3,008,388	$30,427,843
Induced	$7,029,522	$13,372,419	$32,340,621	$40,665,590	$29,544,359	$20,488,217	$2,864,941	$53,074,479
Total	$37,603,869	$70,713,690	$171,805,856	$217,207,050	$158,392,423	$110,240,621	$15,434,031	$176,349,365

proposed SNS would not have disproportionately high and adverse effects on minority or low-income populations.

Radiation doses to the public from both normal operations and accident conditions would not create high and adverse impacts. Less than one (0.3) LCF is calculated at the 4-MW power level over a 40-year operations period. If the facility operated for 10 years at 1 MW and 30 years at 4 MW, the calculated number of LCFs would be reduced (refer to Section 5.2.9.2.1). An LCF is a cumulative measure from the entire population (within 50 mi or 80 km radius) of about 880,000 people used for comparing alternatives and does not necessarily indicate that a fatality would occur (refer to Section 5.2.9.2.1). Also, there are 25 accident scenarios that would result in airborne releases. The consequences of most of these accidents would be negligible at power levels of both 1 MW and 4 MW. Three accidents are calculated to induce LCFs in the offsite population. The prevailing winds follow the general topography of the ridges. Up-valley winds come from the southwest during the daytime, and down-valley winds come from the northeast during the nighttime (refer to Figure 4.1.3-2). Figures 4.1.6.5-1 and 4.1.6.5-2 show a concentration of minority and low-income population and nonminority higher income population northeast of the proposed SNS site in the path of the daytime prevailing wind. These figures indicate that no concentrations of minority or low-income population are located southwest (path of the nighttime prevailing wind) of the proposed SNS site. The public, including minority and low-income persons, could be in the path of an offsite airborne release. However, the analysis has shown that there would not be high and/or adverse impacts to any of the population; therefore, there would be no disproportionate risk of significantly high and adverse impacts to minority and low-income populations.

A number of uncertainties are associated with the evaluation of potential impacts due to subsistence consumption. ANL developed an article reviewing the literature on subsistence consumption (Elliot 1994) and found that (1) ”the majority of the studies that have been conducted to date are focused on site- or region-specific exposure concerns. … At present, it is unclear whether the findings of these studies are representative of consumption and exposure levels among minority populations at a national level;” (2) “a large number of risk assessment studies focusing on fish and wildlife consumption examined whole populations without distinguishing between consumption and exposure patterns of specific ethnic (or other) subpopulations;” (3) “the vast majority of studies have focused on fish consumption as an exposure pathway. Few examined wildlife consumption and contamination, and even in such cases, the studies were not motivated by minority exposure concerns;” and (4) “the majority populations were not significantly higher than for the population as a whole.” Specific data on subsistence living are not available for the ORR region, and DOE is unaware of any subsistence populations residing in the vicinity of the proposed SNS site. Therefore, no adverse impacts to such populations are expected.

To assemble and disseminate information on subsistence hunting and fishing, DOE began publishing *A Department of Energy Environmental Justice Newsletter: Subsistence and Environmental Health* in the spring of 1996. The newsletter is available in the public reading rooms. Three goals of the newsletter are (1) “to provide useful information about the health implications of consuming contaminated fish, wildlife, livestock products, or vegetation;" (2) "to provide information about projects and programs at DOE and other federal and state agencies that address the problems associated with consuming contaminated fish, wildlife, livestock products, or vegetation;" and (3) "to receive relevant information from readers." In addition to the newsletter, DOE has a new project under way to identify what information is being collected on subsistence consumption by other federal agencies and to serve as a clearinghouse for such information (DOE 1996e).

No discharges of radioactive water to surface waters would occur because these liquids would be trucked to existing waste processing facilities at ORNL. These facilities and the management processes for these wastes are described in Section 5.2.11. All chemical releases would be regulated by NPDES permits and would be in compliance with federal and state regulations. As such, there would be no incremental effects on fish or other edible aquatic life in areas surrounding the proposed SNS site.

The analyses indicate that socioeconomic changes resulting from implementing the proposed SNS would not lead to environmental justice impacts. The proposed SNS project would provide economic benefits through generating additional employment and income in the affected region (refer to Table 5.2.6.4-1). There would be increased traffic congestion; however, this impact would not disproportionately affect minority or low-income communities because traffic patterns would not be different between low income and minority populations and the rest of the surrounding population (see Section 5.2.10.1). Overall, there is nothing from the construction or operation of the proposed SNS that would pose high and adverse human health or environmental effects that disproportionately affect minority and low-income populations.

5.2.7 CULTURAL RESOURCES

Surface and subsurface cultural resources can be affected by a number of activities. Surface resources such as standing structures, TCPs, artifacts, and landscape features are especially susceptible to damage by activities that involve their direct physical impact by objects such as heavy equipment. These activities include land clearing and grading. Subsurface artifacts and the archaeological context of the artifacts can be damaged by any activity that disturbs the soil. Such activities include the clearing of vegetation, excavations, and compression of soil by heavy objects resting or moving on the ground surface.

The SNS design team has not established the areas where construction or improvement of utility corridors would be necessary to support the proposed SNS, and the full route of the southwest access road has not been determined. As a result, the effects of the proposed action on cultural resources in these areas cannot be assessed at this time. If the proposed site at ORNL were chosen for construction, a cultural resources survey and an assessment of potential effects would be conducted prior to the initiation of construction-related activities in these areas. Appropriate measures would be implemented to mitigate any identified effects on cultural resources. These measures would include avoidance, where possible, or data recovery operations, including detailed recording of surface features and/or archaeological excavation.

5.2.7.1 Prehistoric Resources

No prehistoric archaeological sites have been identified on the 110-acre (45-ha) proposed SNS site at ORNL. As a result, implementation of the proposed action on this site would have no effect on prehistoric cultural resources listed on or eligible for listing on the NRHP.

Loci FN-1, FN-1A, and FN-7 denote isolated occurrences of prehistoric artifacts in the vicinity of the proposed SNS site. In addition, a prehistoric component was identified at 40RE488, which is also located in the vicinity of the proposed SNS site. Because of their locations, the isolated occurrence loci may be destroyed by heavy equipment movements. Access road improvements under the proposed action may destroy the east portion of the prehistoric component at 40RE488. Neither these loci nor the site component are listed on or considered to be eligible for listing on the NRHP. Consequently, their destruction would not represent an effect on prehistoric cultural resources.

5.2.7.2 Historic Resources

No Historic Period archaeological sites, structures, or features have been identified on the 110-acre (45-ha) proposed SNS site at ORNL. As a result, implementation of the proposed action on this site would have no effect on Historic Period cultural remains listed on or eligible for listing on the NRHP.

A Historic Period archaeological component has been identified in the vicinity of the proposed SNS site at 40RE488. This site is in an area slated for access road improvements under the proposed action. The east portion of this previously disturbed late 19th or early 20th century farmstead component may be destroyed by the proposed road improvements. However, this component is not listed on or considered to be eligible for listing on the NRHP. As a result, partial destruction of the component by road improvements would not be an effect on a cultural resource.

5.2.7.3 Traditional Cultural Properties

DOE-ORO has consulted with the Eastern Band of the Cherokee concerning the presence of TCPs on the ORR. No TCPs of special sensitivity or concern to the Cherokee are known to exist anywhere on the ORR. Consequently, no TCPs would be affected by implementation of the proposed action on the proposed SNS site at ORNL.

5.2.8 LAND USE

Land use in the vicinity of the ORR, within the boundaries of the reservation including ORNL, and on the proposed SNS site are assessed in this section for potential effects of the proposed action. The assessments cover potential effects on current land uses and zoning for future land use. Furthermore, the potential effects of the proposed action on parklands, nature preserves, major recreational resources, and visual resources are assessed.

5.2.8.1 Current Land Use

Current land use in the area surrounding the ORR is driven by the relationship between existing land characteristics and socioeconomic forces acting at the local and regional levels. Similarly, current land use on the ORR results from selectively using the existing characteristics of the land to meet various DOE mission requirements. The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the basic land characteristics and other forces that influence land use in these areas. Consequently, implementation of the proposed action on the proposed SNS site at ORNL would have no reasonably discernible effects on land use in the vicinity of the ORR and throughout most of the reservation. However, current uses of the land within the proposed SNS site and in nearby areas would be more subject to effects.

The proposed SNS site and adjoining land are located within a current land use category referred to as Mixed Research/Future Initiatives. This category includes most of the Oak Ridge NERP and applies to predominantly undeveloped land that is used or available for use in environmental field research. This land is also reserved for future DOE initiatives, including new research facilities. With the exception of Chestnut Ridge Road, utility corridors, a system of unimproved access roads, and a few other features, this area is undeveloped land that has been returning to its natural state since 1942. Implementation of the proposed action would introduce large-scale development to the proposed SNS site, utility corridors, and rights-of-way. However, this would result in minimal overall effects on undeveloped ORR land, because approximately 64 percent of the 34,516 acres (13,794 ha) of land on the reservation is undeveloped.

DOE has a federally mandated role as trustee of the natural and cultural resources on its lands. The use of undeveloped land for the SNS is proposed only because no previously developed ORR lands that meet project requirements are available.

Construction and operation of the proposed SNS would effectively change land use on the proposed SNS site from the current Mixed Research/Future Initiatives use category to the Institutional/Research category. In addition, the current uses of land within planned utility corridors and road rights-of-way would be changed from their current uses to these new infrastructure uses.

5.2.8.1.1 Walker Branch Watershed

The National Oceanic and Atmospheric Administration/Atmospheric Turbulence and Diffusion Division (NOAA/ATDD) is conducting the Temperate Deciduous Forest Continuous Monitoring Program (TDFCMP) in the Walker Branch Watershed. This project is measuring the continuous exchange of CO_2, water vapor, and energy between the deciduous forest in the Walker Branch Watershed and the atmosphere. The aim of the program is to continuously monitor these exchanges over a long period of time to gain a better understanding of local, regional, and global carbon budgets and the effects of elevated atmospheric CO_2 on temperate forests worldwide.

The facility heating system for the proposed SNS would include ten natural gas boiler units with ten small stacks. The operation of these units would result in the emission of combustion products to the atmosphere. These products would include CO_2, water vapor, and NO_x. Heavy equipment and automobile traffic associated with proposed SNS construction and operations would produce additional CO_2. Minor sources such as chain saws, mowing equipment, and diesel-powered electric generators may be used during construction and operation. Construction would begin in the year

2000, and operation of the proposed SNS facility would begin in late 2005.

The monitoring instruments for the TDFCMP are located 0.75 mi (1.2 km) east of the proposed SNS site. The prevailing winds blow from the proposed SNS site to the east-northeast toward the Walker Branch Watershed and the instrument stations during the daytime hours. Wind movement from the proposed SNS site towards the Walker Branch Watershed is also a function of current weather conditions. Consequently, the CO_2 from the proposed SNS could be transported to the monitoring instruments in the Walker Branch Watershed. It was recognized that this could affect the quality of the CO_2 monitoring data being collected, because some measurements would reflect activity from the proposed SNS instead of the physical, chemical, and biological activity in the forest biomass and soils of the Walker Branch Watershed. Furthermore, the presence of these nonrepresentative measurements could hinder comparisons of data collected after the start of construction of the proposed SNS to monitoring data collected prior to construction and operation.

An initial stage (Phase I) of air quality modeling was performed to provide a preliminary assessment of the potential effects the proposed SNS boiler stack emissions would have on CO_2, NO_x, and water vapor monitoring data collected at the NOAA/ATDD research tower in the Walker Branch Watershed area. This modeling was conservative in nature, essentially reflecting the results of a worst-case scenario. Basic assumptions in the modeling effort were operation of the proposed SNS at a fully upgraded power of 4 MW and continuous annual operation of the natural gas boilers at their full rated capacity. This level of operation would consume 1,447 lb/hr of natural gas and emit 4,184 lb/hr of CO_2. The 1991 meteorological data input to the model were collected at the NOAA/ATDD tower in the Walker Branch Watershed area. These data were 1 year of 15-minute averages for wind direction, mean wind speed, ambient temperature, solar radiation, and sigma-theta. Missing data were filled by using data from nearby monitoring towers or by averaging surrounding period data for short missing periods. The full report on the results of the air quality modeling is in Appendix G.

The modeling indicated that local winds would transport CO_2 toward the NOAA/ATDD tower 15 to 20 percent of the time. The maximum 15-minute average CO_2 detection at the monitoring tower would be 27,569 μg/hr.

NOAA/ATDD has determined a threshold limit to serve as an indicator of potential effects of the proposed SNS on the quality of CO_2 monitoring data for the Walker Branch Watershed. This threshold is any amount > 6680 $\mu g/m^3$, which is 1 percent of the background level of CO_2 at the Walker Branch Watershed. A number of the modeled 15-minute average CO_2 measurements at the NOAA/ATDD tower exceed the established threshold. The numbers of modeled CO_2 measurements that exceed the threshold are listed in Table 5.2.8.1.1-1.

These results reflect a worst-case scenario, as previously noted. Normal operating conditions may produce fewer exceedances. Nonetheless, the presence of these measurements indicates that emissions from the proposed SNS boiler

Table 5.2.8.1.1-1. Modeled CO_2 measurements exceeding the effects threshold (6,680 $\mu g/m^3$) at the NOAA/ATDD tower in the Walker Branch Watershed.

Measurement Period (Based on 1991 Data)	Total Measurements in Period	Number of Measurements Exceeding Threshold	Percent of Measurements Exceeding Threshold
January – March	8,760	184	2.10
April – June	8,760	258	2.95
June- September	8,760	317	3.62
October – December	8,760	212	2.42
Annual Average	35,040	971	2.77

stacks would adversely affect the quality and temporal comparability of the CO_2 monitoring data collected under the TDFCMP.

The effects of CO_2 from construction equipment and automobiles on TDFCMP monitoring data are not entirely known. During construction of the proposed SNS, workers could park their personal vehicles at parking lots on the floor of Bethel Valley. The CO_2 emissions from these vehicles would be expected to have little more effect on TDFCMP monitoring than current traffic in the Bethel Valley Road area. However, emissions from onsite construction vehicles and the parking of automobiles at the proposed SNS site after operational startup could further affect TDFCMP monitoring data.

Two approaches to mitigating the adverse effects of CO_2 emissions from the proposed SNS on TDFCMP data are being considered.

- Relocate the NOAA/ATDD meteorological monitoring tower to a Walker Branch Watershed location less susceptible to the effects of CO_2 emissions from the proposed SNS or build a new tower at this new location.
- Eliminate CO_2 emissions from the proposed SNS heating system by installing electric heat pumps rather than natural gas boilers.

Proper relocation of the meteorological monitoring tower would have the potential to mitigate effects on CO_2 readings from both construction and operation of the SNS. These effects would potentially result from emissions by boiler stacks in the operational SNS heating system, vehicles, and minor sources.

The use of electric heat pumps instead of natural gas boilers would eliminate all CO_2 emissions and effects from direct operation of the SNS heating system, which would be the largest and most continuous emitter of CO_2. However, this option would not mitigate the effects of vehicle emissions on CO_2 readings during construction and operation of the SNS. In addition, it would not mitigate any effects that might result from minor sources during SNS construction and operations.

It is anticipated that the effects of the proposed SNS on CO_2 monitoring at the NOAA/ATDD tower would be minimal after implementation of a mitigation measure.

The cooling towers at the proposed SNS would emit water vapor to the atmosphere. Modeling indicated that the maximum 15-minute average detection of the proposed SNS water vapor at the NOAA/ATDD monitoring tower would be 1.04 g/m^3 of air. However, the results of Phase I modeling did not allow an assessment of potential effects on TDFCMP monitoring data. Phase II modeling would be needed to make this assessment. If DOE and NOAA agree to perform this additional modeling, the results of this modeling would be included in the final EIS.

The boiler stacks at the proposed SNS would emit NO_x at a rate of 3.48 lb/hr. Modeling indicated that the maximum 15-minute average detection of NO_x from the proposed SNS boilers at the NOAA/ATDD monitoring tower would be 23 μg/$m^3$of air. NOAA/ATDD has indicated that these low levels would have minimal effects on their monitoring efforts in the Walker Branch Watershed.

The ORNL-Environmental Sciences Division (ESD) has nine major ecological research projects in the Walker Branch Watershed. Most of these projects depend on data inputs from the long-term NOAA/ATDD atmospheric and deposition monitoring sites associated with the watershed. Although these sites are located on the side of the Walker Branch Watershed nearest to the proposed SNS site, their data are considered to be representative of the entire watershed.

Emissions from the natural gas boilers at the proposed SNS would adversely affect CO_2 measurements at the NOAA/ATDD tower in the Walker Branch Watershed. Emissions of CO_2 from construction equipment and automobiles may also affect these measurements. If such nonrepresentative data were used in current ecological research projects, they could result in inaccurate experimental results. These projects would be further affected because the data obtained and the experimental results would not be comparable to data and results obtained prior to construction and operation of the proposed SNS. Furthermore, the inability to use accurate data would constitute a loss of ability to drive experiments and meet project objectives.

One of the nine current ecological research projects in the Walker Branch Watershed would be adversely affected by the incorporation of nonrepresentative CO_2 data from the NOAA/ATDD tower (refer to Table 4.1.8.2-1). Project No. C-9 is a long-term project (>10 years) that incorporates CO_2 exchange measurements from the tower into the modeling of ecosystem carbon cycle processes. After implementation of a mitigation option, it is anticipated that these effects would be minimal.

The potential effects of water vapor emissions from the proposed SNS cooling towers on the ORNL-ESD ecological research projects in the Walker Branch Watershed are unknown, pending the results of Phase II air quality modeling. The current research efforts that may be adversely affected are Project Nos. C-1 and C-2, which are long-term projects extending beyond the fiscal year (FY) 2005 start date for operation of the proposed SNS and its cooling towers. Project Nos. C-3, C-4, C-6, and C-9 would not be affected because the current efforts on these projects would be completed by FY 2005. The results of the Phase II modeling would be included in the final EIS.

5.2.8.2 Future Land Use

The land on the proposed SNS site and adjacent land are zoned as Mixed Research/Future Initiatives. This DOE zoning allows for a mixture of environmental research in the NERP, which includes all of the proposed SNS site land, with the construction and operation of future research facilities. Construction of the proposed SNS would be compatible with this zoning. Consequently, implementation of the proposed action would have no potential effects relevant to current DOE zoning of the proposed SNS site.

Portions of the proposed SNS site would become contaminated with pollutants from operations. Current plans call for in-situ decommissioning of the SNS when its operational life cycle is completed. As a result of in-situ decommissioning, some contaminated components would remain in place on the SNS site. This could limit the future use of land on the site for other purposes. Construction and operation of the SNS could limit the future use of land areas adjacent to the SNS site.

The zoning of the proposed SNS site and adjacent land is currently overlain by the buffer zone for the Walker Branch Watershed (Figure 4.1.8.2-2). The purpose of this buffer zone is to exclude from its boundaries any future activities and operations that could adversely affect environmental monitoring and experiments in the Walker Branch Watershed. The entire proposed SNS site is located within this buffer zone.

Construction and operation of the proposed SNS would adversely affect on-going and future environmental monitoring and research efforts in the Walker Branch Watershed, as indicated in Section 5.2.8.1.1 and the following subsection. Consequently, construction and operation of the proposed SNS on the preferred site at ORNL would be at variance with the intended purpose of the Walker Branch Watershed buffer zone.

The Reservation Management Organization (RMO) has been charged with reviewing proposed activities in the Walker Branch Watershed buffer zone (refer to Section 4.1.8.3). After reviewing the ORNL siting options for the proposed SNS, the RMO has recommended use of the preferred site within the Walker Branch Watershed buffer zone for construction of the proposed SNS (Teer 1997: 1). The site selection report, which documents the process used for selection and recommendation of the preferred proposed SNS site at ORNL, is in Appendix B.

5.2.8.2.1 Walker Branch Watershed

The TDFCMP is a long-term monitoring project that NOAA/ATDD plans to continue for many years (> 10 years) into the future. Operation of the proposed SNS over a 40-year period would have continuing adverse effects on CO_2 monitoring under the TDFCMP. The potential effects would be the same as those indicated in Section 5.2.8.1.1, and they would be mitigated by implementing one of the options identified in that section of the EIS. After implementation of a mitigation measure, it is anticipated that the effects of the proposed SNS on CO_2 monitoring at the NOAA/ATDD tower would be minimal.

A number of the current ORNL-ESD ecological research projects in the Walker Branch Watershed are expected to continue for many years. Other projects are expected to generate closely related follow-on work. Several major ORNL-ESD proposals for future ecological research in the Walker Branch Watershed are pending, and a number of the future research initiatives identified in the ORNL-ESD Strategic Plan would be tied to the historical research record and an understanding of ecological processes gained on the Oak Ridge NERP, including the Walker Branch Watershed.

Project No. C-9 is a long-term effort that would be adversely affected by the future incorporation of nonrepresentative CO_2 data from the NOAA/ATDD tower into its modeling of ecosystem carbon cycling processes (refer to Table 4.1.8.2-1). Project No. C-7 involves theoretical studies of CO_2 and energy exchange in the Walker Branch Watershed ecosystem. A proposal is anticipated to continue this project beyond the current FY 1999 completion date. This project could also be adversely affected by the incorporation of nonrepresentative CO_2 data from the NOAA/ATDD tower, especially if the project extends beyond late 2005 when the proposed SNS operations begin. After implementation of a mitigation option specified in Section 5.2.8.1.1, it is anticipated that the effects on both projects would be minimal.

The potential effects of water vapor emissions from the proposed SNS cooling towers on future TDFCMP monitoring and ORNL-ESD ecological research projects in the Walker Branch Watershed are unknown, pending the results of Phase II air quality modeling.

These water vapor emissions could affect ORNL-ESD Project Nos. C-1 and C-2, which are long-term projects that would continue for more than 10 years. Project No. C-4, a priority subject for long-term research, could also be affected. Anticipated follow-on work on Project Nos. C-3 and C-8 could also be affected, but only if these efforts extend beyond the start date for the proposed SNS operations.

Proposals are pending on four major ecological research projects in the Walker Branch Watershed. Project Nos. F-1, F-2, and F-3 may also be affected by water vapor (refer to Table 4.1.8.3-2). Project Nos. F-1 and F-2 would be long-term projects (> 10 years). Project No. F-3 would be completed by FY 2001, but the subject of this project is a priority for long-term research in the future. In all cases, the potential effects on project data and objectives would be the same as those indicated in Section 5.2.8.1.1.

The potential effects of the proposed action on future research initiatives identified in the ORNL-ESD Strategic Plan cannot be fully determined at this time. However, given the potential for effects from nonrepresentative CO_2 and water vapor monitoring inputs to experiments, the effects described in Section 5.2.8.1.1 may apply to a number of these initiatives.

5.2.8.2.2 Common Ground Process and End Uses of ORR Land

The Common Ground process has resulted in citizen stakeholder recommendations to DOE on the future use of ORR land. Based on the presence of areas with High Significance and Very High Significance biodiversity rankings, their recommendation for the proposed SNS site and adjacent land is a zoning category called Conservation Area Uses. These uses would include protection of the environment, environmental research sites, forestry, agricultural research, and passive recreation. Extensive development of the proposed site and related areas such as utility corridors and roads would be at variance with this zoning recommendation.

Recommendations for the end use of contaminated sites on the ORR are being developed by the End Use Working Group. The final results of their evaluations are expected to consist of recommendations for the end use of contaminated sites in specific watersheds and a broader set of community guidelines. The recently drafted community guidelines recommend the siting of additional DOE facilities on brownfield sites rather than greenfield sites. The proposed SNS site at ORNL is a greenfield site.

The siting of the proposed SNS at ORNL would appear to be at variance with the recommendation of the End Use Working Group. However, construction of the proposed SNS would require a large 110-acre (45-ha) brownfield site with a configuration that could accommodate the proposed facility. This site would need to be available by the scheduled FY 2000 start date for construction of the proposed SNS. No brownfield site that meets these criteria is present on the ORR, thus necessitating use of a greenfield site for the proposed SNS.

5.2.8.3 Parks, Preserves, and Recreational Resources

The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics that support park, nature preserve, and recreational land uses outside the ORR and at one location on the ORR. Consequently, implementation of the proposed action on the SNS site at ORNL would have no reasonably discernible effects on the following specific land uses: University of Tennessee Arboretum, University of Tennessee Forest Experiment Station, Tennessee Valley Authority (TVA) recreation areas on Melton Hill Lake and Watts Bar Lake, and Clark Center Recreation Park.

The proposed SNS site is located within the Oak Ridge Wildlife Management Area on the ORR, and it is within a zone of the management area designated for public deer hunting. The proposed action would affect recreational hunting by slightly reducing the area of ORR land open to the public for deer hunting. The reduction would be approximately 110 acres (45 ha) of undeveloped land. This effect would be minimal because approximately 26,604 acres (10,735 ha) of ORR land would still be open to the public for recreational deer hunting.

The land areas within and adjacent to the proposed SNS site are part of the Oak Ridge NERP. The NERP would be affected by the proposed action. The potential effects of the proposed action within the NERP are discussed in the two preceding sections of the EIS and Section 5.2.5.

5.2.8.4 Visual Resources

The proposed SNS would not be visible to the public from land-based vantage points outside the ORR and from most points on the reservation, including points along Bethel Valley and Bear Creek Roads. The proposed SNS facilities would come into view only along the upper reaches of Chestnut Ridge Road and the southwest access road to the proposed SNS site. During construction, these roads would be traveled by DOE and ORNL personnel, construction workers, and service providers. During operations, they would be traveled by DOE personnel, SNS employees, service providers, and visitors to the SNS facilities, including visiting scientists. Moreover, there are no established visual resources on the reservation that would include the proposed SNS. Therefore, implementation of the proposed action on the SNS site at ORNL would have minimal effects on visual resources.

5.2.9 HUMAN HEALTH

Construction and operation of the proposed SNS at ORNL could pose a potential risk of adverse effects on the health of workers and of the public living in the vicinity of the facility. Potential adverse effects include:

- Traffic-related fatalities and injuries to workers and the public.
- Occupational fatalities and injuries to workers.
- Exposure of workers and the public to radiation or radioactive materials.
- Exposure of workers and the public to toxic or hazardous materials.

This section evaluates the potential magnitude of these effects and the likelihood that they would occur during three phases or conditions:

- construction,
- normal operations, and
- accident conditions.

5.2.9.1 Construction

Construction of the 1-MW proposed SNS would require a total of 2,074 person-years of labor during the 7-year construction period and would reach a peak of 578 full-time workers during the fourth year of construction. At this stage of design, estimates of the number of workers that would be required to upgrade the facility for 2-MW or 4-MW operation are not available. Potential adverse effects on the health of workers and the public during construction activities include an increased risk of vehicle accidents due to increased traffic and the risk of occupational injuries or fatalities among construction workers. Construction workers, other ORNL site workers, and the public would not be exposed to toxic or radioactive materials as a result of construction activities because the preferred site for the proposed SNS at ORNL is not contaminated with such materials.

The increase in risk of disabling injuries or fatalities to the public and other ORNL workers due to construction workers commuting to the site can be estimated based on data provided in Section 5.2.10.1. The 9,690 workers now employed at ORNL make an estimated 7,810 daily round-trips as they enter and leave (0.806 round-trips/worker). During the peak year of construction, construction workers would add 466 round-trips (0.806 round-trips/worker × 578 workers), an increase of 6 percent.

It is assumed that the average round-trip distance traveled by construction workers is the same as that for other workers at ORNL. An increase of no more than 6 percent in injuries and fatalities from motor vehicle accidents would be expected during construction of the proposed SNS. It is also assumed that the average round-trip distance for an ORNL worker is 20 mi (32 km); the total of 417,911 daily round-trips by construction workers over the 7-year construction period (2,074 person-years × 250 work days/person-year × 0.806 daily round-trips/worker) would add 8,360,000 mi (13,400,000 km) of travel. Data available from the National Safety Council (http://www.nsc.org/lrs/statinfo/afp78.html) for 1996 indicate that 1.74×10^{-8} fatalities per vehicle mile and 1.05 $\times$ 10^{-6} disabling injuries per vehicle mile occurred on average in the U.S. On the basis of these rates and the anticipated total mileage, less than one additional fatality (0.15) and nine additional disabling injuries could occur as the result of increased commuter traffic during the 7-year construction period of the proposed SNS. Although these impacts would be due to the addition of SNS construction workers to traffic flow, the injuries or fatalities could affect anyone operating a motor vehicle in the vicinity, including other ORNL workers and members of the public.

The potential risk of occupational injuries and fatalities to workers constructing the proposed SNS would be expected to be bounded by injury and fatality rates for general industrial construction. Data available from the National Safety Council for the years 1992 through 1996 (http://www.nsc.org/lrs/statinfo/afp48.htm) indicate that the fatality rate of construction workers has been relatively constant, averaging 15 to 16 deaths per 100,000 workers (0.00015 to 0.00016 fatalities per worker-year). For 1996 the risk of occupational fatality was 0.00015 per construction worker-year, and the risk of disabling injury was 0.053 per construction worker-year. On this basis, less than 1 fatality (0.000015 fatalities/worker-year $\times$ 2,074 worker-years = 0.31 fatalities) and 110 disabling injuries (0.053 disabling injuries/worker-year $\times$ 2,074 worker-years) could occur as the result of occupational accidents during construction of the proposed SNS.

The previous discussion is based on construction of the 1-MW proposed SNS facility. At this stage of design, estimates of the number of workers that would be required to upgrade the facility to 4-MW operation are not available. Because the amount of construction required for upgrade to 4 MW would be less than that required for construction of the original facility, injuries and fatalities for traffic-related and construction accidents for the 4-MW facility would be less than those for construction of the original facility regardless of where the SNS is located.

5.2.9.2 Normal Operations

During normal (accident-free) operations, a maximum of 375 workers would commute daily to the proposed SNS. This number of workers would represent an increase of approximately 4 percent in traffic due to the ORNL workforce and could be expected to increase the number of motor-vehicle-related disabling injuries and fatalities to workers and the public in the vicinity by this same percentage.

On the basis of national traffic accident rates (0.0174 fatalities per million vehicle-mile and 1.05 disabling injuries per million vehicle-mile) and the anticipated total mileage of 60 million miles (375 commuting workers $\times$ 20 miles/trip $\times$ 0.806 trips/day $\times$ 250 days/year $\times$ 40 years), one additional fatality and 63 additional disabling injuries could occur as the result of increased commuter traffic during the 40-year operational life of the proposed SNS.

Based on 1996 data available from the National Safety Council (http://www.nsc.org/lrs/statinfo/afp48.htm), 3.4 accident deaths and 3,400 disabling injuries would be expected each year in a work force of 100,000 in a standard industrial environment. Applying this data to the work force for the proposed SNS, less than 1 fatality (3.4 deaths annually/100,000 workers $\times$ 375 workers $\times$ 40 years = 0.5 deaths) and 510 disabling injuries (3,400 disabling injuries annually/100,000 workers $\times$ 375 workers $\times$

40 years = 510 disabling injuries) could occur over the 40-year operational life of the proposed SNS.

The proposed SNS would generate and release direct radiation, radioactive materials, and toxic materials. Members of the public and workers at the proposed SNS and other adjacent facilities would be exposed to such radiation and emissions. The quantities and release rates of these materials would be the same as for the preferred alternative. The impact of the ORNL site-specific meteorology, distances to site boundaries, and population density and distribution are discussed in the following sections.

5.2.9.2.1 Radiation and Radioactive Emissions

This section assesses the potential effects of direct radiation and airborne emissions of radioactive materials from the proposed SNS based on the methods and dose-to-risk conversion factors discussed in Section 5.1.9.

Direct Radiation

Direct radiation is ionizing, penetrating radiation emitted from sources external to the human body. High levels of direct radiation would exist in the linac and beam tunnels, and very high levels would exist in the target area when the proton beam is on. These levels would subside rapidly in most areas once the beam is cut off; however, the mercury target itself and some target components would continue to emit radiation levels high enough to require that these components be handled remotely.

At the current stage of design, specific estimates of potential direct radiation exposures of workers or the public from the proposed SNS are not available. The Shielding Design Policy for the proposed SNS has been established to guide design by specifying maximum allowable radiation exposure rates for various areas inside and outside the SNS (ORNL 1997a). The policy is intended to ensure that facility design incorporates sufficient shielding to allow compliance with the requirements of 10 CFR Part 835, *Occupational Radiation Protection*, and DOE Order 5400.5, *Radiation Protection of the Public and the Environment for Operation of the SNS* at a proton beam power of 4 MW. The policy is based on consideration of dose limits and requirements for the use of personal dosimeters by members of the public in controlled areas, for nonradiological workers, and for radiological workers. This policy is also based on the length of time that each category of individual could be expected to occupy a given area.

Under this policy, the annual dose to members of the public, including site visitors, would not exceed 100 mrem outside the controlled area or 50 mrem inside the controlled area. The annual dose to workers who are not radiological workers would not exceed 100 mrem at any location from the proposed SNS operations. Radiological workers (workers who could receive an annual dose of more than 100 mrem during performance of their routine duties) could receive up to 5 rem annually under the regulations of 10 CFR Part 835. However, common practice at DOE facilities is to impose administrative controls that limit exposures to some fraction of the allowable limit.

Actual doses from direct radiation at the proposed SNS are expected to be much less than these limits, based on experience at other particle accelerators operated by DOE. These accelerators include electron, positron, proton, and heavy ion accelerators. These accelerators must address many of the same radiation protection issues as the proposed SNS. These issues include activation of air and accelerator components due to beam loss and high radiation levels from nuclear interactions in targets and target components. During the period 1994 through 1996, individual monitored workers at any DOE accelerator facility did not receive an annual dose in excess of 2 rem, and the average annual dose to monitored individuals at all DOE accelerator facilities ranged from 0.065 rem to 0.098 rem (DOE 1996f). These average annual doses include both external and internal exposures and are less than 2 percent of the 5-rem limit. These data indicate that doses to the public would also be far below the 100-mrem annual limit.

During the first full year of operation, approximately 250 people would work at the proposed SNS. This number would increase to 375 people when the second target is completed. Based on a risk factor for workers of 0.0004 LCF per person-rem, less than one excess LCF could be estimated among these workers if each worker received an annual dose of 0.098 rem each year of the 40-year life of the facility (0.4 excess LCF for 250 workforce and 0.6 excess LCF for 375 workforce).

Radioactive Emissions

Radioactivity would not be discharged from the proposed SNS to surface water under normal conditions of operation. LLLW and process waste would be collected and transported by tanker truck to existing waste processing facilities. As discussed in Section 5.2.11, the existing waste management systems at ORNL have sufficient capacity to accommodate the proposed SNS wastes. Effluents from treatment of the proposed SNS wastes would be released in accordance with existing permits for these facilities.

Radioactive emissions to the atmosphere from the proposed SNS would consist of releases from two stacks—the Tunnel Confinement Exhaust Stack and the Target Building Exhaust Stack. The locations of these stacks are shown in Figure 3.2.1.5-1. Annual emissions from these systems are summarized in Table 3.2.3.5-1 for power levels of both 1 MW and 4 MW. A detailed list of radionuclide emissions used for dose calculations is provided in Table F-1 of Appendix F.

Doses to workers and members of the public due to exposures from routine operational releases of radionuclides from the SNS at ORNL are shown in Table 5.2.9.2.1-1. Based on the conservative assumptions and calculation methods discussed in Section 5.1.9, annual doses to workers and the public from airborne emissions from the SNS would be comparable to annual doses from existing ORNL airborne emissions. The estimated dose from all 1996 airborne emissions at ORNL to the maximally exposed offsite individual was 0.45 mrem, and estimated dose to the offsite population was 9.9 person-rem (ORNL, OR Y-12, and ETTP 1997). If it is assumed that the current ORNL maximally exposed individual and the proposed SNS maximally exposed individual would be in the same location, then SNS operations would increase the annual dose to the maximally exposed individual to 0.84 mrem for operations at 1 MW and to 2.0 mrem for operations at 4 MW. The limit for annual dose to the public from all airborne emissions from DOE facilities is 10 mrem (40 CRF Part 61). These doses would be 8 percent and 20 percent, respectively,

Table 5.2.9.2.1-1. Estimated annual radiological dose from proposed SNS normal emissions at ORNL.[a]

Receptor	1-MW Power Level		4-MW Power Level	
	Target Building[b]	Tunnel Confinement[c]	Target Building[b]	Tunnel Confinement[c]
Maximum Individuals (mrem)				
Offsite Public[d]	0.39	0.008	1.5	0.009
Uninvolved Workers[d]	0.31	0.20	1.2	0.30
Populations (person-rem)				
Offsite Public[e] (879,546 persons)	3.3	0.049	13	0.049
Uninvolved Workers[e] (271 persons)	0.006	0.001	0.023	0.002

[a] Doses shown include the contributions of inhalation, immersion, and “ground shine” for workers and the offsite public and ingestion for the offsite public.

[b] Target Building emissions include hot offgas exhaust, primary confinement exhaust, secondary confinement exhaust from the target building, and activated air from the beam dump buildings.

[c] Tunnel confinement emissions include activated air and concrete dust from the linac tunnel, high-energy beam transport (HEBT) tunnel(s), ring tunnel(s), and ring-to-target beam transport tunnel(s).

[d] The maximally exposed individuals are hypothetical receptors. The member of the public is assumed to occupy a position at the ORR boundary for 8,760 hr/yr and to produce their entire food supply at this location. The maximally exposed uninvolved worker is assumed to occupy a position within 1.2 mi (2 km) of the stack for 2,000 hr/yr.

[e] The offsite population consists of all individuals residing outside the ORR boundary within 50 mi (80 km) of the site and is assumed to be present for 8,760 hr/yr. The involved/uninvolved worker population consists of all workers normally within 1.2 mi (2 km) of the facility. These workers are assumed to be present for 2,000 hr/yr.

of this limit for all exposure pathways for airborne emissions.

Dose at the ORNL boundary due to emissions from the Tunnel Confinement Exhaust is 0.008 mrem and dominated by radionuclides in activated concrete dust. The annual dose at the ORNL boundary due to emissions from the Target Building Exhaust is 0.39 mrem and is dominated by H-3 (54 percent) with smaller contributions from C-14, I-125, Hg-203, and Te-121. These radionuclides are listed in order of decreasing dose and account for 99 percent of the annual dose.

To estimate the total potential risk from the proposed SNS emissions of radioactive materials over the entire life of the facility, annual population dose is multiplied by the operating life of the facility and the dose-to-risk conversion factor of 0.0005 LCF/person-rem. For 40 years of operation at 1 MW, 0.07 excess LCF would be projected in the offsite population (3.3 person-rem/yr $\times$ 40 years $\times$ 0.0005 LCF/person-rem = 0.07 LCF). For 40 years of operation at 4 MW, 0.3 LCF could be projected (13 person-rem/yr $\times$ 40 years $\times$ 0.0005 LCF/person-rem = 0.3 LCF).

The proposed SNS would not operate at a single power level over its entire life, so the projected impact is between the two values indicated. After several years of operation at lower power levels, facilities would be upgraded to operate at 4 MW. If the facility operated for 10 years at 1 MW and 30 years at 4 MW, the projected number of excess LCFs would drop to 0.2. These projections are based on very conservative assumptions regarding pathway exposures and on the assumption that any exposure to radiation, no matter how small, involves some potential risk. Calculated excess LCFs provide a quantified value of risk to compare alternative actions.

5.2.9.2.2. Toxic Material Emissions

The only toxic material that would be emitted from the proposed SNS during normal operations is elemental mercury vapor. Lead would be used for radiation shielding in the target areas and other areas of the proposed SNS, but it is not volatile at the temperatures to which it would be subjected. Methods used to estimate atmospheric concentrations of toxic material emissions are discussed in Section 5.1.9.

At the annualized mercury release rate of 0.0171 mg/sec and considering historical wind patterns at ORNL, the maximally exposed uninvolved worker (one who is outside and within 2,000 m or 6,500 ft of the SNS) would be exposed to a peak concentration of 3.3 × 10-6 mg/m^3 (1/300,000th of the OSHA limit) and to an 8-hr average concentration of 1.1 × 10-6 mg/m^3 (1/200,000th of the ACGIH limit). On this basis, toxic effects due to mercury exposure would not be expected among workers.

Using the same annual mercury release rate and historical wind patterns, the maximum airborne concentration of mercury at the ORNL boundary is estimated to be 8.7×10^{-9} mg/m^3. This is only 1/800,000th of the EPA RfC applicable to the general public residing in the vicinity of the proposed SNS site. On this basis, toxic effects due to mercury exposure would not be expected among the offsite population.

5.2.9.3 Accident Conditions

This section discusses the impacts on human health of accidents that could potentially occur during operation of the proposed SNS at ORNL. Methods used in the calculation of accident consequences are discussed in Section 5.1.9. Accident consequences are calculated based on the assumption that an accidental release has occurred; the probability that the consequences would actually appear depends on the probability that the accident actually occurs. Probabilities or frequencies of accidents are addressed in Appendix A.

5.2.9.3.1 Accident Scenarios

The accident scenarios and source terms for accidents that could potentially occur at the proposed SNS facility are the same for all alternative sites and are summarized in Table F-2 (refer to Appendix F). The details of these scenarios and source terms are provided in Appendix A. Table 3.2 defines the terminology used to describe the probability or likelihood that a given accident could occur.

5.2.9.3.2 Direct Radiation

The frequencies of occurrence and consequences of accidents involving exposure to direct radiation have not been specifically analyzed by DOE. DOE's Shielding Design Policy for the proposed SNS is such that for the worst-case design-basis accident, the dose to the maximum exposed individual in an uncontrolled area would be limited to 1 rem and for a worker in a controlled area would be limited to 25 rem. The risks of this category of accidents would be the same for all alternative sites.

5.2.9.3.3 Radioactive Materials Accidents

DOE has performed a hazard analysis of potential accidents at the proposed SNS facility; for those that could result in a release of radioactive material, it has estimated source terms. The DOE analysis is included as Appendix A. Accident scenarios, estimated frequencies of occurrence, and source terms are summarized in Table F-2 and are the same for all SNS alternative sites. The methods used to evaluate the consequences of these accidents are discussed in Section 5.1.9 and in more detail in Appendix F. Consequences of accidents vary by alternative due to site-specific weather patterns and population distributions.

Doses for these accidents, should they occur at the proposed SNS facility at ORNL, are listed in Table 5.2.9.3.3-1. Source terms listed in Table 5.2.9.3.3-1 are expressed in terms of percent of the inventory (mass or volume) of material released. With the exception of accident ID 16, source terms expressed in these terms are independent of power level; that is, the accident releases the same mass of the source materials, but at 4-MW operation, the mass has four times as much radioactivity as at 1-MW operation. For accident ID 16, this 4:1 ratio is not maintained; while the radioactivity per gram is still four times as much, the target boiling assumed to occur in the 4-MW accident releases more volume, so that the radioactivity released is greater than four times as much (refer to Exhibit F of Appendix A).

The quantities of radioactive materials that could be released in many of the accidents that could potentially occur at the proposed SNS are so small that the individual worker or member of the public would not be expected to receive a dose of more than 0.001 mrem. This is approximately 1/1,000th of the radiation exposure that the average person in the U.S. receives from natural background in a single day.

For accidents involving targets or target components, the beyond-design-basis mercury spill (ID 16) would have the greatest calculated doses. Based on the dose-to-risk conversion factor of 0.0005 LCF/person-rem, adverse health effects in the offsite population are estimated at 0.29 excess LCF for the 1-MW accident and 31 excess LCFs for the 4-MW accident. The probability of this accident is categorized as "beyond extremely unlikely" or less than 1/1,000,000 per year.

Two accidents involving the off-gas waste system could result in high consequences. Doses for these two accidents, an "anticipated" valve sequence error for the off-gas decay tank (ID 24) and an "extremely unlikely" failure of the decay tank itself (ID 31), are identical. For the accident at 1-MW operation, the population dose of 290 person-rem corresponds to 0.14 excess LCF. For the accident at 4-MW operation, the dose to the offsite population of 1,100 person-rem corresponds to 0.57 excess

Table 5.2.9.3.3-1. Radiological dose for SNS accident scenarios at ORNL.

				Maximum Individual (mrem) [a]				Population (person-rem) [a]			
				Offsite Public		Uninvolved Workers		Offsite Public		Uninvolved Workers	
ID	**Event**	**Frequency[b]**	**Source Term[c]**	**1-MW Beam**	**4-MW Beam**	**1-MW Beam**	**4-MW Beam**	**1-MW Beam**	**4-MW Beam**	**1-MW Beam**	**4-MW Beam**
A. Accidents Involving Proposed SNS Target or Target Components											
2	Major Loss of Integrity of Hg Target Vessel or Piping (Appendix A, Section 3.3)	a) Unlikely	Percent Inventory Mercury Iodine 0.142 0.142	2.2	8.8	7.9	31.6	81.0	324.0	0.20	0.80
		b) Extremely Unlikely	Percent Inventory Mercury Iodine 0.243 100	9.5	38.0	19	76.0	360.0	1,440.0	0.47	1.88
8	Loss of Integrity in Target Component Cooling Loop (Appendix A, Section 3.9)	a) Anticipated	Bounded by annual release limits[d]	<10	<10	NA	NA	NA	NA	NA	NA
		b) Anticipated	Gases + Mist + 150 L of D_2O	0.33	1.32	0.62	2.48	6.1	24.4	0.006	.024
		c) Anticipated	18 L of D_2O	<0.001	<0.001	0.003	0.012	0.016	0.064	<0.001	<0.001
		d) Anticipated	Gases + Mist + 150 L of H_2O	0.20	0.80	0.54	2.16	0.91	3.64	0.004	0.016
16	Beyond-Design-Basis Hg Spill (Appendix A, Section 3.17)	a) Beyond Extremely Unlikely	1 MW Percent Inventory Mercury Iodine 1.11 100	16		57		570		1.4	
		b) Beyond Extremely Unlikely	4 MW Percent Inventory Mercury Iodine 1.28 100		1,600		1,800		62,000		46

Table 5.2.9.3.3-1. Radiological dose for SNS accident scenarios at ORNL – (continued).

				Maximum Individual (mrem) [a]				Population (person-rem) [a]			
				Offsite Public		Uninvolved Workers		Offsite Public		Uninvolved Workers	
ID	**Event**	**Frequency[b]**	**Source Term[c]**	**1-MW Beam**	**4-MW Beam**	**1-MW Beam**	**4-MW Beam**	**1-MW Beam**	**4-MW Beam**	**1-MW Beam**	**4-MW Beam**
	B. Accidents Involving Proposed SNS Waste Systems										
17	Hg Condenser Failure (Appendix A, Section 4.1.1)	Anticipated	13.7 g mercury	0.005	0.02	0.009	0.036	0.16	0.64	<0.001	<0.004
18	Hg Charcoal Absorber Failure [e] (Appendix A, Section 4.1.2)	Unlikely	14.8 g mercury	<0.001	<0.001	0.006	0.024	0.031	0.124	<0.001	<0.001
19	He Circulator Failure (Appendix A, Section 4.2.1)	Anticipated	1 day of tritium production	<0.001	<0.001	<0.001	<0.001	0.003	0.012	<0.001	<0.001
20	Oxidation of Getter Bed (Appendix A, Section 4.2.2)	Unlikely	1 day of tritium production	<0.001	<0.001	<0.001	<0.001	0.003	0.012	<0.001	<0.001
21	Combustion of Getter Bed (Appendix A, Section 4.3.1)	Extremely Unlikely	1 year of tritium production, 200 g depleted uranium	2.9	11.6	2.0	8.0	120	480	0.050	0.20
22	Failure of Cryogenic Charcoal Absorber [f] (Appendix A, Section 4.4.1)	Unlikely	1 day of xenon production	0.089	0.356	0.038	0.152	3.0	12.0	<0.001	<0.001
23	Valve Sequence Error in Tritium Removal System (Appendix A, Section 4.5.1)	Unlikely	1 year of tritium production	2.8	11.2	1.9	7.6	110	440	0.048	0.192
24	Valve Sequence Error in Offgas Decay System (Appendix A, Section 4.5.2)	Anticipated	7 days of xenon accumulation (1 decay tank)	7.3	29.2	4.8	19.2	290	1,160	0.12	0.48

Table 5.2.9.3.3-1. Radiological dose for SNS accident scenarios at ORNL – (continued).

				Maximum Individual (mrem) [a]				Population (person-rem) [a]			
				Offsite Public		Uninvolved Workers		Offsite Public		Uninvolved Workers	
ID	Event	Frequency[b]	Source Term[c]	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam
25	Spill During Filling Of Tanker Truck For LLLW Storage Tanks (Appendix A, Section 4.5.3)	Anticipated	0.00005% of contents of LLLW tank	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
26	Spray During Filling Of Tanker Truck For LLLW (Appendix A, Section 4.5.4)	Anticipated	1.9 ml of LLLW	0.03	0.12	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
27	Spill During Filling Of Tanker Truck For Process Waste Storage Tanks (Appendix A, Section 4.5.5)	Anticipated	51,100 L process waste to surface water + 57 L to atmosphere	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
28	Spray During Filling Of Tanker Truck For Process Waste (Appendix A, Section 4.5.6)	Anticipated	28.4 L of process waste	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
29	Offgas Treatment Pipe Break (Appendix A, Section 4.6.1)	Unlikely	24 hrs of xenon production	0.96	3.84	0.28	1.12	13	52	0.009	0.036
30	Offgas Compressor Failure (Appendix A, Section 4.6.2)	Unlikely	1 hr of xenon production	0.14	0.56	0.35	1.4	2.0	4.0	0.001	0.004

Table 5.2.9.3.3-1. Radiological dose for SNS accident scenarios at ORNL – (continued).

				Maximum Individual (mrem) [a]				Population (person-rem) [a]			
				Offsite Public		Uninvolved Workers		Offsite Public		Uninvolved Workers	
ID	Event	Frequency[b]	Source Term[c]	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam
31	Off-gas Decay Tank Failure (Appendix A, Section 4.6.3)	Extremely Unlikely	7 days of xenon accumulation	7.3	29.2	4.8	19.2	290	1,160	0.12	0.48
32	Offgas Charcoal Filter Failure (Appendix A, Section 4.6.4)	Unlikely	7 days of iodine production	0.048	0.192	0.042	0.168	0.30	1.2	<0.001	<0.001
33	LLLW System Piping Failure (Appendix A, Section 4.6.5)	Unlikely	0.00005% of contents of LLLW tank	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
34	LLLW Storage Tank Failure (Appendix A, Section 4.6.6)	Extremely Unlikely	0.00005% of contents of LLLW tank	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
37	Process Waste Storage Tank Failure (Appendix A, Section 4.6.9)	Extremely Unlikely	57 L to atmosphere	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 5.2.9.3.3-1. Radiological dose for SNS accident scenarios at ORNL – (continued).

[a] Unless otherwise indicated, radiological doses are based on radiological source terms for a 1-MW power level and would be four times greater if the facility is operating at 4 MW. These doses are total EDEs and include dose from inhalation and immersion. "Offsite" means outside the site boundary rather than outside the proposed SNS facility boundary. Individual receptors are hypothetical and do not correspond to any actual person. Population receptors are based on the actual number of people residing outside the site boundary and within 50 mi (80 km) of the facility and the number of site workers normally within 1.2 mi (2 km) of the facility and not involved in facility operation.

[b] See Table 5.2.9-2 for the numerical ranges associated with accident frequencies categories.

[c] Source terms are expressed in units that are independent of power level. Except for beyond-design-basis accidents (IDs 16a, 16b), the radioactivity released in accidents at 4 MW is four times that released at 1 MW.

[e] Installation of sulfur-impregnated charcoal filters is being considered to serve as a "polishing filter" for the mercury condenser (refer to Event 17).

[f] Cryogenic charcoal absorbers are being considered as an alternative to the offgas compressor, decay storage tanks, and ambient temperature charcoal filters (refer to Events 24, 30, 31, and 32).

NA - Not available.

LCF. The scenario for ID 24 is "anticipated" due to an accident caused by a human error, but it takes no credit for possible mitigation factors such as administrative procedures that could require independent verification of valve sequences for the tank or a radiation-activated valve on the vent line. Either of these additional factors would probably reduce the frequency of ID 24 to "unlikely."

5.2.9.3.4. Hazardous Materials Accidents

The analysis of accidents at the proposed SNS (Appendix A) classifies accidents involving nonradioactive materials as standard industrial accidents and does not estimate source terms for these accidents. Four accident scenarios involve the release of radioactive mercury: IDs 2a, 2b, 16a, and 16b. Each of these accidents involves relatively high rates of mercury release during the first few minutes of the accident followed by much lower rates of release. The second and third stages of these accidents are conservatively assumed to last from 7 to 30 days. In reality, administrative and emergency response actions would more probably terminate the release in a shorter time period.

Three of these accidents could result in workers being exposed to airborne concentrations of mercury in excess of the OSHA ceiling concentration of 0.1 mg/m^3. The peak concentrations for these accidents are 0.65 mg/m^3 for ID 2b, 0.28 mg/m^3 for ID 16a, and 7.9 mg/m^3 for ID 16b. In all cases, concentrations would fall below the ceiling concentration within minutes after the beginning of the release. OSHA does not specify a time-weighted-average or peak concentration above the ceiling for mercury; however, the ACGIH recommended concentration limit of 0.05 mg/m^3 is an 8-hr averaged concentration.

For only a few minutes at the start of the accident, mercury concentrations at or beyond the site boundary might exceed the temporary emergency exposure limit (TEEL)-1 (0.075 mg/m^3) but would not exceed TEEL-2 (0.10 mg/m^3) described in Appendix F.5.2. Individuals at the boundary at the precise passage of the initial emission might perceive an odor but would not experience or develop irreversible health effects or symptoms that could impair the ability to take protective action.

During the second and third phases of the release, maximum mercury concentrations are two to three orders of magnitude below TEEL-0 of 0.05 mg/m^3. Since maximum concentrations at the ORNL boundary are approximately one-half the maximum concentrations in areas that could be occupied by workers, it is likely that any observable health effects would not occur among workers or the public should any of these accidents occur.

Accident ID 2b is "extremely unlikely," and IDs 16a and 16b are "beyond extremely unlikely." Accordingly, the risk of adverse health effects due to accidental releases of toxic materials from the proposed SNS is very low.

5.2.10 SUPPORT FACILITIES AND INFRASTRUCTURE

This section summarizes the facilities and infrastructure effects to ORNL transportation and utility systems resulting from construction and operation of the proposed SNS project.

5.2.10.1 Transportation

As described in Section 3.2.5, Alternative Sites, construction of the proposed SNS-related infrastructure and support systems would occur at ORNL, located in the vicinity of the City of Oak Ridge, Tennessee. The site would be accessible by numerous state and federal highways and would be serviced on the north by Bear Creek Road and on the south by Bethel Valley Road.

As noted in Section 4.1.10.1, the transportation analysis for the Advanced Neutron Source (ANS) (Blasing et al. 1992) included a detailed transportation analysis that is directly relevant to the proposed SNS action. Evaluated roadways included Bethel Valley Road, State Road (SR)-95, and SR-62.

Construction employee and vehicle activity would increase during the first years of construction of the proposed SNS, peaking in the year 2002, and would decrease significantly during the last year (2004) of construction. The estimated total of 578 construction-related employees in the peak construction year (2002), is expected to add approximately 466 daily round-trips and 10 material/service trucks to the total ORNL site traffic of 6,771 round-trips. This represents a 7 percent increase.

Traffic impacts could include changes in existing vehicle flow, speed, and maneuverability and general congestion because of new vehicles traveling the roadways as a result of construction of the proposed SNS.

Operation of the proposed SNS project would result in an additional 250 resident/visiting scientists by the year 2006, plus another 125 employees during future facility upgrades, such as a second target station. If fully upgraded to the 4-MW power level, 375 employees and 3 service trucks per day would result in approximately 305 daily round-trips, or a 5 percent increase. Traffic effects would occur from the increased volume created by the proposed SNS. Traffic effects could include changes in existing vehicle flow, speed, and maneuverability and general congestion as a result of the comparatively high amount of new vehicles traveling the roadways.

Table 5.2.10.1-1 compares the No-Action Alternative with the proposed action at the Oak Ridge site. The table provides the percent increase in traffic resulting from the proposed SNS during construction and operation, as compared to the No-Action Alternative. The effect on traffic on the ORR is expected to be minimal. These potential effects could be reduced by having craft and non-craft workers report to work at different times, thus reducing the adverse effects on traffic flow during rush

Table 5.2.10.1-1. ORNL traffic increases compared to No-Action Alternative.

	Baseline/ No-Action	**(Peak Year) SNS Construction**	**(4-MW) SNS Operation**
Passenger vehicle trips[a]/day	6295	466	302
Material transport trucks/day	0	7	0
Service trucks/day	0	3	3
Total (% increase)	0 (0%)	476 (7%)	305 (5%)

[a]Based on 7810 ORNL employees (Blasing et al. 1992)

hours. Additionally, this analysis assumed there would be no transferring of personnel from within ORNL. If some of the workers were previously working at ORNL, the impact on traffic would be reduced.

5.2.10.2 Utilities

Effects from meeting the proposed SNS utility requirements would be limited to extending the existing site services to the Chestnut Ridge area. Substantial upgrades or construction of new facilities would not be required. Modifications to existing electrical, steam, natural gas, water, and sewage treatment are discussed in the subsections below.

5.2.10.2.1 Electrical Service

As described in Section 4.1.10.2.1, two existing 161-kV transmission lines terminate into a substation approximately 6,000 ft (1800 m) west of the proposed site. TVA has adequate capacity to supply the 90 MW of electrical power required for the 4-MW SNS via the existing 161-kV transmission line (Schubert 1997).

A new 161-kV transmission line would be constructed from the existing transmission line, approximately 3,000 ft (914 m) west of the proposed site, to a new substation to be located on the SNS site. Construction effects would be limited to minor excavation for the transmission line poles, and a minor amount of clearing and excavation for electrical equipment pads at the proposed SNS. No upgrades to the existing site service are expected. Environmental effects from constructing a new transmission line to the proposed SNS are expected to be negligible.

5.2.10.2.2 Steam

The current design calls for steam to be produced at the proposed SNS facility using natural-gas-fired boilers (refer to Section 5.2.10.2.3). However, steam requirements during operation of the proposed SNS could be satisfied by the existing onsite steam service. ORNL has the capacity to service the proposed SNS without upgrading the steam plant. The available capacity of the existing onsite steam is sufficient to accommodate any demand for steam that the proposed SNS may require. As described in Section 4.1.10.2.2, the closest tie in point is an existing 8-in. (20.3-cm) steam line located between the 6000 and 7000 Areas. To service the proposed SNS facility, this line would be extended approximately 1.5 to 2 mi (2.4 to 3.2 km) to the proposed SNS facility. Environmental effects from constructing a new steam line to the proposed SNS are expected to be negligible. A final decision on the steam supply would be made during Title 1 design and would take into account environmental effects as well as cost.

5.2.10.2.3 Natural Gas

Natural gas would provide energy for operational functions in the proposed SNS, such as fuel for the boilers and localized unit heaters in the facility heating system. East Tennessee Natural Gas (ETNG) has indicated that the current 22-in. (55.9-cm) gas main has adequate capacity for proposed SNS operational requirements.

As described in Section 4.1.10.2.3, the distribution header is approximately 1 mi (1.6 km) from the proposed SNS site. Based on current design plans, approximately 5,000 ft (1,524 m) of new natural gas pipeline would be required to service the proposed SNS facility. Current plans would route the pipeline extension along Chestnut Ridge Road, the main access road, to the proposed SNS facility. This would encroach on 0.12 acres of wetlands (see Section 5.2.5.2).

5.2.10.2.4 Water Service

The proposed SNS would require water supplies for the following systems: tower water cooling, deionized cooling, chilled water, building heating, process water, potable water, demineralized water, fire suppression, and target moderators. Based on the operational needs of the proposed SNS facility, ORNL's water distribution system is considered adequate and has available capacity to serve the proposed SNS facility.

As described in Section 4.1.10.2.4, the existing water service is located adjacent to the southern and eastern edge of the proposed SNS site. However, there are no water lines onsite. Environmental effects from constructing a new water line to the proposed SNS are expected to be negligible.

5.2.10.2.5 Sanitary Waste Treatment

The existing sewage treatment plant (STP) at ORNL has adequate capacity for demands of the proposed SNS. Approximately 100,000 gpd (378,540 lpd) of sewage treatment capacity is available at the STP. Operation of the proposed SNS would generate approximately 12,500 gpd (47,318 lpd) at the 1-MW facility and 18,150 gpd (68,705 lpd) at the 4-MW facility.

The proposed SNS sewage system would tie into the existing sewage system at a point west of the 6000 Area and approximately 1 mi (1.6 km) from the site. This is a gravity system with an 8-in. (20.3-cm) line. Environmental effects from constructing a new sewer line to the proposed SNS are expected to be negligible.

5.2.11 WASTE MANAGEMENT

All of the wastes generated during construction and operation of the proposed SNS would be transferred to ORNL for processing. The existing waste management systems, either at ORNL or at other facilities on the ORR, have sufficient capacity to accommodate the proposed SNS waste streams. Therefore, DOE anticipates only minimal effects on the ORNL waste management system.

The proposed SNS facility construction/operations projection of waste streams includes the following: hazardous waste, low-level waste (LLW), mixed waste, and sanitary/industrial waste, as listed in Table 3.2.3.7. A summary of existing waste management facilities located at ORNL, along with facility design and/or permitted capacities and remaining capacities available, can be found in Table 5.2.11-1. The projected waste stream forecast for ORNL's individual operations, proposed SNS operations at 4 MW, and the projected combination of the aforementioned wastes, as well as potential effects, are also included in Table 5.2.11-1. Forecasts are projected from 1998 to 2040, unless otherwise noted, and they are based on estimates received from waste management facility contacts and waste management documentation.

Table 5.2.11-1. ORNL waste management facility description and capacities.

Waste Disposition	Waste Type and Facility	Total Design Capacity for ORNL Site	ORNL Waste Projections for 1998-2040	Total Remaining Capacity for ORNL Site (Excludes Proposed SNS Operations)	Proposed SNS Waste Operations Projection for 1998-2040	Potential Effect on Waste Management Facility
HAZARDOUS WASTE						
STORAGE	Drummed Liquid and Solids 7507, 7651, 7652, 7653	139 m³	160 m^3/yr	NA	Hazardous Liquid 40 m^3/yr	No effect anticipated. DOE has contract in place to dispose of hazardous waste from 90-day storage area.
LOW-LEVEL WASTE						
TREATMENT	Liquid a) LLLW Evaporator Facility b) Process Waste Treatment Plant (PWTP) c) Nonradiological Wastewater Treatment Plant	a) LLW Evaporator 2.63E06 gal/yr capacity b) PWTP - 350 gpm c) 760 gpm	a) LLW Evaporator- 500,000 gal/yr b) Process waste 140 gpm (0.74E08 gal/yr) c) 320 gpm (1.68E08 gal/yr)	a) LLW Evaporator- 2.13E06 gal/yr b) Process wastes - 210 gpm (1.1E08 gal/yr) c) 440 gpm (2.3E08 gal/yr)	a) LLW Evaporator 175,600 gal/yr b) 4.15E06 gal/yr potentially LLW c) 4.3E06 gal/yr	a) No effect anticipated. b) No effect anticipated. c) No effect anticipated.
	Solid None					
STORAGE	Liquid None					
	Solid Buildings 7823B, 7823C, 7823E, 7827, 7878A	NA	Solid 2,520 m³/yr	Limited	Solid 1,026 m³/yr	Limited storage available. Long-term storage is not necessary. DOE has contracts in place to dispose of LLW as generated.

Table 5.2.11-1. ORNL waste management facility description and capacities (continued).

Waste Disposition	Waste Type and Facility	Total Design Capacity for ORNL Site	ORNL Waste Projections for 1998-2040	Total Remaining Capacity for ORNL Site (Excludes Proposed SNS Operations)	Proposed SNS Waste Operations Projection for 1998-2040	Potential Effect on Waste Management Facility
MIXED WASTE						
STORAGE	Solid/ Liquids 7654, 7507W, 7830a, 7823	Maximum storage is 300 drums.	Liquid 55 drums/yr Solid 45 drums/yr	NA	Liquid 50 drums/yr Solid 35 drums/yr	No effect anticipated. DOE has contracts in place to dispose of mixed waste from 90-day storage.
SANITARY WASTE						
TREATMENT	Liquid Waste Water Treatment Facility	300,000 gpd	240,000 gpd	60,000 gpd	18,000 gpd	No effect anticipated.
	Solid None					
DISPOSAL	Solid ORR Landfills	1.45E6 m^3	7,645 m^3/yr	1.09E6 m^3	1,350 m^3/yr	No effect anticipated.

NA - Not applicable.
Sources: Martin Marietta Energy Systems, Inc. 1994; Parrott et al. 1991; DeVore 1998a; 1998b; 1998c; 1998d; 1998e; 1998f; and 1998g.

Waste streams for the proposed SNS would be required to meet ORNL treatment, storage, and disposal (TSD) facilities' or offsite facilities' waste acceptance criteria (WAC) before they would be accepted for TSD. Currently, the exact quantities and radionuclide constituents of the LLLW stream that would be produced by the proposed SNS operations are uncertain. To meet the LLLW treatment facility WAC, the site would need to evaluate which regulatory authority's limits on discharges to surface waters [i.e., Atomic Energy Act (AEA), EPA, or NRC] should take precedence and be implemented as part of ORNL's LLLW WAC. The AEA regulates radionuclides from operation of nuclear reactors emitted into surface waters. Radionuclide emissions from accelerators are excluded from AEA regulations. However, EPA does regulate accelerator emissions via NPDES permits. The AEA does not limit the quantity or concentration of radionuclides that can be discharged from source, by-product, or special nuclear materials to surface waters, as long as the treated effluent does not demonstrate the potential for causing radiation doses in excess of dose limits. EPA establishes NPDES permit limits that designate allowable concentrations of radionuclides in discharges from accelerator facilities, as well as quantity limitations on certain other types of discharges. Due to the potential commingling of accelerator (SNS operations LLLW) and reactor-produced liquid wastes at the ORNL LLLW treatment facility, the more restrictive discharge limit (AEA, EPA) for specific radionuclides of concern may need to take precedence (DeVore 1997).

As shown in Table 5.2.11-1, ORNL does have the capability to store hazardous wastes; however, there are no hazardous waste treatment or disposal facilities at ORNL. DOE is phasing out the use of onsite hazardous waste [Resource Conservation and Recovery Act (RCRA)-permitted] storage facilities. Hazardous wastes will be collected and transferred to facilities at East Tennessee Technology Park (ETTP) or commercial facilities. Oil acceptable for offsite recycling is accumulated onsite prior to transporting to an offsite facility (ESWMO 1995).

ORNL's solid LLW that meets GTS Duratek WAC is shipped directly to them for three volume reduction treatments including incineration, compaction, and smelting. LLW that cannot be sent to GTS Duratek is grouted at Solid Waste Storage Area (SWSA) 6, temporarily stored, and then transported to an offsite commercial disposal facility.

Presently, no facilities specifically designed for the disposal of mixed wastes are located at ORNL. Mixed wastes are temporarily stored on the ORR then transported to an offsite commercial disposal facility. Liquid mixed wastes that meet the WAC of the LLLW treatment facility or the process waste treatment facility can be treated at ORNL.

ORNL has a waste certification process in place to assure that wastes meet the WACs for LLW disposal. However, because of the uncertainty of the composition of LLW and mixed wastes that may be generated from operation of the SNS, the waste may not meet the current WAC for waste management facilities at ORNL. DOE would take action to assure the proper disposition of these wastes. For example, pretreatment of the wastes may assure they meet the WAC. DOE may be able to amend the license at current waste disposal facilities to allow acceptance of wastes from the SNS.

Solid sanitary/industrial wastes from ORNL are disposed of at Sanitary Landfill II, Industrial Landfill V, and Construction Disposal Landfill VI, located on Chestnut Ridge. ORNL solid sanitary waste projections indicate that a total of 7,645 m^3/yr of solid sanitary/industrial and construction/demolition wastes will be generated for the next 40 years. As listed in Table 3.2.3.7-1, the proposed SNS operations would add an additional 1,349 m^3/yr over the next 40 years to the ORNL solid sanitary/ industrial waste stream. Wastes must meet appropriate WAC before being transported for disposal (ESWMO 1995; DeVore 1998d).

Soil, construction, and sanitary wastes would be generated during the construction phase of the proposed SNS facility. Excavated soil and rock would be utilized, when applicable, for backfill, erosion control, or other environmental purposes. Construction debris would be sent to a Class IV landfill. Liquid sanitary wastes would be transported to the site sanitary wastewater treatment plant for disposal, and solid sanitary wastes would be sent to a sanitary landfill (ORNL 1997b).

To minimize the production of waste streams from the proposed SNS facility and to comply with the Pollution Prevention Act of 1990, along with other federal pollution prevention regulations, the SNS conceptional design team developed the *NSNS Waste Minimization and Pollution Prevention Plan NSNS/97-5*. This written plan includes use of the Pollution Prevention Electronic Design Guideline (P2-Edge) software database. The P2-Edge software allows for assessment and identification of pollution prevention opportunities, evaluation of their cost, and selection of appropriate opportunities for implementation. An example of categories and considerations included in the P2-Edge software package can be found in Attachment 1 of the *NSNS Waste Minimization and Pollution Prevention Plan* (ORNL 1997a, LMES 1997).

5.3 LOS ALAMOS NATIONAL LABORATORY

This section describes the potential environmental effects or changes that would be expected to occur at LANL if the proposed action were to be implemented. Included in the discussion of this section are effects on the physical environment; ecological and biological resources; the existing social and demographic environment; cultural, land, and infrastructure resources; and human health.

5.3.1 GEOLOGY AND SOILS

Effects on geology and soils from construction and operation of the SNS on the proposed LANL site are described in this section.

5.3.1.1 Site Stability

The proposed SNS site at LANL is situated on a high mesa with a thin, unsaturated soil horizon overlying competent bedrock. Rockfalls from steep canyon ledges could be a potential problem if the proposed SNS is located near the edge of the mesa. However, the proposed setback from the mesa rim is sufficient to ensure that rockfalls or landslides are not a problem. Because of the nature of the soils and bedrock at this proposed site, neither soil liquefaction nor subsidence is considered likely. Construction and operation of the proposed SNS at TA-70 would not be affected by site stability problems.

5.3.1.2 Seismic Risk

A LANL seismic hazards study indicates that the Pajarito fault system provides the greatest potential seismic risk with an estimated maximum earthquake magnitude of about seven. The PGAs for an earthquake at eight technical areas within LANL (not including TA-70) were calculated, and the maximum results among those areas were 0.15 gravity for a 500-year return period; 0.22 gravity for a 1,000-year return period; 0.31 gravity for a 2,000-year return period; and 0.57 gravity for a 10,000-year return period. Proximity to the three main faults of the Pajarito system increases the potential for higher ground acceleration during earthquakes (other factors being equal). While a site-specific seismicity study has not been conducted for TA-70, it is the location within the LANL reservation farthest from the surface expression of documented faults. PGA estimates for the proposed SNS location (TA-70) would be less than the maximum predictions for the other technical areas.

Components of the proposed SNS facility would be built at LANL to the DOE Standard 1020-94 (DOE 1996a) and would be capable of withstanding maximum horizontal ground accelerations in the range of 0.10 to 0.14 for a 500-year return period; 0.14 to 0.19 for a 1,000 year-return period, 0.17 to 0.25 for a 2,000-year return period; and 0.31 to 0.43 for a 10,000-year return period. The beam for the proposed SNS would be designed to immediately shut down in the event of an earthquake. Predictable seismicity for the TA-70 site would have no effect on the construction, operation, or retirement of the proposed SNS.

5.3.1.3 Soils

Excavation required for construction of the proposed SNS would disturb the native soils. Excavated soils would be stockpiled according to soil types and horizon. If the excavated soils possess the proper characteristics, they would be used to construct the shielding berm. Otherwise the soils would be placed in the spoils area (refer to Section 3.2.5.3). Top soil removed during excavation would be used for grading and landscaping of the site at the finish of construction.

Construction of the SNS would require removal grading of the site and removal of vegetative cover. As a result the potential exists for soil erosion and stream siltation especially during periodic storm events. Best management practices would be followed to minimize the impacts of erosion during construction activities. Section 3.2.2.3, Site Preparation, discusses the elements (retention basin, silt fences, temporary storm water drainages, etc.) that would follow an erosion control.

Although limited borrow materials are available within LANL, the Los Alamos County Landfill could supply additional soil for the berm. The material use for the proposed SNS would not affect the local supply for other uses.

Operation of the proposed SNS at LANL would activate soils adjacent to the linac tunnel (refer to Section 5.2.1.3). Site-specific calculations of nuclide concentrations and transport potential have not been performed for LANL. In general, however, groundwater at LANL is not very susceptible to contamination for two reasons.

Soils and bedrock aquifers in the LANL region are derived from volcanic materials that exhibit a mineralogical composition that retards nuclide transport. The depth to the main bedrock aquifer is much greater than at ORNL (refer to Section 5.3.2.3). This combination of factors indicates that potential exposure effects would be the same or less than those at ORNL, which are predicted to be minimal.

5.3.2 WATER RESOURCES

The effects on water resources from construction and operation of the proposed SNS on the Pajarito Mesa site in TA-70 at LANL are described in the following sections. Best management practices would be employed to minimize any effects on surface water due to erosion and siltation during construction (see Section 5.2.1.3).

5.3.2.1 Surface Water

No surface water would be used to support construction or operation of the proposed SNS; therefore, there would be no effects on surface water supplies.

Conventional cooling tower blowdown for the proposed SNS would be released into surface drainages at TA-70. Continuous releases would occur at a rate of 250 gpm (946 lpm) for a 2-MW facility and 350 gpm (1,325 lpm) for a 4-MW facility. Surface water drainages in this area exhibit only intermittent flow. Flow volume attributable to blowdown would range between 0.36 to 0.50 mgpd (1.4 to 1.9 million lpd). The nearest perennial stream is the Rio Grande River approximately 1 to 2 mi (1.6 to 3.2 km) away. A significant portion, if not all, of the cooling tower blowdown would be dispersed by infiltration and evapotranspiration before it would reach the Rio Grande.

At the site, cooling tower blowdown would be temporarily held in a retention basin before release to the surface drainages. This basin would be designed to allow sufficient residence time for the discharge to cool to ambient temperatures. If necessary, active cooling systems such as recirculating fountains would be employed.

Polyphosphonates for antiscaling and ozone as a biocide would be used in the cooling towers. Discharge from the towers would be regulated to contain about four times the dissolved solids content of potable water (i.e., 1,000 to 1,200 mmhos conductivity). Contributions of solids or chemical agents are not anticipated to significantly effect the stream. Releases from the basin would be regulated under an NPDES permit that defines water quality parameters.

Effects on surface waters at TA-70 would result in sustained flow that is currently intermittent, thereby providing additional recharge to the groundwater and supporting limited flora and fauna in the drainage channels. It is not expected that the amount of infiltration from the limited discharge would impact parched water tables at depth or the occurrence of springs along the canyon walls.

5.3.2.2 Flood Potential and Floodplain Activities

The proposed SNS site at LANL does not lie within a floodplain or designated flood fringe area. Therefore, no flood potential exists. Seasonal storm events may cause localized flooding along the Pajarito Plateau and portions of the proposed SNS site when man-made storm drains and natural drainage exceed capacity. This result would be infrequent and temporary.

5.3.2.3 Groundwater

The main aquifer beneath LANL is the primary source of water for LANL and surrounding communities. Demands ranging from 800 to 1,600 gpm (3,028 lpm to 6,057 lpm) would be required to support the proposed SNS facility that may be upgraded from 1 MW to 4 MW. If, for example, one-half of the maximum water usage for a 4-MW facility would be the continuous daily demand for facility operations, then production from the main aquifer must increase by more than 25 percent. Sustained pumping at this magnitude could create a cone of depression that would lower water levels in nearby wells and ultimately affect the long-term productivity from the main aquifer (if withdrawal rates exceed recharge). Future water demands of the proposed SNS would be in direct competition with future growth demands from commercial and residential users.

Operation of the proposed SNS would affect the soil adjacent to the linac tunnel. This soil would act as a radiological source available for leaching and transport of nuclides via the groundwater system. Calculations for LANL have not been performed; however, characteristics of the groundwater system at LANL would make this site less susceptible than ORNL to effects on the groundwater from radionuclide contamination. The vadose zone is about 820 ft (250 m) thick at LANL, providing a much longer pathway for nuclides to reach the main aquifer. In addition, the vertical migration rate at LANL would be less due to reduced groundwater infiltration (approximately 5 cm/yr compared to 38 cm/yr at ORNL). The additional time would allow for greater radioactive decay and would result in less nuclide concentrations in the groundwater. Relative to ORNL (which has been shown to have minimal potential for concern), it is less likely that these activation products would be transported to offsite receptors at levels of concern. Effects causing groundwater contamination are considered minimal for LANL.

5.3.3 CLIMATOLOGY AND AIR QUALITY

Effects on the climate and air quality from construction and operation of the proposed SNS in TA-70 at LANL are described in the following sections.

5.3.3.1 Climatology

Construction and operation of the proposed SNS would not affect regional or localized climates within the LANL area.

5.3.3.2 Air Quality

Impacts on nonradiological air quality are presented in this section. Airborne radiological releases are evaluated under human health impacts (Section 5.3.9). Construction activities would create temporary effects in regard to particulate matter (PM_{10}) measurements during the construction phase of the project. These effects would be greatest during early clearing and excavation efforts but would decrease within a relatively short time period. While no formal estimates of suspended particulate matter have been prepared, this level is predicted to be minimal when weighted over the usual 24-hr averaging period. Moreover, the proposed SNS site is located several miles from residential inhabitants in a remote section of LANL.

The primary nonradiological airborne release during operations at the proposed SNS would be combustion products from the use of natural gas. Currently, natural gas is not available at TA-70; pipeline construction would be necessary to extend service into this area. The primary nonradiological airborne release during operations at the proposed SNS would be combustion products from the use of natural gas. Peak usage of natural gas would be during the winter months at an approximate rate of 1,447 lb/hr (4-MW scenario). Emission rates related to the maximum period of natural gas usage are listed in Table 5.2.3.2-1.

Ambient effects from natural gas usage can be projected with the Screen 3 model as in Section 5.2.3.2. However, since this location is relatively flat (unlike the Oak Ridge location), zero terrain height is used. The results of this modeling are shown in Table 5.3.3.2-1. Adding maximum background concentrations to maximum projected effects from the proposed SNS sources (a very conservative procedure since the two do not occur at the same location or time) does not provide any violations of the NAAQS.

5.3.4 NOISE

Construction and operation of the proposed SNS at LANL would slightly elevate ambient noise levels. Sensitive receptors (except for native wildlife) are not present at this remote location. Any noise effects on wildlife would be temporary; habitualized wildlife behavior patterns would be re-established in short duration.

Five 200-kW diesel backup generators would be tested for short durations several times a year. Periodic discharges from these generator testings would not affect overall air quality, and effects on air quality from the construction or operation of the proposed SNS would be negligible.

Table 5.3.3.2-1. Impact of natural gas combustion at the proposed SNS.

NAAQS Compound	Period[a]	Estimate (μg/m³) at 984 ft (300 m)	Maximum Concentration[b]	Assumed Background (μg/m³) (Table 4.2.3.3-1)	Background + 300-m Location (μg/m³)	NAAQS Limits (μg/m³)
Sulfur dioxide (SO_2)	Annual[c]	0.03	0.05	7.4	7.4	80
	24-hr	0.30	0.60	26.6	26.9	365
	3-hr	0.70	1.40	108.9	109.6	1,300
Carbon monoxide (CO)	8-hr	21	40	2,672	2,693	10,000
	1-hr	30	57	8,365	8,395	40,000
Nitrogen dioxide (NO_2)[d]	Annual[c]	5.0	9.0	5.7	10.7	100
Particulate (PM_{10})	Annual[c]	0.60	1.10	9.0	9.6	50
	24-hr	6.80	13.30	29.0	35.8	150

[a] Factors used to convert from 1-hr averages to long periods taken from EPA 1977.
[b] Concentration at 984-ft (300-m) estimated boundary and maximum concentration [occurring at 174 ft (53 m)] estimated by EPA – Screen 3 Model (v. 96043). Maximum concentration location is expected to be "onsite."
[c] Annual concentrations reflect 33% estimated (conservative) annual usage factor.
[d] Estimated concentration in this table includes all NO_x compounds and not only NO_2 for NAAQS.

5.3.5 ECOLOGICAL RESOURCES

This section describes the potential effects that the proposed SNS would have on ecological resources at LANL.

5.3.5.1 Terrestrial Resources

Construction of the proposed SNS in TA-70 would result in the clearing of vegetation from 110 acres (45 ha) of land dominated by piñon-juniper woodlands and scattered juniper savannas. This clearing represents approximately 10 percent of the land area within TA-70. Implementation of erosion control measures and revegetation of disturbed areas would minimize soil erosion during construction.

Rocky Mountain elk use piñon-juniper woodlands for wintering habitat, and some year-round use of these areas by elk has been documented. However, because 90 percent of the land in TA-70 would remain undeveloped after construction of the proposed SNS, minimal impacts on the movements of elk or other wildlife across this area would be expected from implementation of the proposed action. Losing 10 percent of the piñon-juniper habitat in TA-70 would not be expected to affect bird populations that use the area for roosting, feeding, and reproduction.

Clearing operations for construction of the SNS may cause the direct loss of small animals. Also, wildlife would be displaced from cleared areas and the surrounding habitat. Large mammals would be mostly excluded from controlled areas by access control fences.

Construction and operation activities and the associated noise and human presence would disturb wildlife occupying areas adjacent to the proposed site. This could result in emigration of some sensitive species from the surrounding area, although many of the species would adjust to the disturbance. To help minimize disturbance to wildlife, construction machinery would be kept in proper operating condition and workers would be prevented from entering undisturbed areas delineated before construction.

The proposed SNS would operate on land where natural features will have been largely removed or altered by construction activities. Consequently, the proposed SNS operations would have a minimal effect on terrestrial resources at this location and in immediately adjacent areas.

5.3.5.2 Wetlands

Construction and operation of the proposed SNS would not be expected to affect wetlands since these resources are not located on or near the proposed site. Cooling tower blowdown released to an arid land drainage feature would not reach the intermittent riverine wetlands associated with the arroyos in Ancho Canyon or the unnamed canyon to the northeast, except possibly in the case of a heavy rain event.

Overland runoff would be mitigated by the SNS retention basin. Consequently, the proposed action would have a minimal effect on wetland areas.

5.3.5.3 Aquatic Resources

Construction and operation of the proposed SNS would not be expected to affect aquatic resources since these resources are not located on or near the proposed site. All aqueous discharges from the proposed SNS would be directed to the sediment retention basin. A water outflow from the basin of up to 350 gpm (1,325 lpm) would empty into dryland drainage. This discharge would not be expected to reach the Rio Grande River.

5.3.5.4 Threatened and Endangered Species

Construction of the proposed SNS would reduce the foraging habitat for the American peregrine falcon and the foraging and roosting habitat for the bald eagle in TA-70 by approximately 10 percent. The nearest identified peregrine falcon nesting habitat is in White Rock Canyon, approximately 1.2 mi (1.9 km) from the proposed SNS site. The area surrounding the site would not be extensively used by peregrine falcons (Johnson 1985). The bald eagle uses White Rock Canyon and connecting canyons for foraging and roosting. Also, this species may use White Rock Canyon as a migration route.

These small reductions in nonnesting habitat would result in permanent, but minimal effects on the peregrine falcon and bald eagle.

A systematic survey of the potential habitat areas for protected species would be conducted prior to the start of land clearing and construction on the proposed SNS site. Because definitive identification of many protected plants can only be made when the plant is flowering, this survey would extend over the spring, summer, and fall seasons to maximize the probability of finding them. If found, appropriate mitigation measures would be taken to protect these species during construction and operation of the proposed SNS.

5.3.6 SOCIOECONOMIC AND DEMOGRAPHIC ENVIRONMENT

The socioeconomic impact section identifies whether construction and operation of the proposed project (and associated worker in-migration from outside the ROI) may adversely affect regional services and infrastructure. It also presents an estimate of the financial effects (employment, income, taxes, and economic output) that would be generated locally in the form of worker salaries, indirect effects, and induced effects. Unless otherwise noted, economic effects are described in escalated-year dollars.

The ROI associated with the LANL site includes Los Alamos, Rio Arriba, and Santa Fe Counties in New Mexico. This 7,800-mi^2 (20,202-km^2) region was selected because it forms the area within which at least 90 percent of Los Alamos workers currently reside. It is, therefore, the region within which the majority of socioeconomic impacts are expected to occur. Socioeconomic effects beyond the ROI are generally expected to be minor.

The total local construction cost is estimated to be approximately $332 million (escalated dollars), and the peak construction year would be 2002, when 578 workers would be onsite (Brown 1998a). Of this total, about three-fourths (433 individuals) would likely be hired from the local area, and 144 would come from outside the ROI. An approximate average of 300 workers per year would be onsite, including all construction, management, and engineering design personnel and other technical and commissioning staff. Construction of the 1-MW

SNS is the bounding case for analysis of construction effects. If the SNS is upgraded to 4 MW, additional construction would occur, but this would be much less than the effects associated with the initial construction of the 1-MW SNS.

Operations of the proposed SNS at 1 MW would begin in the year 2006 with a staff of 250 persons. Later, if the proposed SNS is upgraded to 4 MW, 375 persons would be employed. The 4-MW case is used for this analysis as the bounding case, and the effects of the proposed 1-MW SNS on the ROI would be similar but slightly less than the 4-MW case.

5.3.6.1 Demographic Characteristics

It is assumed that approximately 75 percent of all construction workers would come from the local area (Brown 1998a). Most of the construction workers would be general craft laborers, and the specialized technical components would be contracted out and fabricated in places not yet known. All locally hired construction workers would commute to the job site from existing residences and would not relocate closer to the site. The experience with other past major construction projects is that most in-migrating workers would temporarily move to the project area but would usually commute home on weekends or periodically. These individuals would generally not bring families to the local area for the construction period. However, even if all of the in-migrating workers brought families into the area, the total (temporary) population increase would be less than 500 persons in the peak year, including spouses and children. This would be a temporary increase in population of about 0.02 percent and is, therefore, negligible.

People with the technical expertise needed to operate the proposed SNS currently reside in the ROI. However, it is also expected that some plant operators would come from outside the local region. It is assumed that about half of the 375-person operating (for the bounding 4-MW case) workforce would come from outside the area. It is further assumed that these households would be the same size as the national average because it is not known from where they would in-migrate. It is conservatively estimated that in 2006 the total population increase associated with operations would be about 600 individuals, including spouses and children. The facility operators would be “permanent” residents of the ROI, and little additional in-migration would occur in subsequent years. The population increase associated with construction and operations would represent about 0.03 percent of the local population and is, therefore, negligible.

5.3.6.2 Housing

With about 6,900 vacant “dwelling units” (refer to Section 4.2.6.2) in the three-county ROI, workers should easily be able to find apartments to rent or houses to purchase. Some new houses would probably be constructed. However, existing vacancies and historic construction rates indicate that housing would be available to accommodate this small in-migration.

5.3.6.3 Infrastructure

Potential impacts on infrastructure are closely tied to population growth. Because the expected permanent in-migration is only 600 individuals, effects upon infrastructure would be relatively minor.

Nearly 29,000 students reside in the area. The addition of less than 300 children to the ROI would, therefore, be minor. Even if all 300 children attended schools in Los Alamos County, the current teacher-student ratio of 1:15 would be unchanged. Effects would also be minor for police and fire protection, health care, and other services.

5.3.6.4 Local Economy

Design of the proposed SNS would begin in 1999, and the first construction managers and workers would begin work in FY 2000. The majority of the construction would occur from FY 2001 through FY 2004, with the peak construction employment occurring in FY 2002. Testing of the proposed SNS would be from FY 2003 through FY 2005. Operations are planned to begin by the end of FY 2005; FY 2006 would be the first full year of operations (see Figure 3.2.2-1).

Table 5.3.6.4-1 presents the results of the IMPLAN modeling for the period 1999 through 2006. Economic benefits in the form of jobs, wages, business taxes, and income would begin to accrue during the first year of the project in FY 1999. These economic benefits in the ROI would increase as construction and other associated project activities increase. Design and construction employment would be highest in FY 2002, and there would be an estimated 1,447 total (direct, indirect, and induced) new jobs created at LANL. This trend would begin to diminish in FY 2003 as design and construction employment decreased and would continue to decrease until construction is completed in FY 2004. Facility operations would begin in FY 2005. Operations would reflect substantial regional spending for operator salaries, supplies, utilities, and administrative costs.

The proposed SNS is planned to operate for 40 years. If the level of operation is the same as the 4-MW case measured in the first full year (FY 2006), it is estimated that facility operation would continue to support 1,486 jobs for each of the following years of operation. Other annual operations effects would include $66.8 million in local wages, $7.6 million in business taxes, $71.4 million in personal income, and $171.6 million in total output.

Construction of the facility would create new jobs and may potentially result in the region's unemployment rate dropping from 6.6 percent to 5.8 percent. During operations, the unemployment rate may decrease further, depending on whether construction workers and engineers (unemployed following project completion) stay in the ROI. The effects of operating the proposed 1-MW SNS would be similar but slightly lower.

5.3.6.5 Environmental Justice

As identified in Figures 4.2.6.5-1 and 4.2.6.5-2, minority populations and low-income populations reside within 50 mi (80 km) of the proposed SNS site. The minority populations living around the proposed site are mostly Native American and Hispanic. For environmental justice impacts to occur, there must be high and adverse human health or environmental impacts that disproportionately affect minority populations or low-income populations.

The human health and safety analyses show that hazardous chemical and radiological releases from normal operations of the proposed SNS at

Table 5.3.6.4-1. LANL IMPLAN modeling results—construction and operations impacts.

	1999	2000	2001	2002	2003	2004	2005	2006
Employment								
Direct	92	195	448	531	369	245	34	640
Indirect	82	147	353	441	317	217	30	288
Induced	87	161	384	476	340	232	32	558
Total	261	503	1,185	1,447	1,026	694	95	1,486
Wages								
Direct	$6,610,816	$12,470,472	$30,283,823	$38,259,362	$27,888,348	$19,401,919	$2,716,178	$44,814,575
Indirect	$2,035,776	$3,730,568	$9,121,179	$11,624,370	$8,516,543	$5,954,408	$833,978	$8,781,731
Induced	$1,826,780	$3,430,981	$8,318,759	$10,493,959	$7,636,286	$5,303,408	$741,161	$13,209,288
Total	$10,473,371	$19,632,020	$47,723,761	$60,377,691	$44,041,177	$30,659,735	$4,291,317	$66,805,595
Business Tax								
Direct	$178,758	$425,227	$973,483	$1,139,218	$790,864	$524,064	$73,037	$3,282,725
Indirect	$341,175	$629,504	$1,532,020	$1,941,854	$1,416,708	$986,383	$137,798	$1,302,234
Induced	$416,484	$781,464	$1,892,840	$2,385,320	$1,733,919	$1,202,897	$167,919	$2,989,309
Total	$936,417	$1,836,194	$4,398,343	$5,466,393	$3,941,491	$2,713,345	$378,754	$7,574,269
Income								
Direct	$7,189,941	$13,608,341	$33,015,093	$41,663,724	$30,349,857	$21,101,180	$2,953,885	$45,883,971
Indirect	$2,291,450	$4,210,366	$10,294,973	$13,119,963	$9,614,889	$6,724,403	$942,463	$10,341,188
Induced	$2,094,716	$3,935,365	$9,544,454	$12,043,588	$8,766,393	$6,089,960	$851,317	$15,176,644
Total	$11,576,106	$21,754,073	$52,854,520	$66,827,274	$48,731,139	$33,915,543	$4,747,665	$71,401,805
Output								
Direct	$23,287,632	$44,348,648	$107,410,220	$135,264,146	$98,411,126	$68,341,639	$9,565,690	$101,858,828
Indirect	$5,662,857	$10,547,981	$25,664,403	$32,527,007	$23,755,543	$16,561,696	$2,319,388	$27,128,753
Induced	$5,849,635	$10,998,301	$26,695,085	$33,711,512	$24,557,695	$17,073,685	$2,388,646	$42,617,261
Total	$34,800,123	$65,894,930	$159,769,708	$201,502,664	$146,724,363	$101,977,020	$14,273,724	$171,604,842

Source: IMPLAN Pro.

1-MW and 4-MW power levels would be within regulatory limits. Annual radiological doses are given in Section 5.3.9, and the data show that normal air emissions of the proposed 1-MW SNS would be negligible and would not result in adverse human health or environmental impacts to the public offsite. Therefore, operation of the proposed SNS would not have disproportionately high and adverse impacts on minority or low-income populations.

Radiation doses to the public from both normal operations and accident conditions would not create high and adverse impacts. Less than one (0.1) LCF is calculated at the 4-MW power level over a 40-year operations period. If the facility operated for 10 years at 1 MW and 30 years at 4 MW, the calculated number of LCFs would be reduced (refer to Section 5.2.9.2.1). Twenty-five accident scenarios at the SNS would result in airborne releases. The consequences of most of these accidents would be negligible at power levels of both 1 MW and 4 MW. Only one accident is calculated to induce LCFs in the offsite population. An LCF is a cumulative measure from the entire population (within 50 mi or 80 km radius) of approximately 250,000 people used for comparing alternatives and does not necessarily indicate that a fatality would occur (see Section 5.2.9.2.1). If the facility operated for 10 years at 1 MW and 30 years at 4 MW, the calculated number of LCFs would be reduced (see Section 5.2.9.2.1). Winds over the plateau show considerable spatial structure and temporal variability, but a southerly flow usually prevails during the day. The prevailing nighttime flow over the western portion of the site is west-southwesterly to northwesterly (Figures 4.2.3.2-1 and 4.2.3.2-2). Figures 4.2.6.5-1 and 4.2.6.5-2 show that the proposed SNS site is completely surrounded by minority and low-income populations greater than the national average. The highest concentrations of these communities are located to the north of the site, and the highest concentration of non-minority and higher income populations are located closest to the site on the north, south, and western borders (DOE-AL 1995b, Figures 4-22 and 4-24). The public, including minority and low-income persons, could be in the path of an offsite airborne release. However, the analysis has shown that there would not be high and/or adverse impacts to any of the population; therefore, there would be no disproportionate risk of significantly high and adverse impacts to minority and low-income populations.

A number of uncertainties are associated with the evaluation of potential impacts due to subsistence consumption. ANL developed an article reviewing the literature on subsistence consumption (Elliot 1994) and found that (1) "the majority of the studies that have been conducted to date are focused on site- or region-specific exposure concerns. . . At present, it is unclear whether the findings of these studies are representative of consumption and exposure levels among minority populations at a national level;" (2) "a large number of risk assessment studies focusing on fish and wildlife consumption examined whole populations without distinguishing between consumption and exposure patterns of specific ethnic (or other) subpopulations;" (3) "the vast majority of studies have focused on fish consumption as an exposure pathway. Few examined wildlife consumption and contamination, and even in such cases the studies were not motivated by minority exposure concerns;" and (4) "the majority populations were not significantly higher than for the population as a whole." Specific data on subsistence populations are not available for the LANL region. However, DOE is unaware of any subsistence populations residing in the vicinity of the proposed SNS site. Therefore, no adverse impacts on such populations are expected.

To assemble and disseminate information on subsistence hunting and fishing, DOE began publishing *A Department of Energy Environmental Justice Newsletter: Subsistence and Environmental Health* in the spring of 1996. The newsletter is available in the public reading rooms. Three goals of the newsletter are (1) "to provide useful information about the health implications of consuming contaminated fish, wildlife, livestock products, or vegetation;" (2) "to provide information about projects and programs at DOE and other federal and state agencies that address the problems associated with consuming contaminated fish, wildlife, livestock products, or vegetation;" and (3) "to receive relevant information from readers." In addition to the newsletter, DOE has a new project under way to identify information being collected on subsistence consumption by other federal agencies and to serve as a clearinghouse for such information (DOE 1996e).

All of the wastes generated during construction and operations would be transferred to LANL waste operations for processing. The waste management facilities and the disposal processes for these wastes are described in Section 5.3.11. However, the LANL treatment facility cannot accommodate wastes from tritium, and an alternative disposal method would be necessary for these wastes from the SNS. All chemical releases would be regulated by NPDES permits and would be in compliance with federal and state regulations. As such, there would be no incremental effects on fish or other edible aquatic life in areas surrounding the proposed SNS site.

The analyses indicate that socioeconomic changes resulting from implementing the proposed SNS would not lead to environmental justice impacts. The proposed SNS project would provide economic benefits through generating additional employment and income in the affected region (refer to Table 5.3.6.4-1). Traffic congestion would increase; however, this impact would not disproportionately affect minority or low-income communities because traffic patterns would not be different between low-income and minority populations and the rest of the surrounding population (refer to Section 5.3.10.1). Overall, nothing associated with construction or operation of the proposed SNS would pose high and adverse human health or environmental effects that disproportionately affect minority and low-income populations.

5.3.7 CULTURAL RESOURCES

The potential effects of the proposed action on cultural resources in the vicinity of the proposed SNS site at LANL are assessed in this section. These assessments involve prehistoric archaeological sites; structures, features, and archaeological sites dating to the Historic Period; and TCPs.

The SNS design team has not established the areas where construction or improvement of utility corridors and roads would be necessary to support the proposed SNS at LANL. In addition, the locations of ancillary structures such as a retention basin, switchyard, and waste treatment system have not been determined. As a result, the effects of the proposed action on any cultural resources that may occur in these areas cannot be assessed at this time. If the proposed SNS site at LANL were chosen for construction, a cultural resources survey and an assessment of potential effects would be conducted prior to the initiation of construction-related activities in these areas. Appropriate measures would be implemented to mitigate any identified effects on cultural resources. These measures would include avoidance, where possible, or data recovery operations, including detailed recording of surface features and/or archaeological excavation.

Approximately 35 percent of the proposed SNS site and an associated buffer zone have not been surveyed for cultural resources. If the proposed site at LANL were chosen for construction of the SNS, a survey of this area and an assessment of specific effects on cultural resources would be conducted prior to the initiation of construction-related activities in these areas. These effects would be mitigated through data recovery operations, including detailed recording of surface features and/or archaeological excavation.

5.3.7.1 Prehistoric Resources

Five prehistoric archaeological sites have been identified on and adjacent to the proposed SNS site at LANL. These sites are pueblos with 2 to 10 rooms and field houses with 1 to 2 rooms. Three of the sites date to the Coalition Period (A.D. 1100-1325), and two sites date to the Classic Period (A.D. 1325-1600).

All of these sites are significant cultural resources, and they are eligible for listing on the NRHP under Criterion D. Construction on the proposed SNS site would affect these cultural resources. They would be destroyed by site preparation activities. In the unsurveyed area of the proposed SNS site, any prehistoric sites listed on or eligible for listing on the NRHP would also be destroyed during site preparation. These effects would be mitigated through archaeological data recovery.

5.3.7.2 Historic Resources

No archaeological sites, structures, or features dating to the Historic Period have been identified on the surveyed portion (65 percent) of the proposed SNS site or in its vicinity. Consequently, in these areas, no Historic Period cultural resources listed on or eligible for listing on the NRHP would be affected by implementation of the proposed action. Site preparation activities in the unsurveyed portion (35 percent) of the proposed SNS site would destroy any historic sites, structures, or features listed on or eligible for listing on the NRHP. These effects would be mitigated through data recovery.

5.3.7.3 Traditional Cultural Properties

Five prehistoric archaeological sites have been identified on and adjacent to the SNS site at LANL. All are located within the 65 percent area that has been surveyed for cultural resources. These sites would be considered TCPs by American Indian groups in the area. They would be destroyed by site preparation activities associated with construction of the proposed SNS. If any prehistoric archaeological sites are located within the unsurveyed 35 percent of the proposed SNS site, these TCPs would also be destroyed by site preparation.

Some tribal groups have identified water resources (surface water and groundwater) as TCPs (DOE-AL 1998: 5-120). As discussed in Sections 5.2.2.3 and 5.2.10.2.3, the high water demand of the SNS during operations could adversely affect local groundwater supplies.

The specific identities and locations of other TCPs on and adjacent to the SNS site are not known and cannot be reasonably estimated (see Section 4.2.7.3). As a result, the specific effects of the proposed action on such TCPs would be uncertain.

DOE and the LANL Cultural Resource Management Team have implemented a program to manage the laboratory's cultural resources for compliance with the American Indian Religious Freedom Act and the Native American Graves Protection and Repatriation Act. When an action is proposed, DOE and LANL arrange for site visits by tribal representatives, particularly representatives of the San Ildefonso, Santa Clara, Jemez, and Cochiti pueblos. These consultations are used to solicit concerns and comply with applicable requirements and agreements. If the SNS site at LANL were selected for construction, representatives of tribal groups and the Hispanic community would be further consulted about the occurrence of specific TCPs on and adjacent to the SNS site. If any are identified, potential effects of the proposed action on these resources would be assessed. If effects would occur, appropriate and feasible mitigation measures would be designed and implemented in consultation with the affected groups and communities.

5.3.8 LAND USE

The potential effects of the proposed action on land use in the vicinity of LANL, within the boundaries of LANL, and on the SNS site are assessed in this section. The assessments cover potential effects on current land use and zoning for future land use. Furthermore, the potential effects of the proposed action on parklands, nature preserves, major recreational resources, and visual resources are assessed.

5.3.8.1 Current Land Use

Current land use in the urban areas and tribal lands surrounding LANL is driven by the relationship between existing land characteristics and socioeconomic forces acting at the local and regional levels. Similarly, current land use in Santa Fe National Forest, Bandelier National Monument, and LANL result from the selective use of existing land characteristics to meet federal mission requirements. The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the basic land characteristics and other forces that influence land use in these areas. Therefore, implementation of the proposed action on the SNS site at LANL would have no reasonably discernible effects on current land use in the vicinity of the laboratory and across the laboratory as a whole. However, uses of the land within and near the proposed SNS site would be more subject to effects.

The current use of land on and adjacent to the proposed SNS site in TA-70 is categorized as Environmental Research/Buffer. This classification indicates that the land is largely undeveloped open space suitable for use in NERP environmental research and as a buffer zone between activity areas at the laboratory. The proposed action would introduce large-scale development to the proposed SNS site, utility corridors, and rights-of-way. Current land use on the site would change from Environmental Research/Buffer to Experimental Science.

The 110-acre section (45 ha) of undeveloped land on the proposed SNS site is only about 3 percent of the total undeveloped land in TA-6, 69, 70, and 71 and only about 0.6 percent of the 16,000 acres (6,478 ha) of LANL land that has never been developed. In addition, the piñon-juniper woodlands that cover the proposed SNS site constitute less than 1 percent of the 12,770 acres (5,108 ha) of piñon-juniper woodlands at LANL. Consequently, the loss of 110 acres (45 ha) of undeveloped piñon-juniper woodlands would represent a minimal effect on undeveloped lands as a whole at LANL.

DOE has a federally mandated role as trustee of the natural and cultural resources on its lands. The use of undeveloped trusteeship land for the SNS is proposed only because no previously developed LANL lands that meet project requirements are available.

The land on and in the vicinity of the proposed SNS site is not being used for environmental research projects. As a result, the proposed action would have no effects on the use of land by such projects.

5.3.8.2 Future Land Use

The land on the proposed SNS site is zoned for future use in Experimental Science. This zoning category applies to land reserved for the construction and operation of future research facilities. The proposed SNS would be a new research facility. Consequently, implementation of the proposed action would have no potential effects relevant to current DOE zoning of the proposed SNS site.

Portions of the proposed SNS site would become contaminated with pollutants from operations. Current plans call for in-situ decommissioning of the SNS when its operational life cycle is completed. As a result of in-situ decommissioning, some contaminated components would remain in place on the SNS site. This could limit the future use of land on the site for other purposes. Construction and operation of the SNS could also limit the future use of land areas adjacent to the SNS site.

No future uses of proposed SNS site and vicinity land for environmental research are planned. As a result, effects of the proposed action on specific future research projects cannot be assessed.

5.3.8.3 Parks, Preserves, and Recreational Resources

The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics and other factors that support park, nature preserve, and recreational land uses outside the LANL boundaries. Consequently, implementation of the proposed action on the SNS site at the laboratory would have minimal effects on the use of nearby land for Santa Fe National Forest or Bandelier National Monument.

The proposed action would have no reasonably discernible effects on most recreational uses of LANL land, and it would have no effect on environmental research activities within the NERP. However, public use of the hiking trails located near the proposed SNS site could potentially be restricted or eliminated.

5.3.8.4 Visual Resources

The proposed SNS facilities would be located in a remote woodland area. Their presence would change the viewscape of the area from that of undeveloped pinion-juniper woodlands to industrial development. During construction and operations, they would be visible to travelers along State Route 4 and the access road leading to the facilities. The SNS facilities would also be visible from points on the proposed SNS site and various points within TA-70. This would include locations on the recreational hiking trails used by the public in TA-70. During the night hours, facility lighting would be highly noticeable to viewers because no other large, lighted facilities are present in this remote area.

These facilities would not be visible from the nearby community of White Rock or popular public use areas in Bandelier National Monument.

5.3.9 HUMAN HEALTH

Construction and operation of the proposed SNS at LANL could pose a potential risk of adverse effects on the health of workers and of the public living in the vicinity of the facility. Potential adverse effects include:

- Traffic-related fatalities and injuries to workers and the public.
- Occupational fatalities and injuries to workers.
- Exposure of workers and the public to radiation or radioactive materials.
- Exposure of workers and the public to toxic or hazardous materials.

This section evaluates the potential magnitude of these effects and the likelihood that they would occur during three phases or conditions:

- construction,
- normal operations, and
- accident conditions.

5.3.9.1 Construction

The potential effects on the health of construction workers, other LANL workers, and members of the public would be essentially the same as those for any of the proposed locations because the size of the construction work force would be the same. Potential effects of construction of the SNS include construction accidents and traffic accidents.

On the basis of national traffic accident rates (1.74×10^{-8} fatalities per vehicle mile and 1.05×10^{-6} disabling injuries per vehicle mile) and the anticipated total mileage of commuting construction workers (2,074 person-years × 250 work days/person-year × 0.806 daily round-trips/worker × 20 miles/round trip), less than one additional fatality and nine additional disabling injuries could occur as the result of increased commuter traffic during the seven-year construction period of the proposed SNS.

On the basis of national construction accident rates, 0.31 fatality (0.00015 fatalities/worker-year × 2,074 worker-years) and 110 disabling injuries (0.053 disabling injuries/ worker-year × 2,074 worker-years) could occur as the result of occupational accidents during construction of the proposed SNS. The existing LANL workforce of 8,655 is smaller than that of ORNL and larger than BNL and ANL, so that the relative increase in traffic-related injuries and fatalities would be slightly greater during construction of the proposed SNS facility at LANL. Based on traffic data shown in Section 5.3.10.1 and the approach described in Section 5.2.9.1, traffic-related disabling injuries and fatalities would be expected to increase by approximately 6.7 percent during the peak year of construction relative to existing injury and fatality rates at LANL.

No known construction activities or requirements would place construction workers at the proposed SNS facility and the public at LANL at a different risk of occupational injury or fatalities than the risk posed to these same groups by construction at any of the proposed locations.

The previous discussion is based on construction of the 1-MW proposed SNS facility. At this stage of design, estimates of the number of workers that would be required to upgrade the facility for 4-MW operation are not available. Because the amount of construction required for upgrade to 4-MW would be less than that required for construction of the original facility, injuries and fatalities for traffic-related and construction accidents for the 4-MW facility would be less than those for construction of the original facility regardless of where the SNS is located.

5.3.9.2 Normal Operations

The number of SNS workers is independent of the location of the facility. The absolute number of industrial accidents and traffic-related injuries and fatalities would be expected to be essentially the same as at the other proposed locations.

On the basis of national traffic accident rates (0.0174 fatalities per million vehicle-mile and 1.05 disabling injuries per million vehicle-mile) and the anticipated total mileage of 60 million miles (375 commuting workers × 20 miles/trip × 0.806 trips/day × 250 days/year × 40 years), one additional fatality and 63 additional disabling injuries could occur as the result of increased commuter traffic during the 40-year operational life of the proposed SNS.

National industrial workplace accident rate data applied to the work force for the proposed SNS would yield less than one fatality (3.4 deaths annually/100,000 workers × 375 workers × 40 years) and 500 disabling injuries (3,400 disabling injuries annually/100,000 workers × 375 workers × 40 years) occurring over the 40-year operational life of the proposed SNS.

The relative increase of disabling injuries and fatalities would be less than the other proposed locations at LANL because of the larger existing work force. Based on data shown in Section 5.3.10.1, the addition of the maximum of 375 SNS workers to the daily LANL traffic flow could increase the number of disabling injuries and fatalities by approximately 4.3 percent relative to existing rates at LANL.

The proposed SNS facility would generate and release direct radiation, radioactive materials, and toxic materials. Members of the public and workers at the proposed SNS facility and other adjacent facilities would be exposed to these radiations and emissions. The quantities and release rates of these materials would be the same for any of the proposed locations. The impact of the LANL site-specific meteorology, distances to site boundaries, and population density and distribution are discussed in the following sections.

5.3.9.2.1 Radiation and Radioactive Emissions

This section assesses the effects of direct radiation and airborne emissions of radioactive materials from the proposed SNS based on the methods and dose-to-risk conversion factors discussed in Section 5.1.9.

Direct Radiation

Exposure of SNS workers to direct radiation at LANL is expected to be the same as at other proposed locations because the SNS Shielding Design Policy is applicable regardless of location (e.g., ORNL, LANL, ANL, or BNL).

Because the preferred location of the proposed SNS facility at LANL is remote from other facilities and at generally greater distances from areas where members of the public could reside, direct radiation exposures to the public may be somewhat less than for other proposed locations. This difference, if real, would be small and cannot be quantified based on information currently available.

Radioactive Emissions

Radioactive emissions during normal operations of the proposed SNS at LANL would include airborne releases from the Tunnel Confinement Exhaust Stack and the Target Building Exhaust Stack. These emissions are the same regardless of facility location and are listed in Table F-1 of Appendix F. As discussed in Section 5.3.11, the LLLW and process waste generated by the proposed SNS facility at LANL would be handled by the TA-53 RLW, which is currently under construction.

The estimated annual doses to workers and the public for normal airborne emissions from the proposed SNS facility are shown in Table 5.3.9.2.1-1. The methods and assumptions used in the calculation of doses is discussed in Section 5.1.9 and in greater detail in Appendix F.

Even under the conservative assumptions made in this assessment regarding exposure pathways, doses shown in Table 5.3.9.2.1-1 for the maximally exposed individuals are comparable to those for the maximally exposed individuals for existing LANL operations, but SNS population doses are higher. Calculations reported by LANL for National Emissions Standards for Hazardous Air Pollutants (NESHAP) compliance estimated a dose of 1.93 mrem/yr to the maximally exposed individual in 1996 (LANL 1997d). More realistic calculations, based on a combination of environmental measurements and transport modeling, estimated a median dose of 1.4 mrem/yr to the maximally exposed individual and a dose of 1.2 person-rem to the offsite population (LANL 1997d). LANL estimates that 99 percent of these doses are the result of airborne releases.

Annual doses to the maximally exposed individual for proposed SNS operations at LANL would be 0.47 mrem at 1 MW and 1.8 mrem at 4 MW. Population doses from the proposed SNS facility would be 2.0 person-rem at 1 MW and 5.3 person-rem at 4 MW. Using the information from the LANL environmental report (LANL 1997d), this would increase the estimated dose to the maximally exposed individual to 2.4 mrem, which is 24 percent of the 10-mrem limit (40 CFR Part 61).

Dose at the LANL boundary due to emissions from Tunnel Confinement Exhaust is 0.008 mrem and is dominated by radionuclides in activated concrete dust. Dose at the LANL boundary due to emissions from Target Building Exhaust would be dominated by ^{3}H (58 percent), with smaller contributions from ^{14}C, ^{203}Hg, ^{125}I, and ^{121}Te. These radionuclides are listed in order of decreasing dose and account for

Table 5.3.9.2.1-1. Estimated annual radiological dose from proposed SNS normal emissions at LANL.[a]

Receptor	1-MW Power Level: Target Building[b]	1-MW Power Level: Tunnel Confinement[c]	4-MW Power Level: Target Building[b]	4-MW Power Level: Tunnel Confinement[c]
Maximum Individuals (mrem)				
Offsite Public[d]	0.46	0.008	1.8	0.009
Uninvolved Workers[d]	0.098	0.12	0.39	0.19
Populations (person-rem)				
Offsite Public[e] (246,294 persons)	2.0	0.036	5.2	0.032
Uninvolved Workers[e] [None within 1.2 mi (2 km)]	NA	NA	NA	NA

[a] Doses shown include the contributions from inhalation, immersion, and "ground shine" for workers and the offsite public and ingestion for the offsite public.

[b] Target Building emissions include hot off-gas exhaust, primary confinement exhaust, secondary confinement exhaust from the target building, and activated air from the beam dump buildings.

[c] Tunnel confinement emissions include activated air and concrete dust from the linac tunnel, HEBT tunnel(s), ring tunnel(s), and ring-to-target beam transport tunnel(s).

[d] The maximally exposed individuals are hypothetical receptors. The member of the public is assumed to occupy a position at the LANL site boundary for 8,760 hr/yr and to produce the entire food supply at this location. The maximally exposed uninvolved worker is assumed to occupy a position within 1.2 mi (2 km) of the stack for 2,000 hr/yr.

[e] The offsite population consists of all individuals residing outside the LANL site boundary within 50 mi (80 km) of the site and is assumed to be present for 8,760 hr/yr. The involved/uninvolved worker population consists of all workers normally within 1.2 mi (2 km) of the facility. There are no workers within 1.2 mi (2 km) of the preferred SNS location at LANL.

NA - Not applicable. No workers within 2 km.

99 percent of the dose of this component of the total air pathway dose.

To estimate the total risk to members of the public from the proposed SNS facility emissions of radioactive materials over the entire life of the facility, annual population dose is multiplied by operating life of the facility and by the dose-to-risk conversion factor of 0.0005 LCF per person-rem. For 40 years of operation at 1 MW, 0.04 excess LCF would be projected. For 40 years at 4 MW, 0.1 excess LCF would be projected. If the facility operated for 10 years at 1 MW and 30 years at 4 MW, 0.09 excess LCF would be projected. These projected excess LCFs do not mean that any actual fatalities would occur as the result of the proposed SNS operations, but provide a quantified magnitude for comparison to excess LCFs estimated for the other alternatives.

5.3.9.2.2. Toxic Material Emissions

As discussed in Section 5.2.9.2.2, elemental mercury vapor is the only toxic material expected to be released from the proposed SNS facility under normal conditions. The mercury would be released from the Target Building Exhaust Stack at an annualized rate of 0.0171 mg/s. Based on atmospheric dispersion factors specific to LANL, the maximum mercury concentration in areas that could be occupied by uninvolved workers is 2.35×10^{-6} mg/m^3 in any 2-hr period and 3.41×10^{-7} mg/m^3 in any 8-hr period. These concentrations are at least 1/100,000th of the OSHA ceiling limit (0.1 mg/m^3) and the ACGIH-recommended threshold limit value-time weighted average (TLV-TWA) (0.05 mg/m^3) for workers. The average annual airborne mercury concentration at the site boundary would be 8.77×10^{-9} mg/m^3, 1/35,000th of the EPA Reference concentration for members of the public (0.0003 mg/m^3).

5.3.9.3 Accident Conditions

This section discusses the impacts on human health of accidents that could potentially occur during operation of the proposed SNS at LANL.

5.3.9.3.1 Accident Scenarios

The accident scenarios and source terms for accidents that could potentially occur at the proposed SNS facility are the same for all proposed sites and are summarized in Table F-2 (refer to Appendix F). The details of these scenarios and source terms is provided in Appendix A. Table 3.2 defines the terminology used to describe the likelihood that a given accident could occur.

5.3.9.3.2 Direct Radiation

The frequencies of occurrence and consequences of accidents involving exposure to direct radiation have not been specifically analyzed. DOE’s Shielding Design Policy for the proposed SNS is such that for the worst-case design-basis accident, the dose to the maximum exposed individual in an uncontrolled area would be limited to 1 rem, and a worker in a controlled area would be limited to 25 rem. The risks of this category of accidents would be the same for all proposed sites.

5.3.9.3.3 Radioactive Materials Accidents

DOE has performed a hazard analysis of potential accidents at the proposed SNS facility, and for those that could result in a release of radioactive material, it has estimated source terms. The DOE analysis is included as Appendix A. Accident scenarios, estimated frequencies of occurrence, and source terms are summarized in Table F-2 and are the same for all proposed SNS sites. The methods used to evaluate the consequences of these accidents are discussed in Section 5.1.9 and in more detail in Appendix F.

Doses for these accidents, should they occur at the proposed SNS facility at LANL, are listed in Table 5.3.9.3.3-1. With the exception of accident ID 16, all doses for accidents at a 4-MW facility would be four times higher than at a 1-MW facility. This is not the case for ID 16, the beyond-design-basis mercury spill, due to differences in the source term model (refer to Exhibit F of Appendix A). At 4 MW (ID 16b) some boiling of mercury is assumed, releasing a larger quantity of mercury than at 1 MW (16a) where only evaporation is assumed.

The pattern of accident doses for the proposed SNS facility at LANL is essentially the same as for the other proposed locations, but the magnitude of the doses is somewhat less. This mainly is due to the remoteness of the proposed SNS site at LANL and the lower population density.

Table 5.3.9.3.3-1. Radiological dose for SNS accident scenarios at LANL.

ID	Event	Frequency[b]	Source Term[c]	Maximum Individual (mrem)[a]				Population (person-rem)[a]			
				Offsite Public		Uninvolved Workers		Offsite Public		Uninvolved Workers	
				1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam
A. Accidents Involving Proposed SNS Target or Target Components											
2	Major Loss Of Integrity of Hg Target Vessel or Piping (Appendix A, Section 3.3)	a) Unlikely	Percent Inventory Mercury Iodine 0.142 0.142	1.2	4.8	4.9	19.6	12.0	48.0	NA	NA
		b) Extremely Unlikely	Percent Inventory Mercury Iodine 0.243 100	4.0	16.0	11	44	49	196	NA	NA
8	Loss of Integrity in Target Component Cooling Loop (Appendix A, Section 3.9)	a) Anticipated	Bounded by Annual Release Limits[d]	<10	<10	NA	NA	NA	NA	NA	NA
		b) Anticipated	Gases + Mist + 150 L of D_2O	0.33	1.32	0.41	0.84	1.7	6.8	NA	NA
		c) Anticipated	18 L of D_2O	<0.001	<0.001	0.002	0.008	0.003	0.012	NA	NA
		d) Anticipated	Gases + Mist + 150 L of H_2O	0.29	1.16	0.36	1.44	1.1	4.4	NA	NA
16	Beyond-Design-Basis Hg Spill (Appendix A, Section 3.17)	a) Beyond Extremely Unlikely	1 MW Percent Inventory Mercury Iodine 1.11 100	9.0		35		88		NA	
		b) Beyond Extremely Unlikely	4 MW Percent Inventory Mercury Iodine 1.28 100		590		1,100		8,000		NA

Table 5.3.9.3.3-1. Radiological dose for SNS accident scenarios at LANL – (continued).

				Maximum Individual (mrem) [a]				Population (person-rem) [a]			
				Offsite Public		Uninvolved Workers		Offsite Public		Uninvolved Workers	
ID	Event	Frequency[b]	Source Term[c]	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam
B. Accidents Involving Proposed SNS Waste Systems											
17	Hg Condenser Failure (Appendix A, Section 4.1.1)	Anticipated	13.7 g mercury	0.002	0.008	0.006	0.024	0.025	0.10	NA	NA
18	Hg Charcoal Absorber Failure[e] (Appendix A, Section 4.1.2)	Unlikely	14.8 g mercury	<0.001	<0.001	0.003	0.012	0.006	0.024	NA	NA
19	He Circulator Failure (Appendix A, Section 4.2.1)	Anticipated	1 day of tritium production	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	NA	NA
20	Oxidation of Getter Bed (Appendix A, Section 4.2.2)	Unlikely	1 day of tritium production	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	NA	NA
21	Combustion of Getter Bed (Appendix A, Section 4.3.1)	Extremely Unlikely	1 year of tritium production, 200 g depleted uranium	0.97	3.88	1.2	4.8	14	56	NA	NA
22	Failure of Cryogenic Charcoal Absorber [f] (Appendix A, Section 4.4.1)	Unlikely	1 day of xenon production	0.040	0.16	0.023	0.92	0.45	3.6	NA	NA
23	Valve Sequence Error in Tritium Removal System (Appendix A, Section 4.5.1)	Unlikely	1 year of tritium production	0.93	3.72	1.2	4.8	14	56	NA	NA
24	Valve Sequence Error in Offgas Decay System (Appendix A, Section 4.5.2)	Anticipated	7 days of xenon accumulation (1 decay tank)	2.5	10.0	3.0	12.0	36	144	NA	NA

Table 5.3.9.3.3-1. Radiological dose for SNS accident scenarios at LANL – (continued).

				Maximum Individual (mrem) [a]				Population (person-rem) [a]			
				Offsite Public		Uninvolved Workers		Offsite Public		Uninvolved Workers	
ID	Event	Frequency[b]	Source Term[c]	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam
25	Spill During Filling of Tanker Truck for LLLW Storage Tanks[g] (Appendix A, Section 4.5.3)	Anticipated	0.00005% of Contents of LLLW Tank	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NA	NA
26	Spray During Filling of Tanker truck for LLLW[g] (Appendix A, Section 4.5.4)	Anticipated	1.9 ml of LLLW	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NA	NA
27	Spill During Filling of Tanker Truck for Process Waste Storage Tanks[g] (Appendix A, Section 4.5.5)	Anticipated	51,100 L Process Waste to Surface Water + 57 L to Atmosphere	See footnote "h"		See footnote "h"		See footnote "h"		NA	NA
28	Spray During Filling of Tanker Truck for Process Waste[g] (Appendix A, Section 4.5.6)	Anticipated	28.4 L of Process Waste	See footnote "h"		See footnote "h"		See footnote "h"		NA	NA
29	Offgas Treatment Pipe Break (Appendix A, Section 4.6.1)	Unlikely	24 hrs of xenon production	0.49	1.96	0.17	0.68	3.9	15.6	NA	NA
30	Offgas Compressor Failure (Appendix A, Section 4.6.2)	Unlikely	1 hr of xenon production	0.056	0.224	0.021	0.084	0.52	2.08	NA	NA
31	Offgas Decay Tank Failure (Appendix A, Section 4.6.3)	Extremely Unlikely	7 days of xenon accumulation	2.5	10.0	3.0	12.0	36	144	NA	NA
32	Offgas Charcoal Filter Failure (Appendix A, Section 4.6.4)	Unlikely	7 days of iodine production	0.040	0.160	0.027	0.108	0.21	0.84	NA	NA

Table 5.3.9.3.3-1. Radiological dose for SNS accident scenarios at LANL – (continued).

				Maximum Individual (mrem) [a]				Population (person-rem) [a]			
				Offsite Public		Uninvolved Workers		Offsite Public		Uninvolved Workers	
ID	Event	Frequency[b]	Source Term[c]	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam	1-MW Beam	4-MW Beam
33	LLLW System Piping Failure (Appendix A, Section 4.6.5)	Unlikely	0.00005% of Contents of LLLW Tank	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NA	NA
34	LLLW Storage Tank Failure (Appendix A, Section 4.6.6)	Extremely Unlikely	0.00005% of Contents of LLLW Tank	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NA	NA
37	Process Waste Storage Tank Failure (Appendix A, Section 4.6.9)	Extremely Unlikely	57 L to Atmosphere	See footnote “h”		See footnote “h”		See footnote “h”		NA	NA

[a] Unless otherwise indicated, radiological doses are based on radiological source terms for a 1-MW power level and would be four times greater if the facility is operating at 4 MW. These doses are total EDEs and include dose from inhalation and immersion. “Offsite” means outside the site boundary rather than outside the proposed SNS facility boundary. Individual receptors are hypothetical and do not correspond to any actual person. Population receptors are based on the actual number of people residing outside the site boundary and within 50 mi (80 km) of the facility and on the number of site workers normally within 1.2 mi (2 km) of the facility and not involved in facility operation.

[b] See Table 5.2.9-2 for the numerical ranges associated with accident frequencies categories.

[c] Source terms are expressed in units that are independent of power level. Except for beyond-design-basis accidents (IDs 16a, 16b), the radioactivity released in accidents at 4 MW is four times that released at 1 MW.

[d] 40 CFR 61 limits dose to members of the public from airborne emissions from DOE facilities to 10 mrem/yr.

[e] Installation of sulfur-impregnated charcoal filters is being considered to serve as a “polishing filter” for the mercury condenser (refer to Event 17).

[f] Cryogenic charcoal absorbers are being considered as an alternative to the offgas compressor, decay storage tanks, and ambient temperature charcoal filters (refer to Events 24, 30, 31, and 32).

[g] Accidents involving tanker trucks may not be applicable for the proposed SNS facility at this site. It has not been determined how LLLW and process waste would be treated and disposed.

[h] Process waste accidental airborne releases occur at ground level. Only atmospheric dispersion factors for elevated releases were calculated for this site. Based on the radionuclide contents of LLLW, process waste source terms, and results for ORNL, doses for process waste accidents at this site are anticipated to be approximately 0.001 mrem or less for individuals and to be less than approximately 0.050 person-rem for the offsite population.

NA - Not available.

At a power level of 1 MW, the beyond-design-basis mercury spill accident (ID 16a) would be the highest dose of the potential accidents involving the target and target system. Maximum doses to individuals would be 9 mrem for the public and 35 mrem for the uninvolved worker. The dose to the member of the public is about 3 percent of the annual dose from natural background radiation and that to the worker is about 12 percent of the dose from natural background radiation. The offsite population dose of 88 person-rem corresponds to 0.044 excess LCF.

At a power level of 1 MW, accident IDs 24 and 31 involving the offgas decay system have the highest doses of potential accidents involving waste handling systems. In these two accidents, maximum individual doses would be 2.5 mrem to the public and 3.0 mrem to an uninvolved worker. The dose of 36 person-rem to the offsite population corresponds to 0.018 LCF. Although these accidents represent a low risk of health impacts, accident ID 24, a valve sequence error in the offgas decay system, has been classified as an "anticipated" event by DOE while ID 31 is "extremely unlikely" (Appendix A). As discussed in Section 5.2.9.3.3, the likelihood of accident ID 24 could be reduced by a number of means.

The consequences of all potential accidents, except ID 16, would be four times greater at a power level of 4 MW. The "worst-case" accidents for waste-handling systems (IDs 24 and 31) would correspond to 0.071 LCF in the offsite population. The beyond-design-basis mercury spill (ID 16b) yields maximum individual doses of 590 mrem to the public and 1,100 mrem to an uninvolved worker. The offsite population dose of 8,000 person-rem in this accident corresponds to 4.0 excess LCFs (8,000 person-rem $\times$ 0.0005 LCF/person-rem = 4.0 LCFs). As discussed in Section 5.2.9.2.1, LCF values of 1.0 or greater do not mean that fatalities would actually occur in the offsite population, but they provide a quantified value for use in comparison between alternatives. In addition, there is less than a 1 in 1,000,000 chance that this accident would occur in a given year at the proposed SNS facility.

5.3.9.3.4 Hazardous Materials Accidents

Accidents involving potential exposure to toxic materials are discussed in Section 5.2.9.3.4. All involve spills of irradiated mercury. Accident IDs 2b, 16a, and 16b could result in the OSHA ceiling concentration of 0.1 mg/m^3 being exceeded for a few minutes during the initial stages of these accidents in locations accessible to workers, but it would not be exceeded at or beyond the LANL site boundary. Thus, for only a few minutes at the start of the accident, mercury concentrations at or beyond the site boundary might exceed the TEEL-1 limit (0.075 mg/m^3) but would not exceed the TEEL-2 limit (0.10 mg/m^3); individuals at the boundary at the precise occurrence of the initial emission might perceive an odor, but would not experience or develop irreversible health effects or symptoms that could impair the ability to take protective action.

The second and third stages of these accidents are conservatively assumed to last from 7 to 30 days, while in reality, administrative and emergency response actions would more probably terminate the release in a shorter time period. During these stages, airborne concentrations of mercury would remain two to three orders of magnitude below the TEEL-0 limit of 0.05 mg/m^3, and no observable detrimental effects would be expected to occur.

5.3.10 SUPPORT FACILITIES AND INFRASTRUCTURE

This section summarizes the facilities and infrastructure effects on LANL transportation and utility systems from construction and operation of the proposed SNS.

5.3.10.1 Transportation

As described in Section 3.2.5, Alternative Sites, construction of the proposed SNS, related infrastructure, and support systems would occur at LANL, located in Los Alamos County, in north-central New Mexico approximately 25 mi (40.2 km) from the City of Albuquerque, New Mexico. Only two major roads, State Highway 502 and State Highway 4, access Los Alamos County.

Construction vehicles would access the proposed SNS facility location at the LANL site from State Highway 4 via a new access road. The new access road would be for the exclusive use of the proposed SNS project and would not provide access to other LANL facilities. As such, traffic circulation effects internal to LANL are not expected. Construction employee and vehicle activity would increase during the first years of construction, peaking in the year 2002, and it would decrease significantly during the last year (2004) of construction. The estimated total of 578 construction employees in the peak construction year (2002) is expected to add approximately 466 daily round-trips and 10 material/service trucks to projected site traffic of 6,980 round-trips. This represents a 6 percent increase.

Assumptions used to evaluate the traffic impacts at LANL were based on the location of employment centers relative to the proposed SNS and the existing commuting patterns discussed in Section 4.2.10.1. Approximately 90 percent of construction vehicles would originate from areas east of LANL and travel southbound to the proposed SNS site via State Highway 4; the other 10 percent would access the site from the east on State Highway 4. State Highway 4 is currently a lightly used road. The traffic volume currently experienced on State Highway 4 between the entrance to Bandelier National Monument and State Highway 502 is approximately 1,029 with the peak hr traffic being approximately 154. The average daily trips (ADT) on State Highway 4 between State Highway 501 and the entrance to Bandelier National Monument is approximately 758 vehicle trips. The number of vehicles counted during the peak hr is 114. The expected construction vehicles associated with the proposed SNS would add 857 daily vehicle trips during the peak year of construction (45 percent increase) to the current ADT on State Highway 4 between the entrance to Bandelier National Monument and State Highway 502. An additional 93 daily vehicle trips would occur on State Highway 4 between State Highway 501 and the entrance to Bandelier National Monument (10 percent increase). Some minor traffic effects could be expected from construction of the proposed SNS facility at this location. Construction-related traffic would be near the capacity of State Highway 4 during the peak years of construction.

Operation of the proposed SNS facility would result in an additional 250 resident/visiting scientists by the year 2006, plus another 125 employees during future facility upgrades, such as a second target station. An additional 375 people and 3 service trucks/day (305 round-trips) associated with the proposed SNS project would not be expected to create traffic effects at

LANL. Using current site population data (8,655 people) and associated vehicles (6,980) as a measure for comparison, the increase of 305 round-trips (4 percent increase) associated with operation of the proposed SNS facility would be minor.

Table 5.3.10.1-1 compares the No-Action Alternative with the proposed action located at the Los Alamos site. The table provides the percent increase in traffic resulting from the proposed SNS during construction and operation, as compared to the No-Action Alternative. The potential effects of any traffic increases could be reduced by having craft and non-craft workers report to work at different times, thus reducing the adverse effects on traffic flow during rush hours. Additionally, this analysis assumed there would be no transferring of personnel from within LANL. If some of the workers were previously working at LANL, the impact of the traffic would be reduced.

5.3.10.2 Utilities

This section assesses the potential environmental consequences of the proposed SNS for utilities. Although the existing utilities at LANL are extensive, the logistics of using these site services to support the proposed SNS at TA-70 would involve considerable investment in new infrastructure for all services. Since the proposed site at LANL is isolated from central site services, conventional pipeline tie-ins would not be feasible.

5.3.10.2.1 Electricity

The existing electrical power system at LANL does not have adequate capacity for significant future demands and would not meet the additional demands required by the proposed SNS. Also, future electrical distribution would not be reliable because of the age of the system. To supply power for the proposed SNS, DOE would have to pursue several regional and multistate strategies. Some of these strategies would involve bringing a new 115-kV line from the east side of the site. To provide even a 62-MW supply, other strategies in addition to the proposed line would need to be addressed. These include new regional and multistate power grid configurations and perhaps an SNS, site-specific, power generation station. Current capacity and reliability limitations of the electric power system would not meet the needs of the proposed SNS; significant upgrades would have to be made to meet those needs.

Table 5.3.10.1-1. LANL traffic increases compared to No-Action Alternative.

	Baseline/ No-Action	SNS Construction (Peak Year)	SNS Operation (4 MW)
Passenger Vehicle Trips/Day	6980[1]	466	302
Material Transport Trucks/Day	0	7	0
Service Trucks/Day	0	3	3
Total (% increase)	0 (0%)	476 (6%)	305 (4%)

[1]Based on 8,655 LANL employees.

5.3.10.2.2 Natural Gas

Natural gas would be required to provide energy for operational functions, such as fuel for boilers and localized unit heaters in the facility heating system at the proposed SNS facility. As described in Section 4.2.10.2.2, natural gas capacity would be available to serve the needs of the proposed SNS facility. However, since no existing gas lines or distribution systems are located in the vicinity of the proposed SNS site, an expansion of natural gas infrastructure would be required to serve future needs of the proposed SNS facility. Adequate supplies of natural gas are available; therefore, environmental effects would be limited to expansion of the infrastructure needed to accommodate the proposed SNS.

5.3.10.2.3 Water Service

The proposed SNS would require 1.2 to 2.3 mgpd for the following systems: tower water cooling, deionized cooling, chilled water, building heating, process water, potable water, demineralized water, fire suppression, and target moderators.

As discussed in Section 4.2.10.2.3, based on the current demands of LANL and the surrounding communities (3.3 mgpd), the potable water system with a rated capacity of 3.85 mgpd cannot meet the anticipated demands from future needs, including the needs of the proposed SNS. Accommodating the proposed SNS facility would require delivery system upgrades, including many new lines, lift stations, and storage tanks. Significant water supply effects would be expected with implementation of the proposed SNS facility.

5.3.10.2.4 Sanitary Waste Treatment

While there is sufficient sewage treatment capacity at the existing sanitary waste system in TA-46, the waste would likely have to be trucked to the nearest lift station, located several miles from the proposed SNS site. An alternative would be installing and operating an onsite treatment and discharge system.

5.3.11 WASTE MANAGEMENT

All of the wastes generated during construction and operation of the proposed SNS would be transferred to LANL Waste Operations for processing. The existing waste management systems for hazardous wastes, solid low-level radioactive wastes, and mixed wastes would have sufficient capacity to accommodate the proposed SNS facility's wastes. There would be a minimal effect to the existing sanitary waste treatment and disposal facilities at LANL. The LANL treatment facility for liquid low-level radioactive wastes cannot accommodate wastes with accelerator-produced tritium. However, a new facility is under construction (TA-53 RLW) that will be able to accept LLLW with accelerator-produced tritium.

The proposed SNS facility operation and construction projections of waste streams include the following: hazardous waste, LLW, mixed waste, and sanitary/industrial waste, as listed in Table 3.2.3.7-1. A summarization of existing waste management facilities at LANL, along with facility design and/or permitted capacities and remaining available capacities, can be found in Table 5.3.11-1. Projected waste stream forecasts for LANL's individual operations, proposed SNS operations at 4 MW, and the aforementioned wastes are also included in Table 5.3.11-1. Forecasts are projected from

Table 5.3.11-1. LANL waste management facility description and capacities.

Waste Disposition	Waste Type and Facility	Total Design Capacity for LANL Site	LANL Waste Projections for 1998-2040	Total Remaining Capacity for LANL Site (Excludes Proposed SNS Operations)	Proposed SNS Waste Operations Projection for 1998-2040	Potential Effect on Waste Management Facility
HAZARDOUS WASTE						
TREATMENT	None					
STORAGE	Liquid/Solid a) TA-54 b) Area L	a) Liquid – 80 m^3 Treatment Tank –5,720 gal b) Solid - 749 m^3	a) 273 m^3/yr b) 669 m^3/yr	Included in Mixed Waste Capacity	Hazardous Liquid 40 m^3	No effect anticipated. DOE has contracts in place for offsite disposal of hazardous wastes. Storage facilities can be expanded via RCRA permit modification.
LOW-LEVEL WASTE						
TREATMENT	Liquid a) RLWTF TA-50 b) TA-53 RLW	a) 25,000 m^3/yr b) 340 m^3/month	a) 21,400 m^3/yr b) 40 m^3/month	a) 4,600 m^3/yr	a) 665 m^3/yr 15,700 m^3/yr Process Waste Potentially LLW	LLW with accelerator-produced tritium will not be accepted for treatment at RLWTF according to WAC. A new facility is under construction. Treatment facilities do not have the capacity to treat the process waste. Facility under construction.
	Solid a) WCRRF b) LA Super Compactor	a) WCRRF - N/A b) Compactor - 200 ton Rating – 6,794 m^3/yr Capacity		5,838 m^3/yr	1,026 m^3/yr	Minimal effect anticipated for waste stream without tritium. No effect anticipated. Waste processed through WCRRF in a batch process. Minimal effect anticipated.

Table 5.3.11-1. LANL waste management facility description and capacities (continued).

Waste Disposition	Waste Type and Facility	Total Design Capacity for LANL Site	LANL Waste Projections for 1998-2040	Total Remaining Capacity for LANL Site (Excludes Proposed SNS Operations)	Proposed SNS Waste Operations Projection for 1998-2040	Potential Effect on Waste Management Facility
LOW-LEVEL WASTE - continued						
DISPOSAL	Solid TA-54, Area G - Pits 15, 31, 37, 38, 39 Liquid None	150,000 m^3	2,500 m^3/yr	35,000 m^3	1,026 m^3/yr	No effect anticipated. Continued construction of Area G is under evaluation in the LANL Sitewide EIS.
MIXED WASTE						
STORAGE	Liquid TA-54 Area L	1,013 m^3	Combined Liquid/Solid Mixed waste projection at 622 m^3/yr	NA	11 m^3/yr	No effect anticipated. DOE has contracts in place for offsite disposal of mixed wastes. Storage facilities can be expanded via RCRA permit modification.
	Solid TA-54 Area G (Dome #49)	1,864 m^3		NA	7 m^3/yr	
SANITARY/INDUSTRIAL WASTE						
TREATMENT	Liquid Sanitary Waste System Consolidation (SWSC) TA-46	1,060,063 m^3/yr	692,827 m^3/yr	368,000 m^3/yr	25,900 m^3/yr	No effect anticipated.
	Solid None					
DISPOSAL	Offsite landfill	NA	5,453 m^3/yr	NA	1,350 m^3/yr	No effect anticipated.

RLWTF - Radioactive Liquid Waste Treatment Facility.
WCRRF - Waste Characterization, Reduction, and Repackaging Facility.
Sources: DOE 1996c; DOE-AL 1998; LANL 1997b; LANL 1997f; LANL 1997e; (n,p) Energy, Inc. and Rogers & Associates 1995.
NA - Not applicable.

1998 to 2040, unless otherwise noted, and they are based on estimates provided by LANL waste management operations and waste management documentation.

The proposed SNS facility's waste streams would be certified to meet LANL TSD facilities' WAC before wastes would be accepted for TSD at the site. As mentioned earlier in Section 5.2.11, AEA, EPA, and NRC limits for LLLW treatment facility WAC would also need to be addressed for the LANL site. Currently, the LANL Radioactive Liquid Waste Treatment Facility WAC states that the facility will not accept accelerator-produced wastes with tritium for treatment. This criterion exists because the facility does not have equipment in place to treat and remove tritium from water to meet the State of New Mexico Environment Department's NPDES limit of 20,000 pCi/L in the effluent discharged from the facility. Reactor-produced tritium is expected from these requirements by the AEA. The TA-53 RLW, currently under construction, will be able to accept LLLW with accelerator-produced tritium (Moss 1998; LANL 1997a).

As shown in Table 5.3.11-1, no hazardous waste treatment or disposal facilities are located at LANL. LANL hazardous wastes are shipped offsite to permitted commercial facilities for treatment and disposal (LANL 1997b).

LANL waste management facilities provide treatment and disposal of LLW streams. Since facilities are present onsite for treatment and disposition, long-term storage facilities are not necessary on the site (LANL 1997b and 1997f). However, the LLW facilities do not have sufficient capacity to treat the process waste from the proposed SNS if this waste stream were classified as LLLW.

Currently, in accordance with the *LANL Mixed Waste Site Treatment Plan*, LANL ships mixed waste to approved, offsite commercial treatment and disposal facilities. Onsite treatment methods are being developed for processing mixed waste for which there are no commercially available treatment capabilities (LANL 1997e).

LANL has a waste certification process in place to assure wastes meet the WACs for LLW disposal. However, because of the uncertainty of the composition of LLW and mixed wastes that may be generated from operation of the SNS, the waste may not meet the current WAC for waste management facilities at LANL. DOE would take action to assure the proper disposition of these wastes. For example, pretreatment of the waste may assure they meet the WAC. DOE may be able to amend the license at current waste disposal facilities to allow acceptance of wastes from the SNS.

Excess soil, construction wastes, and sanitary wastes would be generated during construction of the proposed SNS facility. Excavated soil and rock would be used for backfill, erosion control, or other environmental purposes. Construction debris would be sent to a Class IV landfill. Liquid sanitary wastes would be transported to the LANL sanitary wastewater treatment plant at LANL. Solid sanitary waste would be sent to a sanitary landfill (ORNL 1997b).

As stated in Section 5.2.11, in accordance with the *NSNS Waste Minimization and Pollution Prevention Plan*, considerations for minimizing the production of the proposed SNS facility's waste would be implemented.

5.4 ARGONNE NATIONAL LABORATORY

This section describes the potential environmental effects or changes that would be expected to occur at ANL if the proposed action were to be implemented. Included in the discussion of this section are effects on the physical environment; ecological and biological resources; existing social and demographic environment; cultural, land, and infrastructure resources; and human health.

5.4.1 GEOLOGY AND SOILS

Effects on geology and soils from construction and operation of the proposed SNS facility in the 800 Area at ANL are described in this section.

5.4.1.1 Site Stability

The proposed location for the SNS at ANL is a stable site suitable for construction of the facility. The glacial soils (sand and clays) at ANL would provide adequate foundation support for the proposed facilities. Other large-scale buildings and structures such as the Advanced Photon Source (APS), the Tandem Linac Accelerating System, and the Intense Pulsed Neutron Source have been built at ANL without encountering site stability problems.

5.4.1.2 Seismic Risk

The ANL area is a stable region in terms of seismic activity (refer to Figure 4.3.1.4-1). The closest region of significant seismic occurrences is the New Madrid fault zone along the Missouri-Tennessee border. Ground acceleration from seismic activity at New Madrid would be unlikely to significantly affect the proposed SNS facility at ANL. The proposed SNS would be constructed according to DOE Standard 1020-94 (DOE 1996a). It would be capable of withstanding maximum horizontal ground accelerations of 0.09 gravity for a return period of 500 years, 0.12 gravity for a return period of 1,000 years, 0.15 gravity for a return period of 2,000 years, and 0.26 gravity for a return period of 10,000 years. The SNS beam would be designed to shut down immediately in the event of an earthquake. As such, predictable seismicity for the 800 Area would have no impact on the construction, operation, or retirement of the proposed SNS facility.

5.4.1.3 Soils

Excavation required for construction of the proposed SNS facility would disturb the native soils. Excavated soils would be stockpiled according to soil type and horizon. If the excavated soils possess the proper characteristics, they would be used to construct the shielding berm. Otherwise, the soils would be placed in the spoils area (refer to Section 3.2.5.4). Topsoil removed during excavation would be used for grading and landscaping of the site at the finish of construction.

Construction of the SNS would require removal grading of the site and removal of vegetative cover. As a result, the potential exists for soil erosion and stream siltation especially during periodic storm events. Best management practices would be followed to minimize the impacts of erosion during construction activities. Section 3.2.2.3, Site Preparation, discusses the elements (retention basin, silt fences, temporary storm water drainages, etc.) that would follow an erosion control plan to prevent erosion and siltation of Sawmill Creek on Freund Branch.

Borrow material for construction of the berm covering on the tunnels of the proposed SNS facility would be obtained from excavation of retention ponds and from the creation of replacement wetland areas in the 800 Area (refer to Section 5.4.5.1). Any additional material would be obtained from offsite. The amount of soil required for the proposed SNS facility would not affect available supplies for other uses.

Operations of the proposed SNS at ANL would affect soils within the shielding berm surrounding the linac tunnel (refer to Section 5.2.1.3). Site-specific calculations of nuclide concentrations and transport potential have not been performed for ANL. However, the suite of activation products would not be significantly different from those at ORNL. Downward migration of contaminants at ANL would first encounter an impermeable till stratum primarily composed of clay. Retardation of nuclide migration would occur in this interval, slowing its downward movement into the primary aquifers.

5.4.2 WATER RESOURCES

Effects on water resources from construction and operation of the proposed SNS in the 800 Area at ANL are described in this section. Best management practices would be employed to minimize any effects on surface water due to erosion and siltation during construction (see Section 5.2.1.3).

5.4.2.1 Surface Water

No surface water resources within the ANL reservation would be used to supply potable water for operations at the proposed SNS facility. Demands ranging from 800 to 1,600 gpm (3,028 to 6,057 lpm) would be required to support an SNS facility that may be upgraded throughout its operational life from 1 MW to 4 MW. Potable water is currently piped to ANL from Lake Michigan. Nonpotable water suitable for cooling tower operations is available from the Canal Water Distribution System. Approximately 2 mgpd (7.6 million lpd) of capacity are available for this type of use. No effects on water resources or the distribution system for them are expected from the proposed SNS facility.

Conventional cooling tower blowdown would be discharged into Sawmill Creek, which flows into the Des Plaines River. The average flow in Sawmill Creek in 1996 was 6.7 mgpd (25.4 million lpd). By comparison, a cooling tower discharge rate for a 2-MW facility would add a daily volume of 0.36 mgpd (1.4 million lpd), and a cooling tower discharge rate for a 4-MW facility would add 0.50 mgpd (1.9 million lpd) to the Sawmill Creek flow. Blowdown would be temporarily held within a retention basin before being released to the surface drainage system. This basin would be designed to allow sufficient residence time for the discharge to cool to ambient temperatures. If necessary, active cooling systems such as recirculating fountains may be employed. Water released into the northward flowing tributary of Sawmill Creek would exit ANL to an adjacent wetland. Characteristics of the wetlands may be affected due to the increase in flow.

Polyphosphonates for antiscaling and ozone as a biocide would be used in the cooling towers. Discharge from the towers would be regulated to contain about four times the dissolved solids content of potable water (i.e., 1,000 to 1,200 mmhos conductivity). Contributions of solids or chemical agents are not anticipated to significantly affect the stream. Discharge from the cooling towers of the proposed SNS facility would be mixed with other stream flows within ANL and would exit the ANL site at Outfall 001. Discharge at the ANL boundary is monitored under an existing NPDES permit and is required to meet permitted standards.

5.4.2.2 Flood Potential and Floodplain Activities

Executive Order 11988 requires the establishment of procedures to ensure that potential effects of flood hazards and floodplain management are considered for any DOE action undertaken in a floodplain and that floodplain impacts be avoided to the extent practicable. Due to the low-lying nature of the area surrounding ANL, few sites are available that allow a facility the size of the proposed SNS to be constructed. At the proposed SNS site, the eastern edge of the SNS footprint overlies a small portion of the 100-yr floodplain and an associated wetland. Also, the southern tip of the linac tunnel would encroach on the floodplain and wetland associated with Freund Brook. In neither case does the main portion of the SNS footprint overlie primary drainage channels. Construction of the proposed SNS would include filling and stabilizing those portions of the floodplain that are required for buildings and related structures. Hence, placement of the proposed SNS facility in the 800 Area location would require a slight alteration of drainage patterns and construction of storm drains and canals to direct storm flow away from the site. Because of the relatively small area of the 100-year floodplain that would be affected by construction, compared to the total drainage area of the watershed, no downstream effects are predicted from the proposed SNS facility.

5.4.2.3 Groundwater

No groundwater resources would be used for construction or operation of the proposed SNS. Over the life of the facility, groundwater has the potential to be affected by leaching and transport of radionuclides from the berm soils (refer to Section 5.2.1.4). However, the potential effects are mitigated at ANL by natural conditions of the site. The uppermost groundwater occurs at a depth of about 65 ft (20 m) from the ground surface within a complex mixture of silts, clays, and sands (Wadsworth Till). The irregular and localized nature of shallow water sources and the extremely low permeability (1×10^{-8} cm/s) of the till renders this formation unusable as a source of drinking water. The primary aquifers for potable water occur at a depth of about 165 ft (50 m), and the downward rate of water movement through the saturated zone of the till is only about 3 ft/yr (0.9 m/yr). In addition, the high clay content of the till would provide retardation for nuclides. Accurately predicting retardation factors in such a complex environment is difficult, and a complete evaluation of the types and amounts of radionuclides that would be generated in the soils at ANL has not been performed. Groundwater monitoring would be routinely performed (such as on a semiannual or annual basis) to ensure that no migration to the primary aquifers takes place.

5.4.3 Climatology and Air Quality

Effects on climate and air quality from construction and operation of the proposed SNS facility in the 800 Area at ANL are described in this section.

5.4.3.1 Climatology

Construction and operation of the proposed SNS facility would not affect regional or localized climates within the ANL area.

5.4.3.2 Air Quality

Effects on nonradiological air quality are presented in this section. Airborne radiological releases are evaluated under human health impacts (refer to Section 5.4.9). Construction activities would create temporary effects in regard to particulate matter (PM_{10}) measurements during the construction phase of the proposed SNS facility. This effect would be greatest during early clearing and excavation efforts but would decrease within a relatively short time period. Although no formal estimates of suspended particulate matter have been prepared, this level is predicted to be minimal when weighted over the usual 24-hr averaging period.

The primary nonradiological airborne release during operations at the proposed SNS facility would be combustion products from the use of natural gas. However, steam is available at ANL as an alternative heat source. If the proposed SNS facility were to employ steam heat, its usage would be at a maximum rate of about 60,000 lb/hr against available capacity of 300,000 lb/hr. Peak usage of natural gas would be during the winter months at an approximate rate of 1,447 lb/hr. Emission rates related to the maximum period of natural gas usage are listed in Table 5.3.3.2-1. The proposed SNS site is also considered to be flat, and projected air quality impacts from natural gas usage would be as shown in Table 5.4.3.2-1. Adding maximum background concentrations to maximum projected impacts from sources (a very conservative procedure because the two do not occur at the same location or time) of the proposed SNS facility also does not provide any violations of the NAAQS.

Five 200-kW diesel backup generators would be tested for short durations several times a year. Emissions from these generators are rated at 1,450 cfm at 910°F (487°C). Periodic emissions from these generator testings would not affect overall air quality, and effects on air quality from the construction or operation of the proposed SNS facility would be negligible.

5.4.4 NOISE

Sound emitted from construction equipment is expected to be temporary and local in nature. This type of noise is specifically exempted from compliance with the Illinois Noise Pollution Control Regulations (IPCD 1973, Rule 208-Exemption). No unusual or significant noise impacts are expected from construction of the proposed SNS facility.

Operations at the proposed SNS facility would generate some noise, caused particularly by site traffic and cooling towers. However, these facilities would be designed to satisfy Illinois State Noise Standards and DOE criteria for occupational safety and health. In general, sound levels would be characteristic of a light industrial setting. Effects on residential areas would be attenuated by the distance from the SNS [>0.4 mi (>0.6 km)] and by the forested buffer zone [at 0 to 0.4 mi (0 to 0.6 km)]. Onsite, the level of noise from the proposed SNS facility would be typical of accelerator facilities, and any effects would be negligible when compared to ambient levels.

Table 5.4.3.2-1. Impact of natural gas combustion at the proposed SNS.

NAAQS Compound	Period[a]	Estimate (μg/m³) at 984 ft (300 m)	Maximum Concentration[b]	Assumed Background (μg/m³) (Refer to Table 4.3.3.3-1)	Background + 300 m Location (μg/m³)	NAAQS Limits (μg/m³)
Sulfur dioxide (SO_2)	Annual[c]	0.03	0.05	7.9	7.9	80
	24-hr	0.30	0.60	55.8	56.1	365
	3-hr	0.70	1.40	140.7	141.4	1,300
Carbon monoxide (CO)	8-hr	21	40	2,207	2,228	10,000
	1-hr	30	57	3,602	3,632	40,000
Nitrogen dioxide (NO_2)[d]	Annual[c]	5.0	9.0	61.1	66.1	100
Particulate (PM_{10})	Annual[c]	0.60	1.10	20.0	20.6	50
	24-hr	6.80	13.30	47.0	53.8	150

[a] Factors used to convert from 1-hr averages to long periods taken from EPA 1977.
[b] Concentration at 984 ft (300 m) estimated boundary and maximum concentration [occurring at 174 ft (53 m)] estimated by EPA – Screen 3 Model (v. 96043). Maximum concentration location is expected to be "onsite."
[c] Annual concentrations reflect 33% estimated (conservative) annual usage factor.
[d] Estimated concentration in this table includes all NO_x compounds and not only NO_2 for NAAQS.

5.4.5 ECOLOGICAL RESOURCES

This section describes the potential effects construction and operation of the proposed SNS would have on ecological resources in ANL. It includes potential effects on terrestrial and aquatic resources, wetlands, and threatened and endangered species.

5.4.5.1 Terrestrial Resources

For construction of the proposed SNS facility at ANL, 110 acres (45 ha) of land would be cleared of vegetation. A large portion of this area has been disturbed, and its use by wildlife is limited. However, the area in the vicinity of the proposed SNS site has seen little recent disturbance, and the high diversity of habitats in this area supports a large number of wildlife species.

Construction and operation of the proposed SNS facility would reduce wildlife population levels on the proposed SNS site and in adjacent areas over the long term. The Waterfall Glen Nature Preserve may provide a refuge for the displaced wildlife. However, the population levels would be permanently reduced by an amount generally proportional to the amount of habitat lost (Kroodsma 1985, as cited in DOE-CH 1990).

Construction and operation activities and the associated noise and human presence would disturb wildlife occupying areas adjacent to the proposed site. This could result in emigration of some sensitive species from the surrounding area, although many of the species would adjust to the disturbance. To help minimize the disturbance to wildlife, workers would be prevented from entering undisturbed areas delineated before construction.

Except for the fallow deer, the species that would be affected are typical of the surrounding region and are not particularly rare or important as game animals. Generally, these effects on terrestrial biota would be minor.

5.4.5.2 Wetlands

Approximately 3.5 acres (1.4 ha) of wetlands on the proposed SNS site lie within the proposed footprint and would be eliminated by construction activities. This represents approximately 20 percent of the wetlands on and in the vicinity of the proposed SNS site and approximately 7 percent of the total area of jurisdictional wetlands on the ANL property. These wetlands provide habitat for area wildlife, such as amphibians and wetland birds. In accordance with Section 404 of the federal Clean Water Act (CWA), a permit from the USACOE would be required for construction in these wetlands. As part of this permit, DOE would consult with the USACOE on plans to mitigate this loss of wetlands.

A wetland functional assessment has not been completed for these wetland habitats. However, the primary function of these wetlands most likely includes flood-flow alteration, wildlife habitat, nutrient transformation, and organic material production and export. The most common mitigation for destruction of wetlands at ANL is replacement (an equivalent area of wetland habitat created, preferably in the same watershed of the impacted wetlands). Because one of the wetlands that would be destroyed is relatively large, approximately 2.7 acres (1.1 ha), it would be difficult to locate a replacement wetland in the same watershed. One possibility that would be investigated would be enhancement of existing wetlands along Freund Brook.

Wetland areas in the vicinity of the proposed SNS site may be affected during construction. However, these effects would be temporary. In consultation with the USACOE, DOE would develop a plan for the protection of these wetlands.

5.4.5.3 Aquatic Resources

All precipitation runoff from the proposed SNS site would be directed to a sediment retention basin. Cooling tower blowdown would also be released to this basin. The rate of water discharge from the basin would be up to 350 gpm (1,325 lpm) through a standpipe and into a small tributary of Sawmill Creek. The cooling tower blowdown would be elevated in temperature, and it would contain chemical biocides and antiscaling agents. The source of the makeup water for the SNS cooling towers would be the nonpotable laboratory water system; therefore, the blowdown would not contain chlorine. As described in Chapter 3, the sediment retention basin would be designed to reduce the temperature of the water to the ambient temperature of the receiving stream.

Effluent from the sediment retention basin would eventually be discharged to the small stream in the north end of the proposed SNS site. This stream flows through the Waterfall Glen Nature Preserve and empties into Sawmill Creek, which flows into the Des Plaines River. The addition of this discharge to the base flow of the tributary would increase water flow through the stream channel and associated wetlands. Changes in the biotic community of the tributary may result from this increased flow. Unfortunately, little information about this stream was available for inclusion in the EIS. Consequently, the potential effects of the effluent discharge of the proposed SNS facility on the tributary could not be described fully. However, because of its location and the fact that Sawmill Creek receives effluents from ANL, the potential effects from the proposed SNS effluents would be expected to be minor.

Freund Brook would receive no operational discharges from the proposed SNS, but construction activities could increase runoff discharge and sediment loading in this stream. Without protection, this could affect the habitat within Freund Brook. Because the substrate of the brook is coarse rock and gravel, the sediments washed into it could settle on the substrate, displacing the current bottom-dwelling fauna. To avoid this potential effect, DOE would establish a 100- to 200-ft (30- to 68-m) buffer zone along Freund Brook. Vegetation within this buffer zone would not be disturbed during construction of the proposed SNS. Erosion control measures, including silt fencing and preservation of native vegetation, would minimize sediment loading in the brook during construction. As a result, effects upon Freund Brook would be minimal.

5.4.5.4 Threatened and Endangered Species

No protected species have been identified on the proposed SNS site at ANL (see Section 4.3.5.4). The great egret, black-crowned night heron, and pied-billed grebe, three state-listed endangered bird species, have been observed in the wetlands southeast of the site. However, these species are not known to breed there or elsewhere in ANL. In addition, these wetlands would not be affected by the proposed SNS project. No other protected species are known to occur in the vicinity of the proposed SNS site. Consequently, no known protected species would be affected by implementation of the proposed action on the SNS site in ANL.

A systematic survey of the proposed SNS site for protected species would be conducted prior to the start of land clearing and construction. Because definitive identification of many protected plants can only be made when they are flowering, this survey would extend over the spring, summer, and fall seasons to maximize the probability of finding them. If found, appropriate mitigation measures would be taken to protect these plants during construction and operation of the proposed SNS facility.

5.4.6 SOCIOECONOMIC AND DEMOGRAPHIC ENVIRONMENT

The socioeconomic impact section identifies whether construction and operation of the proposed project (and associated worker in-migration from outside the ROI) may adversely affect regional services and infrastructure. It also presents an estimate of the financial effects (employment, income, taxes, and economic output) that would be generated locally in the form of worker salaries, indirect effects, and induced effects. Unless otherwise noted, economic effects are described in escalated-year dollars.

The ROI associated with ANL includes Cook, DuPage, Kane, and Will counties, Illinois. This 2,600 mi^2 (6,734 km^2) region was selected because it forms the area within which at least 95 percent of ANL workers currently reside. It is, therefore, the region within which the majority of socioeconomic effects are expected to occur. Socioeconomic effects beyond the ROI are generally expected to be minor.

The total local construction cost is estimated to be approximately $332 million (escalated dollars), and the peak construction year would be 2002, when 578 workers would be onsite

(Brown 1998a). Of this total, about three-fourths (433 individuals) would likely be hired from the ROI, and 144 would come from outside the area. An approximate average of 300 SNS workers per year would be employed, including all construction, management, engineering design, and other technical and commissioning staff. Construction of the 1-MW SNS is the bounding case for analysis of construction effects. If the SNS is upgraded to 4 MW, additional construction would occur, but this would be much less than the effects associated with the initial construction of the 1-MW SNS.

Operation of the proposed SNS at 1 MW would begin in 2006 with a staff of 250 persons. Later, if the proposed SNS is upgraded to 4 MW, 375 persons would be employed. The 4-MW case is used for this analysis as the bounding case, and the effects of the proposed 1-MW SNS on the ROI would be similar but slightly less than the 4-MW case.

5.4.6.1 Demographic Characteristics

It is assumed that approximately 75 percent of all construction workers would come from the local region (Brown 1998a). Most of the construction workers would be general craft laborers, and the specialized technical components would be contracted out and fabricated in places not yet known. All locally hired construction workers would commute to the job site from existing residences and would not relocate closer to the site. The experience with past major construction projects has been that most in-migrating workers would temporarily move to the project area but would usually commute home on weekends or periodically. These individuals would generally not bring families to the ROI for the construction period. However, even if all of the in-migrating workers brought families into the ROI, the total (temporary) population increase would be less than 500 persons in the peak year, including spouses and children. This would be a temporary increase in population of much less than 0.01 percent and is, therefore, negligible.

People with the technical expertise needed to operate the proposed SNS facility currently reside in the ROI. However, it is also expected that some plant operators would come from outside the local region. It is assumed that about half of the 375-person operating workforce (for the bounding 4-MW case) would come from outside the area. It is further assumed that these households would be the same size as the national average, because it is not known from where they would in-migrate. It is conservatively estimated that in 2006 the total population increase associated with operations would be about 600 individuals, including spouses and children. The facility operators would be "permanent" residents of the ROI, and little additional in-migration would occur in subsequent years. The population increase associated with construction and operations would represent much less than 0.01 percent of the local population and is, therefore, negligible.

5.4.6.2 Housing

With about 196,000 vacant "dwelling units" (refer to Section 4.3.6.2) in the four-county ROI, workers should easily be able to find apartments to rent or houses to purchase. Some new housing would probably be constructed. However, existing vacancies and historical construction rates indicate that housing would be available for this small in-migration.

5.4.6.3 Infrastructure

Potential effects upon infrastructure are closely tied to population growth. Because the expected permanent in-migration is only 600 individuals, effects on infrastructure would be relatively minor.

There are more than 1,100 schools with an enrollment of 1.7 million students in the ROI. The addition of about 300 children to the ROI would, therefore, be minor. Even if all 300 children attended schools in Kane County, the current teacher-student ration of 1:17 would be unchanged. Effects would also be minor for police and fire protection, health care, and other services.

5.4.6.4 Local Economy

Design of the proposed SNS facility would begin in 1999, and the first construction managers and workers would begin work in FY 2000. The majority of the construction would occur from FY 2001 through FY 2004, with the peak construction employment occurring in FY 2002. Testing of the proposed SNS would be from FY 2003 through FY 2005. Operations are planned to begin by the end of FY 2005; FY 2006 would be the first full year of operations (see Figure 3.2.2-1).

Table 5.4.6.4-1 presents the results of the IMPLAN modeling for the period 1999 through 2006. Economic benefits in the form of jobs, wages, business taxes, and income would begin to accrue during the first year of the project in FY 1999. These economic benefits in the ROI would increase as construction and other associated project activities increase. Design and construction employment would be highest in FY 2002, and there would be an estimated 1,795 total (direct, indirect, and induced) new jobs created at ANL. This trend would begin to diminish in FY 2003 as design and construction employment decreased and would continue to decrease until construction is completed in FY 2004. Facility operations would begin in FY 2005. Operations would reflect substantial regional spending for operator salaries, supplies, utilities, and administrative costs.

The proposed SNS is planned to operate for 40 years. If the level of operation is the same as the 4-MW case measured in the first full year (FY 2006), it is expected that facility operation will continue to support 1,776 jobs each of the following years of operation. Other annual operations effects would include $82.9 million in local wages, $8.7 million in business taxes, $91.2 million in personal income, and $211.3 million in total output

Because of the very large regional population, construction of the facility would not be expected to lower the region's total unemployment rate of 5.2 percent. During operations, the unemployment rate may potentially decrease from 5.2 percent to 5.1 percent. The effects of operating the proposed 1-MW SNS would be similar but slightly lower.

5.4.6.5 Environmental Justice

As identified in Figures 4.3.6.5-1 and 4.3.6.5-2, minority populations and low-income populations reside within 50 mi (80 km) of the proposed SNS site. For environmental justice effects to occur, there must be high and adverse human health or environmental effects that disproportionately affect minority populations or low-income populations.

Table 5.4.6.4-1. ANL IMPLAN modeling results—construction and operations impacts.

	1999	2000	2001	2002	2003	2004	2005	2006
Employment								
Direct	115	222	522	634	451	305	42	747
Indirect	88	158	380	475	341	234	32	354
Induced	126	231	551	684	489	334	46	676
Total	328	611	1,452	1,795	1,281	873	120	1,776
Wages								
Direct	$8,288,948	$15,673,685	$38,031,862	$48,011,602	$34,981,555	$24,326,509	$3,405,428	$44,896,760
Indirect	$3,174,669	$5,871,680	$14,351,825	$18,270,892	$13,387,061	$9,361,369	$1,313,399	$15,219,533
Induced	$3,711,096	$6,946,078	$16,868,390	$21,322,235	$15,540,350	$10,810,520	$1,512,284	$22,700,801
Total	$15,174,713	$28,491,443	$69,252,078	$87,604,730	$63,908,966	$44,498,398	$6,231,111	$82,817,092
Business Tax								
Direct	$113,558	$317,964	$701,796	$780,090	$522,183	$332,587	$46,170	$3,322,188
Indirect	$377,034	$702,723	$1,703,248	$2,147,712	$1,561,134	$1,082,963	$151,043	$1,512,655
Induced	$649,948	$1,214,170	$2,942,643	$3,711,773	$2,699,322	$1,873,469	$261,457	$3,915,033
Total	$1,140,540	$2,234,587	$5,347,687	$6,639,575	$4,782,639	$3,289,019	$458,670	$8,749,876
Income								
Direct	$9,303,482	$17,513,984	$42,548,163	$53,794,563	$39,230,485	$27,304,639	$3,822,649	$47,892,968
Indirect	$3,569,229	$6,607,919	$16,167,888	$20,604,452	$15,112,667	$10,579,212	$1,485,821	$17,998,706
Induced	$4,111,446	$7,701,094	$18,715,390	$23,673,539	$17,265,918	$12,018,978	$1,682,444	$25,271,398
Total	$16,984,158	$31,822,997	$77,431,441	$98,072,554	$71,609,070	$49,902,829	$6,990,914	$91,163,074
Output								
Direct	$23,293,804	$44,358,310	$107,435,152	$135,297,745	$98,436,491	$68,359,854	$9,568,254	$103,295,792
Indirect	$8,265,086	$15,431,175	$37,620,415	$47,742,063	$34,913,251	$24,368,507	$3,417,922	$41,430,213
Induced	$10,788,440	$20,221,876	$4,917,774	$62,248,458	$45,430,363	$31,645,379	$4,432,662	$66,623,763
Total	$42,347,330	$80,011,362	$194,233,291	$245,288,267	$178,780,104	$124,373,740	$17,418,838	$211,349,766

Source: IMPLAN Pro.

The human health and safety analyses show that hazardous chemical and radiological releases from normal operations of the proposed SNS facility at 1-MW and 4-MW power levels would be within regulatory limits. Annual radiological doses are given in Section 5.4.9, and the data show that normal air emissions of the proposed 1-MW SNS are negligible and would not result in adverse human health or environmental impacts offsite to the public. Therefore, operation of the proposed SNS would not have disproportionately high and adverse effects on minority or low-income populations.

Radiation doses to the public from both normal operations and accident conditions would not create high and adverse effects. Less than two (1.6) LCFs are calculated at the 4-MW power level over a 40-year operations period. If the facility operated for 10 years at 1 MW and 30 years at 4 MW, the calculated number of LCFs could be reduced (refer to Section 5.2.9.2.1). An LCF is a cumulative measure from the entire population (within a 50-mi or 80-km radius) of over 8,000,000 people used for comparing alternatives and does not necessarily indicate that a fatality would occur (refer to Section 5.2.9.2.1). Also, 25 accident scenarios would result in airborne releases. The consequences of most of these accidents would be negligible at power levels of both 1 MW and 4 MW. Four accidents are calculated to induce LCFs in the offsite population. The predominant wind direction is from the south, and wind from the southwest quadrant occurs almost 50 percent of the time (Figure 4.3.3.2-1). Figures 4.3.6.5-1 and 4.3.6.5-2 show a small concentration of minority population to the west of the proposed SNS site, but the site is mostly surrounded by non-minority, higher income population, especially in the path of the predominant wind direction. The public, including minority and low-income persons, could be in the path of an offsite airborne release. However, the analysis has shown that there would not be high and/or adverse effects on any of the population; therefore, there would be no disproportionate risk of significantly high and adverse effects on minority and low-income populations.

A number of uncertainties are associated with the evaluation of potential effects due to subsistence consumption. ANL developed an article reviewing the literature on subsistence consumption (Elliot 1994) and found that (1) "the majority of the studies that have been conducted to date are focused on site- or region-specific exposure concerns. At present, it is unclear whether the findings of these studies are representative of consumption and exposure levels among minority populations at a national level"; (2) "a large number of risk assessment studies focusing on fish and wildlife consumption examined whole populations without distinguishing between consumption and exposure patterns of specific ethnic (or other) subpopulations"; (3) "the vast majority of studies have focused on fish consumption as an exposure pathway. Few examined wildlife consumption and contamination, and even in such cases the studies were not motivated by minority exposure concerns"; and (4) "the majority populations were not significantly higher than for the population as a whole." Specific data on subsistence living are not available for the ANL region. However, DOE is unaware of any subsistence population residing in the vicinity of the proposed SNS site. Therefore, no adverse effects on such populations are expected.

In order to assemble and disseminate information on subsistence hunting and fishing, DOE began publishing *A Department of Energy Environmental Justice Newsletter: Subsistence and Environmental Health* in the spring of 1996. The newsletter is available in the public reading rooms. Three goals of the newsletter are (1) “to provide useful information about the health implications of consuming contaminated fish, wildlife, livestock products, or vegetation”; (2) ”to provide information about projects and programs at DOE and other Federal and State agencies that address the problems associated with consuming contaminated fish, wildlife, livestock products, or vegetation”; and (3) “to receive relevant information from readers.” In addition to the newsletter, DOE has a new project under way to identify what information is being collected on subsistence consumption by other federal agencies and to serve as a clearinghouse for such information (DOE 1996e).

No discharges of radioactive water to surface water would occur because all of the wastes generated during construction and operation of the proposed SNS facility would be transported to ANL for processing. These facilities and the management processes for these wastes are described in Section 5.4.11. All chemical releases would be regulated by NPDES permits and would be in compliance with federal and state regulations. As such, there would be no incremental effects on fish and other edible aquatic life in areas surrounding the proposed SNS site.

The analyses indicate that socioeconomic changes resulting from implementing the proposed SNS would not lead to environmental justice effects. The proposed SNS project would provide economic benefits through generating additional employment and income in the affected region (refer to Table 5.4.6.4-1). There would be increased traffic congestion; however, this effect would not disproportionately affect minority or low-income communities because traffic patterns would not be different between low-income and minority populations and the rest of the surrounding population (refer to Section 5.4.10.1). Overall, nothing from the construction and operation of the proposed SNS would pose high and adverse human health or environmental effects that would disproportionately affect minority or low-income populations.

5.4.7 CULTURAL RESOURCES

The SNS design team has not established the areas where construction or improvement of utility corridors and roads would be necessary to support the proposed SNS at ANL. In addition, the locations of ancillary structures such as a retention basin and a switchyard have not been determined. As a result, the effects of the proposed action on any cultural resources that may occur in these areas cannot be assessed at this time. If the proposed SNS site at ANL were chosen for construction, a cultural resources survey and an assessment of potential effects would be conducted prior to the initiation of construction-related activities in these areas. Appropriate measures would be implemented to mitigate any identified effects on cultural resources. These measures would include avoidance, where possible, or data recovery operations, including detailed recording of surface features and/or archaeological excavation.

5.4.7.1 Prehistoric Resources

No prehistoric archaeological sites have been identified on the proposed SNS site at ANL, but site 11DU207 is located adjacent to the perimeter of the proposed SNS site. This location may result in disturbance or destruction of the site by construction activities from the proposed SNS. Whether or not this would represent an effect on a significant cultural resource is unknown, because the eligibility of this site for listing on the NRHP has not been assessed by ANL. If it is eligible, construction of the proposed SNS may affect a prehistoric cultural resource. If it is not eligible, construction of the proposed SNS would have no effect on prehistoric cultural resources.

The eligibility of 11DU207 for listing on the NRHP would be assessed prior to the initiation of construction-related activities on the proposed SNS site at ANL if this site is selected for construction. If the site is eligible, appropriate measures would be implemented to mitigate effects. These measures would include avoidance, if possible, or archaeological excavation. As a result of these measures, the overall effects of the proposed action on prehistoric cultural resources would be minimal.

5.4.7.2 Historic Resources

The Historic Period buildings and features in the 800 Area at ANL would be destroyed by site preparation activities under the proposed action. However, they are less than 50 years old, and DOE does not consider them to be significant cultural resources. As a result, they are neither listed on nor considered eligible for listing on the NRHP. Therefore, their destruction would not represent an effect on cultural resources.

5.4.7.3 Traditional Cultural Properties

DOE Chicago Operations Office (DOE-CH) has found no Native American tribal representatives in the ANL area. Consequently, it has not been possible for DOE-CH to consult with them about the potential occurrence of TCPs on the proposed SNS site and at locations in its immediate vicinity. In addition, no Native American TCPs have been identified in the ANL area, and no Native American groups have expressed an interest in the occurrence and preservation of TCPs at ANL. As a result, it has been concluded that no TCPs occur on the proposed SNS site or anywhere else on laboratory land (White, B. 1998c: 1; Wescott 1998a: 1). Therefore, implementation of the proposed action would have no effect on TCPs.

5.4.8 LAND USE

The potential effects of the proposed action on land use in the vicinity of ANL, within the boundaries of ANL, and on the proposed SNS site are assessed in this section. The assessments cover potential effects on current land uses and zoning for future land use. Furthermore, the potential effects of the proposed action on parklands, nature preserves, major recreational resources, and visual resources are assessed.

5.4.8.1 Current Land Use

Current land use in the area surrounding ANL is driven by the relationship between existing land characteristics and socioeconomic forces acting at the local and regional levels. Similarly, current land use within the ANL boundaries results from selectively using the existing characteristics of the land to meet various DOE mission requirements. The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the basic land characteristics and other forces that influence land use in these areas. Consequently, implementation of the proposed action on the proposed SNS site in ANL would have no reasonably discernible effects on land use in the vicinity of ANL and throughout most of the laboratory area. However, current uses of the land within and near the proposed SNS site would be more subject to effects.

The current land use designations within the proposed SNS site are Ecology Plots (Nos. 6, 7, and 8), Support Services (minor laboratory support services operations in the 800 Area), and undeveloped Open Space. Furthermore, several contaminated sites are located within the perimeter of the proposed SNS site. They are Area of Concern (AOC) F and Solid Waste Management Units (SWMUs) 170, 736, and 744.

Construction of the proposed SNS facility would introduce large-scale development to areas of previously undeveloped Open Space and Ecology Plot land within the proposed SNS site utility corridors, and rights-of-way. Considering the density of current development at ANL, Ecology Plot and other Open Space land are in relatively short supply (refer to Figure 4.3.8.2-1). Nonetheless, it should be emphasized that ANL has virtually no other types of land for the construction of large-scale facilities.

DOE has a federally mandated role as trustee of the natural and cultural resources on its lands. Although some undeveloped trusteeship lands would be used for the proposed SNS, this use is necessary. Previously developed lands that meet project requirements are not present in sufficient quantities to meet all project needs.

The proposed action would have no effects on the use of land by environmental research projects. The land on and in the vicinity of the proposed SNS site is not being used for environmental research projects. The ecology plots at ANL are areas of land potentially suitable for ecological research. However, little, if any, ecological research has ever been conducted in these areas. There are no currently ongoing ecological research projects in Ecology Plot Nos. 6, 7, and 8 on the SNS site.

Construction of the proposed SNS facility would displace any remaining support services operations in the 800 Area, and it would result in demolition of the remaining buildings and features in this area. The current land use designations for the proposed SNS site would shift to a programmatic category specific to the facility or the Programmatic Mission—Other Areas category. These effects would be minimal, especially considering the long-established pattern of moving support services operations out of the 800 Area and demolishing area buildings.

Extensive earthmoving during construction of the proposed SNS would have the potential to destroy the SWMUs and AOC on the proposed SNS site. SWMUs 176 and 182, located adjacent to the proposed SNS site, could also be affected by these activities. If these areas are not remediated prior to the initiation of construction of the proposed SNS, contamination could be spread to currently uncontaminated areas (refer to Section 5.4.9.1). Realistically, site preparation and other construction activities could not be initiated on the proposed site until current environmental restoration concerns involving these AOCs and SWMUs are adequately addressed. These concerns include continuing characterization, site remediation, and dealing with already established plans to close SWMU 736 (800 Area Transformer Storage Pad) with an impermeable

RCRA cap. The prospects for adequately addressing these concerns between the timing of a possible decision to construct the proposed SNS on the selected site in ANL and the scheduled start date for SNS construction remain uncertain. If they cannot be addressed in this time frame, the construction schedule for the proposed SNS would be delayed. If they can be addressed within this time frame, a beneficial effect of the proposed action would be use of a partial brownfield site for a new research facility.

5.4.8.2 Future Land Use

The proposed SNS site is zoned for future use according to the following designations: Programmatic Mission—Other Areas, Programmatic Mission—200 Area, Ecology Plot No. 8, Open Space, and Support Services. Most of the site is within the first two zones, which are dedicated to new research facilities, laboratories, and offices. Operation of the proposed SNS would be consistent with this zoning. It would appear to be inconsistent with using a portion of Ecology Plot No. 8 and the Open Space, but the expansion of other land use zones into areas currently designated as Ecology Plots and Open Space has been a guiding principle behind the current zoning of ANL land. Therefore, use of these areas for the proposed SNS may be viewed as a logical extension of this planning principle. Use of the Support Services zone for the proposed SNS is clearly at variance with current zoning, but this zone is barely within the western boundary of the proposed SNS site. As a result, the amount of Support Services land used for the proposed SNS would be negligible.

Portions of the proposed SNS site would become contaminated with pollutants from operations. Current plans call for in situ decommissioning of the SNS when its operational life cycle is completed. As a result of in situ decommissioning, some contaminated components would remain in place on the SNS site. This could limit the future use of land on the site for other purposes. Construction and operation of the SNS could also limit the future use of land areas adjacent to the SNS site.

No future uses of SNS site and vicinity land for environmental research are planned. This includes the portions of Ecology Plot Nos. 6, 7, and 8 that would be adjacent to the proposed SNS site. As a result, the effects of the proposed action on future research projects cannot be assessed.

5.4.8.3 Parks, Preserves, and Recreational Resources

The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics that support park, nature preserve, and recreational land uses outside ANL and within the laboratory boundaries. Consequently, implementation of the proposed action on the proposed SNS site in ANL would have no reasonably discernible effects on these specific land uses: Forest Preserve District of Cook County (recreation on Saganashkee Slough, McGinnis Slough, and small lakes); hunting and fishing in Sawmill Creek and the Des Plaines River; recreational use of an area adjacent to the southwest boundary of ANL; Waterfall Glen Nature Preserve; and ANL Park.

5.4.8.4 Visual Resources

During construction and operations, the proposed SNS facilities would not be visible from points outside the Waterfall Glen Nature preserve because the preserve is heavily forested. Their close proximity to the west perimeter of ANL, which is adjacent to the nature preserve, would make them potentially visible from deep interior points within the preserve, especially on the west side during late autumn, winter, and early spring. The proposed SNS facilities would be visible from points within the laboratory boundaries.

5.4.9 HUMAN HEALTH

Construction and operation of the proposed SNS at ANL could pose a potential risk of adverse effects on the health of workers and of the public living in the vicinity of the facility. Potential adverse effects include

- Traffic-related fatalities and injuries to workers and the public.
- Occupational fatalities and injuries to workers.
- Exposure of workers and the public to radiation or radioactive materials.
- Exposure of workers and the public to toxic or hazardous materials.

This section evaluates the potential magnitude of these effects at ANL and the likelihood that they would occur during three phases or conditions:

- construction,
- normal operations, and
- accident conditions.

5.4.9.1 Construction

The potential effects on the health of construction workers, other ANL workers, and members of the public would be essentially the same for any of the proposed locations, because the size of the construction work force would be the same. Potential effects of construction of the SNS include construction accidents and traffic accidents.

On the basis of national traffic accident rates (1.74×10^{-8} fatalities per vehicle mile and 1.05×10^{-6} disabling injuries per vehicle mile) and the anticipated total mileage of commuting construction workers (2,074 person-years × 250 work days/person-year × 0.806 daily round-trips/worker × 20 miles/round-trip), less than one additional fatality and nine additional disabling injuries could occur as a result of increased commuter traffic during the 7-year construction period of the proposed SNS.

On the basis of national construction accident rates, 0.31 fatality (0.00015 fatalities/worker-year × 2,074 worker-years) and 110 disabling injuries (0.053 disabling injuries/worker-year × 2,074 worker-years) could occur as a result of occupational accidents during construction of the proposed SNS.

The size of the construction workforce would be the same at all of the proposed locations, and the number of traffic-related disabling injuries and fatalities would be expected to be the same; however, because the existing ANL work force is smaller than at ORNL and LANL, the relative increase would be greater. Based on data in Section 5.4.10.1, a maximum increase of approximately 9 percent could occur from the addition of the SNS construction workers to daily commuter traffic in the vicinity of ANL.

SNS construction workers at ANL would be exposed to the same risk of occupational injury or fatalities as construction workers at the other proposed locations, but ANL workers could be exposed to other additional risks. The preferred site for the proposed SNS at ANL is within the 800 Area (refer to Appendix B). A number of RCRA SWMUs are located within the 800 Area. Several of these SWMUs contain low levels of volatile organic compounds (VOC) and semi-volatile organic compounds and polychlorinated biphenyls (PCBs). Some radioactive materials may also be present. Construction activities such as excavation, grading, and filling could disturb these areas and expose workers to toxic materials.

5.4.9.2 Normal Operations

The number of SNS workers is independent of the location of the facility. The absolute number of industrial accidents and traffic-related injuries and fatalities would be expected to be essentially the same as at the other proposed locations.

On the basis of national traffic accident rates (0.0174 fatalities per million vehicle-mile and 1.05 disabling injuries per million vehicle-mile) and the anticipated total mileage of 60 million miles (375 commuting workers × 20 miles/trip × 0.806 trips/day × 250 days/year × 40 years), 1 additional fatality and 63 additional disabling injuries could occur as a result of increased commuter traffic during the 40-year operational life of the proposed SNS.

National industrial workplace accident rate data applied to the workforce for the proposed SNS would yield less than one fatality (3.4 deaths annually/100,000 workers × 375 workers × 40 years) and 500 disabling injuries (3,400 disabling injuries annually/100,000 workers × 375 workers × 40 years) occurring over the 40-year operational life of the proposed SNS.

The relative increase would be greater at ANL than at ORNL or LANL because ANL's smaller existing work force. Based on data shown in Section 5.4.10.1, the addition of the maximum of 375 SNS workers to the daily ANL traffic flow could increase the number of disabling injuries and fatalities by approximately 6 percent relative to existing rates.

The proposed SNS would generate and release direct radiation, radioactive materials, and toxic materials. Members of the public and workers at the proposed SNS facility and other adjacent facilities would be exposed to such radiation and emissions. The quantities and release rates of these materials would be the same as for other proposed locations. The impact of the ANL site-specific meteorology, distances to site boundaries, and population density and distribution are discussed in the following sections.

5.4.9.2.1 Radiation and Radioactive Emissions

This section assesses the potential effects of direct radiation and airborne emissions of radioactive materials from the proposed SNS based on the methods and dose-to-risk conversion factors discussed in Section 5.1.9.

Direct Radiation

Exposure of SNS workers to direct radiation from the proposed SNS at ANL would be expected to be the same as other proposed locations because the SNS Shielding Design Policy is applicable regardless of location.

The preferred location for the proposed SNS facility at ANL is near existing facilities that emit small amounts of direct radiation. As a result, dose to SNS workers could be slightly higher than under the LANL and ORNL alternatives. The difference, if any, would be on the order of a few mrem. The average total EDE to all ANL workers was 92 mrem in 1996 (DOE 1996f).

The preferred site for the proposed SNS facility at ANL is also relatively close to the site boundary at several points. Based on ANL monitoring results for 1996 that reflect the contributions of direct radiation from several major accelerator facilities (Golchert and Kolzow 1997), the potential increase in direct radiation levels at the ANL boundary, if any, would not be expected to be more than a few mrem/yr.

Radioactive Emissions

Radioactive emissions from routine operations of the proposed SNS would consist of releases to the atmosphere from two stacks—the Tunnel Confinement Exhaust Stack and the Target Building Exhaust Stack. Radionuclide activities in these emissions are listed in Table F-1 of Appendix F and are the same regardless of the facility location. Existing EPA-permitted commercial disposal facilities servicing ANL have sufficient capacity to accommodate LLLW and process waste from the proposed SNS, and these wastes would be processed in accordance with existing permits for these facilities.

The estimated annual doses to workers and the public from normal SNS airborne emissions are shown in Table 5.4.9.2.1-1. The methods and assumptions used in the calculation of doses are discussed in Section 5.1.9 and in greater detail in Appendix F.

Even under the conservative assumptions regarding the exposure pathways, these estimated doses would be in compliance with applicable regulations. The annual dose to the maximally exposed individual member of the public for operation at a 1-MW beam power (3.2 mrem) is 32 percent of the 10 mrem/yr limit (40 CFR Part 61), and the maximally exposed individual annual dose for operation at a 4-MW beam power (12 mrem) is 120 percent of the dose. Compliance with 40 CFR Part 61 is determined based on dose at locations actually occupied by people. The maximally exposed individual dose at such locations from existing operations at ANL is very low, only 0.021 mrem in 1996 (Golchert and Kolzow 1997). Because the dose of 12 mrem projected for SNS operations at 4 MW is based on a hypothetical receptor much nearer to the site, ANL would remain in compliance with the addition of emissions from the proposed SNS facility.

Dose at the ANL boundary from emissions from the Tunnel Confinement Exhaust is 0.14 mrem and is dominated by radionuclides in activated concrete dust. Dose at the ANL boundary from emissions from the Target Building Exhaust is dominated by ^{3}H (57 percent) with smaller contributions from ^{14}C, ^{125}I, and ^{203}Hg. These radionuclides are listed in order of decreasing dose and account for 99 percent of this component of the total individual dose.

To estimate the total consequences from SNS emissions of radioactive materials over the entire life of the facility, annual population dose is multiplied by operating life of the facility and by the dose-to-risk factor of 0.0005 LCFs/ person-rem. For 40 years of operation at 1 MW,

Table 5.4.9.2.1-1. Estimated annual radiological dose from proposed SNS normal emissions at ANL.[a]

Receptor	1-MW Power Level: Target Building[b]	1-MW Power Level: Tunnel Confinement[c]	4-MW Power Level: Target Building[b]	4-MW Power Level: Tunnel Confinement[c]
Maximum Individuals (mrem)				
Offsite Public[d]	3.1	0.14	12	0.12
Uninvolved Workers[d]	0.064	0.056	0.26	0.085
Populations (person-rem)				
Offsite Public[e] (8,176,177 persons)	20	0.13	79	0.13
Uninvolved Workers[e] (3,242 persons)	0.037	0.012	0.15	0.019

[a] Doses shown include the contributions of inhalation, immersion, and "ground shine" for workers and the offsite public and ingestion for the offsite public.

[b] Target Building emissions include hot offgas exhaust, primary confinement exhaust, secondary confinement exhaust from the target building, and activated air from the beam dump buildings.

[c] Tunnel confinement emissions include activated air and concrete dust from the linac tunnel, high-energy beam transport (HEBT) tunnel(s), ring tunnel(s), and ring-to-target beam transport tunnel(s).

[d] The maximally exposed individuals are hypothetical receptors. The member of the public is assumed to occupy a position at the ANL site boundary for 8,760 hr/yr and to produce their entire food supply at this location. The maximally exposed uninvolved worker is assumed to occupy a position within 1.2 mi (2 km) of the stack for 2,000 hr/yr.

[e] The offsite population consists of all individuals residing outside the ANL site boundary within 50 mi (80 km) of the site and is assumed to be present for 8,760 hr/yr. The involved/uninvolved worker population consists of all workers normally within 1.2 mi (2 km) of the facility. These workers are assumed to be present for 2,000 hr/yr.

0.4 LCFs would be projected. For 40 years at 4 MW, 1.6 LCFs would be projected. If the facility operated for 10 years at 1 MW and 30 years at 4 MW, 1.3 LCFs would be projected. These projected LCFs do not mean that any actual fatalities would occur as a result of SNS operations but provide a quantified magnitude for comparison to excess LCFs estimated for the other proposed locations.

5.4.9.2.2 Toxic Material Emissions

As discussed in Section 5.2.9.2.2, elemental mercury vapor is the only toxic material expected to be released from the proposed SNS under normal conditions. Based on the continuous annual release rate of 0.0171 mg/s and atmospheric dispersion factors specific to ANL, the maximum mercury concentration in areas that could be occupied by uninvolved workers would be 3.02×10^{-6} mg/m^3 in any 2-hr period and 3.51×10^{-7} mg/m^3 in any 8-hr period. These concentrations are at least 1/100,000th of the OSHA ceiling limit (0.1 mg/m^3) and the ACGIH recommended TLV-TWA (0.05 mg/m^3) for workers. The maximum average annual airborne mercury concentration at the site boundary would be 5.09×10^{-8} mg/m^3, 1/6,000th of the EPA Reference concentration for members of the public (0.0003 mg/m^3).

5.4.9.3 Accident Conditions

This section assesses the affects on human health of accidents that could potentially occur during operation of the proposed SNS at ANL.

5.4.9.3.1 Accident Scenarios

The accident scenarios and source terms for accidents that could potentially occur at the proposed SNS are the same for all alternative sites and are summarized in Table F-2 (refer to Appendix F). The details of these scenarios and source terms are provided in Appendix A. Table 3.2 defines the terminology used to describe the likelihood that a given accident could occur.

5.4.9.3.2 Direct Radiation

The frequencies of occurrence and consequences of accidents involving exposure to direct radiation have not been specifically analyzed. DOE's Shielding Design Policy for the proposed SNS is such that for the worst-case design-basis accident, the dose to the maximally exposed individual in an uncontrolled area would be limited to 1 rem and for a worker in a controlled area would be limited to 25 rem. The risks of this category of accidents would be the same for all proposed sites.

5.4.9.3.3 Radioactive Materials Accidents

DOE has performed a hazard analysis of potential accidents at the proposed SNS, and for those that could result in a release of radioactive material, it has estimated source terms. The DOE analysis is included as Appendix A. Accident scenarios, estimated frequencies of occurrence, and source terms are summarized in Table F-2 and are the same for all proposed SNS alternative sites. The methods used to evaluate the consequences of these accidents are discussed in Section 5.1.9 and in more detail in Appendix F.

Doses for these accidents, should they occur at an SNS facility at ANL, are listed in Table 5.4.9.3.3-1. With the exception of accident ID 16, all doses for accidents at a 4-MW facility would be four times higher than at a 1-MW facility. This is not the case for ID 16, the beyond-design-basis mercury spill, because of differences in the source term model (refer to Exhibit F of Appendix A). At 4 MW (ID 16b), some boiling of mercury is assumed, releasing a larger quantity of mercury than at 1 MW (ID 16a), where only evaporation is assumed.

The pattern of accident doses for the proposed SNS at ANL is similar to that for the other proposed locations. However, doses to individuals reflect the relative proximity of the proposed SNS to the ANL boundary, and population doses reflect the proximity to a major metropolitan area.

At a power level of 1 MW, the beyond-design-basis mercury spill accident (ID 16a) would have the highest dose of the potential accidents involving the target. The maximum dose to an individual in the offsite public would be 49 mrem and 28 mrem for the uninvolved worker. The population dose of 2,100 person-rem would correspond to 1.1 excess LCFs. There is less than a one in a million chance that this accident would occur in a given year at the proposed SNS.

At a power level of 1 MW, accidents involving the off-gas decay system (IDs 24 and 31) would

Table 5.4.9.3.3-1. Radiological dose for SNS accident scenarios at ANL.

				Maximum Individual (mrem) [a]				Population (person-rem) [a]			
				Offsite Public		Uninvolved Workers		Offsite Public		Uninvolved Workers	
ID	**Event**	**Frequency[b]**	**Source Term[c]**	**1 MW Beam**	**4 MW Beam**	**1 MW Beam**	**4 MW Beam**	**1 MW Beam**	**4 MW Beam**	**1 MW Beam**	**4 MW Beam**
A. Accidents Involving Proposed SNS Target or Target Components											
2	Major loss of integrity of Hg Target Vessel or piping (Appendix A, Section 3.3)	a) Unlikely	Percent Inventory Mercury Iodine 0.142 0.142	6.7	26.8	3.8	15.2	300	1,200	3.1	12.4
		b) Extremely Unlikely	Percent Inventory Mercury Iodine 0.243 100	21	84	9.0	36.0	1,300	5,200	7.3	29.2
8	Loss of integrity in Target Component Cooling Loop (Appendix A, Section 3.9)	a) Anticipated	Bounded by annual release limits[d]	<10	<10	NA	NA	NA	NA	NA	NA
		b) Anticipated	Gases + Mist + 150 L of D_2O	3.9	15.6	0.31	1.24	32	128	0.18	0.72
		c) Anticipated	18 L of D_2O	0.002	0.008	0.001	0.004	0.057	0.228	0.001	0.004
		d) Anticipated	Gases + Mist + 150 L of H_2O	3.6	14.4	0.27	1.08	13	52	0.15	0.6
16	Beyond-Design-Basis Hg Spill (Appendix A, Section 3.17)	a) Beyond Extremely Unlikely	1 MW Percent Inventory Mercury Iodine 1.11 100	49		28		2,100		22	
		b) Beyond Extremely Unlikely	4 MW Percent Inventory Mercury Iodine 1.28 100		3,100		880		230,000		710

Table 5.4.9.3.3-1. Radiological dose for SNS accident scenarios at ANL – (continued).

				Maximum Individual (mrem) [a]				Population (person-rem) [a]			
				Offsite Public		Uninvolved Workers		Offsite Public		Uninvolved Workers	
ID	**Event**	**Frequency[b]**	**Source Term[c]**	**1 MW Beam**	**4 MW Beam**	**1 MW Beam**	**4 MW Beam**	**1 MW Beam**	**4 MW Beam**	**1 MW Beam**	**4 MW Beam**
B. Accidents Involving proposed SNS Waste Systems											
17	Hg Condenser Failure (Appendix A, Section 4.1.1)	Anticipated	13.7 g mercury	0.013	0.052	0.004	0.016	0.6	0.24	0.004	0.016
18	Hg Charcoal Absorber Failure.[e] (Appendix A, Section 4.1.2)	Unlikely	14.8 g mercury	0.004	0.016	0.003	0.012	0.12	0.48	0.002	0.008
19	He Circulator Failure (Appendix A, Section 4.2.1)	Anticipated	1 day tritium production	<0.001	<0.001	<0.001	<0.001	0.012	0.048	0.001	0.001
20	Oxidation of Getter Bed (Appendix A, Section 4.2.2)	Unlikely	1 day tritium production	<0.001	<0.001	<0.001	<0.001	<0.012	0.048	0.001	0.001
21	Combustion of Getter Bed (Appendix A, Section 4.3.1)	Extremely Unlikely	1 year tritium production, 200 g depleted uranium	5.0	20.0	0.94	3.76	430	1,720	0.77	3.08
22	Failure of Cryogenic Charcoal Absorber [f] (Appendix A, Section 4.4.1)	Unlikely	1 day production of xenon	0.21	0.214	0.018	0.072	12	48	0.015	0.06
23	Valve sequence error in Tritium Removal System (Appendix A, Section 4.5.1)	Unlikely	1 year tritium production	4.8	19.2	0.90	3.6	410	1,640	0.74	2.96
24	Valve sequence error in Offgas Decay System (Appendix A, Section 4.5.2)	Anticipated	7 days xenon accumulation (1 decay tank)	14	56	2.3	9.2	1,100	4,400	1.9	7.6

Table 5.4.9.3.3-1. Radiological dose for SNS accident scenarios at ANL – (continued).

ID	Event	Frequency[b]	Source Term[c]	Maximum Individual (mrem)[a] Offsite Public 1 MW Beam	Maximum Individual (mrem)[a] Offsite Public 4 MW Beam	Maximum Individual (mrem)[a] Uninvolved Workers 1 MW Beam	Maximum Individual (mrem)[a] Uninvolved Workers 4 MW Beam	Population (person-rem)[a] Offsite Public 1 MW Beam	Population (person-rem)[a] Offsite Public 4 MW Beam	Population (person-rem)[a] Uninvolved Workers 1 MW Beam	Population (person-rem)[a] Uninvolved Workers 4 MW Beam
25	Spill during filling of tanker truck for LLLW Storage Tanks[g] (Appendix A, Section 4.5.3)	Anticipated	0.00005% of contents of LLLW Tank	<0.001	<0.001	<0.001	<0.001	0.001	0.004	<0.001	<0.001
26	Spray during filling of tanker truck for LLLW[g] (Appendix A, Section 4.5.4)	Anticipated	1.9 ml of LLLW	<0.001	<0.001	<0.001	<0.001	0.003	0.012	<0.001	0.001
27	Spill during filling of tanker truck for Process Waste Storage Tanks[g] (Appendix A, Section 4.5.5)	Anticipated	51,100 L Process Waste to surface water + 57 L to atmosphere	See footnote "h"		See footnote "h"		See footnote "h"		See footnote "h"	
28	Spray during filling of tanker truck for Process Waste[g] (Appendix A, Section 4.5.6)	Anticipated	28.4 L of Process Waste	See footnote "h"		See footnote "h"		See footnote "h"		See footnote "h"	
29	Offgas Treatment pipe break (Appendix A, Section 4.6.1)	Unlikely	24 hrs xenon production	2.2	4.4	0.14	0.56	91	364	0.12	0.48
30	Offgas Compressor Failure (Appendix A, Section 4.6.2)	Unlikely	1 hr xenon production	0.24	0.96	0.017	0.174	14	56	0.015	0.06
31	Offgas Decay Tank Failure (Appendix A, Section 4.6.3)	Extremely Unlikely	7 days xenon accumulation	14	56	2.3	9.2	1,100	4,400	1.9	7.6
32	Offgas Charcoal Filter Failure (Appendix A, Section 4.6.4)	Unlikely	7 days iodine production	0.31	1.24	0.021	0.084	3.4	13.6	0.015	0.06

Table 5.4.9.3.3-1. Radiological dose for SNS accident scenarios at ANL – (continued).

				Maximum Individual (mrem) [a]				Population (person-rem) [a]			
				Offsite Public		Uninvolved Workers		Offsite Public		Uninvolved Workers	
ID	Event	Frequency[b]	Source Term[c]	1 MW Beam	4 MW Beam	1 MW Beam	4 MW Beam	1 MW Beam	4 MW Beam	1 MW Beam	4 MW Beam
33	LLLW System piping failure. (Appendix A, Section 4.6.5)	Unlikely	0.00005% of contents of LLLW Tank	<0.001	<0.001	<0.001	<0.001	0.001	0.004	<0.001	<0.001
34	LLLW Storage Tank Failure (Appendix A, Section 4.6.6)	Extremely Unlikely	0.00005% of contents of LLLW Tank	<0.001	<0.001	<0.001	<0.001	0.001	0.004	<0.001	<0.001
37	Process Waste Storage Tank Failure (Appendix A, Section 4.6.9)	Extremely Unlikely	57 L to atmosphere	See footnote "h"		See footnote "h"		See footnote "h"		See footnote "h"	

[a] Unless otherwise indicated, radiological doses are based on radiological source terms for a 1-MW power level and would be four times greater if the facility is operating at 4 MW. These doses are total EDEs and include dose from inhalation and immersion. "Offsite" means outside the site boundary rather than outside the proposed SNS facility boundary. Individual receptors are hypothetical and do not correspond to any actual person. Population receptors are based on the actual number of people residing outside the site boundary and within 50 mi (80 km) of the facility and the number of site workers normally within 1.2 mi (2 km) of the facility and not involved in facility operation.

[b] See Table 5.2.9-2 for the numerical ranges associated with accident frequencies categories.

[c] Source terms are expressed in units that are independent of power level. Except for beyond-design-basis accidents (IDs 16a, 16b), the radioactivity released in accidents at 4 MW is four times that released at 1 MW.

[d] 40 CFR 61 limits dose to members of the public from airborne emissions from DOE facilities to 10 mrem/yr.

[e] Installation of sulfur-impregnated charcoal filters is being considered to serve as a "polishing filter" for the mercury condenser (refer to Event 17).

[f] Cryogenic charcoal absorbers are being considered as an alternative to the offgas compressor, decay storage tanks, and ambient temperature charcoal filters (refer to Events 24, 30, 31, and 32).

[g] Accidents involving tanker trucks may not be applicable for the proposed SNS facility at this site. It has not been determined how LLLW and process waste would be treated and disposed.

[h] Process waste accidental airborne releases occur at ground level. Only atmospheric dispersion factors for elevated releases were calculated for this site. Based on the radionuclide contents of LLLW and process waste source terms and results for ORNL, doses for process waste accidents at this site are anticipated to be approximately 0.001 mrem or less for individuals and to be less than approximately 0.050 person-rem for the offsite population.

NA - Not available.

result in the highest individual and population doses of any potential accidents involving waste handling systems. The potential dose to the maximally exposed member of the public for these two accidents is 14 mrem and 2.3 mrem for the maximally exposed uninvolved worker. Dose to the maximally exposed member of the public is approximately 5 percent of the 300 mrem/yr received by the average person from natural background. The worker dose is 2.5 percent of the average dose received by workers from normal operations at ANL (DOE 1996f). The population dose of 1,100 person-rem corresponds to 0.5 LCFs. The fact that accident ID 24 is "anticipated" but could easily be mitigated is discussed in Section 5.2.9.3.3

At a power level of 4 MW, the potential consequences of all accidents, except ID 16, would increase by a factor of four. For the "beyond extremely unlikely" mercury spill (ID 16b), dose to the maximally exposed member of the public would be 3,100 mrem and 880 mrem to the maximally exposed uninvolved worker. The dose to the maximally exposed member of the public is slightly more than 10 times the annual dose from natural background radiation and corresponds to a risk of LCF of about 1 in 625 chances (0.0016 LCFs).

The dose to the maximally exposed individuals from the offgas decay system accidents (ID 24 and 31) would be 55 mrem for the public individual, about 20 percent of the annual dose for natural background, and 9.3 mrem for the uninvolved worker.

Because of the large offsite population and the assumptions underlying the use of dose-to-risk factors, the quantified adverse effects are large for four accidents should they occur at a power level of 4 MW. The accident with the greatest potential consequences is the beyond-design-basis mercury spill (ID16b). The population dose of 230,000 person-rem corresponds to 120 LCFs. The probability that this accident would occur in a given year is less than one chance in a million. Another mercury spill accident (ID 2b) also has large quantified adverse health effects in the offsite population. The population dose for this accident of 5,400 person-rem corresponds to 2.7 LCFs. The probability that this "extremely unlikely" accident would occur in a given year is between 1 chance in 10,000 and 1 chance in 1,000,000.

The two accidents involving the offgas decay system (IDs 24 and 31) have the same emission source term and also would have the potential for adverse effects in the offsite population. The population dose of 4,300 person-rem corresponds to 2.1 LCFs. Accident ID 31 is "extremely unlikely," and Accident ID 24 is "anticipated." Section 5.2.9.3.3 discusses several simple actions that could be taken that would reduce the frequency of occurrence of Accident ID 24 to "unlikely."

As discussed in Section 5.2.9.2.1, LCF values of 1.0 or greater do not mean that fatalities would actually occur in the offsite population but provide a quantified value for use in comparison between alternatives.

5.4.9.3.4 Hazardous Materials Accidents

Accidents involving potential exposure to toxic materials are discussed in Section 5.2.9.3.4. All involve spills of irradiated mercury. Accident IDs 2b, 16a, and 16b could result in the OSHA ceiling concentration of 0.1 mg/m^3 being exceeded for a few minutes during the initial stages of these accidents in locations accessible to workers, but it would not be exceeded at or beyond the ANL site boundary. Thus for only a few minutes at the start of the accident, mercury concentrations at or beyond the site boundary might exceed TEEL-1 limit (0.075 mg/m^3) but would not exceed the TEEL-2 limit (0.10 mg/m^3); individuals at the boundary at the precise occurrence of the initial emission might perceive an odor but would not experience or develop irreversible health effects or symptoms that could impair the ability to take protective action.

The second and third stages of these accidents are conservatively assumed to last from 7 to 30 days, while in reality, administrative and emergency response actions would more probably terminate the release in a shorter time period. During these stages, airborne concentrations of mercury would remain two to three orders of magnitude below the TEEL-0 limit of 0.05 mg/m^3, and no observable detrimental effects would be expected to occur.

5.4.10 SUPPORT FACILITIES AND INFRASTRUCTURE

This section summarizes the facilities and infrastructure effects on ANL transportation and utility systems from construction and operation of the proposed SNS.

5.4.10.1 Transportation

As described in Section 3.2.5, Alternative Sites, construction of the proposed SNS, related infrastructure, and support systems would occur at ANL, located in DuPage County, Illinois, approximately 30 mi (48 km) from Chicago. ANL is bordered on the north by I-55, on the east by State Highway 83, and on the south by State Highway 171, which intersects with Lemont Road. Lemont Road runs north-south on the western border of the site.

Approximately 32 mi (51 km) of roadway are present within ANL, including the access roads to Cass Avenue and Lemont Road. The site is accessed via three entrances: the main (north) gate, the west gate, and the east gate. Westgate Road is the primary entrance for employees coming from the west. Westgate is a two-lane paved road that currently handles mostly automobile traffic with intermittent heavy truck traffic; it is also capable of handling construction traffic. As of 1994, no marked difficulties were apparent for onsite traffic at any location, either during peak periods of arrival and departure or during midday work hours (ANL 1994). Also, according to Illinois DOT standards, vehicle accumulation at intersections and gates is minor, even during peak hours.

In 2002, the population of the ANL site is projected to be 6,800. Only 15 percent (930 people) of current employees participate in carpools; the remainder travel in single-occupant cars (ANL 1994). Using these data, daily vehicle round-trips were calculated to be 6,290. The *1994 Laboratory Integrated Facilities Plan for ANL* provides the basis for the population projections in Table 5.4.10.1-1.

The 800 Area is the location within ANL that most closely matches the site for the proposed SNS. The footprint for the proposed SNS at this location, however, overlays Westgate Road. Approximately 1 mi (1.6 km) of the existing Westgate Road would be relocated to the north in order to circumvent the proposed SNS site and replace the existing Westgate Road access. For purposes of this analysis, it is assumed that the relocation of Westgate Road would precede other construction activities, thereby avoiding

Table 5.4.10.1-1. Long-range site population projections.

	1994	1999	2004	2009	2014
ANL	5,700	6,200	6,400	6,800	7,120
DOE	500	500	500	500	500
TOTAL	6,200	6,700	6,900	7,300	7,620

Source: *1994 Laboratory Integrated Facilities Plan for ANL.*

regular ANL employee traffic into the facility during construction of the proposed SNS. It is further assumed that the “old” Westgate Road would be dedicated to construction vehicles transporting necessary concrete, steel, and related building materials.

Construction employee and vehicular activity would increase during the first years of construction, peaking in 2002, and would decrease significantly during the last year (2004) of construction. The estimated total of 578 construction employees in the peak construction year (2002) is expected to add approximately 466 daily round-trips and 10 material/service trucks to projected site traffic of 6,290 round-trips. This seven percent increase is considered to be below a level of significance and, therefore, would not result in significant short-term (construction) traffic effects on the site and/or adjacent area. However, the nature of the construction vehicles, given their size and speed, would affect traffic composition and may affect the flow of vehicles approaching/exiting the ANL site during construction. The implementation of mitigation measures, as described in Section 5.11, would minimize such adverse effects.

After construction, operation of the proposed SNS would result in an additional 250 resident/visiting scientists by 2006, plus another 125 employees during future facility upgrades, expected approximately 5 years (2011) after operations begin. The long-term total of an additional 375 people and 3 service trucks/day (305 round-trips) is not expected to exceed the *Laboratory Integrated Facilities Plan* projection of approximately 7,500 people in 2011. Therefore, no significant, long-term effects would be expected on the transportation infrastructure from operation of the proposed SNS on the ANL site.

Table 5.4.10.1-2 compares the No-Action Alternative with the proposed action located at the ANL site. The table provides the percentage increase in traffic resulting from the proposed SNS during construction and operation as compared to the No-Action Alternative. The table also provides the percentage increase using existing site data as well as projected data for the site. The potential effects of traffic increases could be reduced by having craft and non-craft workers report to work at different times, thus reducing the adverse effects on traffic flow during rush hours. Additionally, this analysis assumed there would be no transferring of personnel from within ANL. If some of the workers were previously working at ANL, the impact of the traffic would be reduced.

5.4.10.2 Utilities

This section assesses the potential environmental consequences of the proposed SNS on utilities and utility infrastructure at ANL.

Table 5.4.10.1-2. ANL traffic increases compared to No-Action Alternative.

	Baseline/ No-Action	(Peak Year) SNS Construction	(4 MW) SNS Operation
Passenger vehicle trips[a]/day	6,290	466	302
Material transport trucks/day	0	7	0
Service trucks/day	0	3	3
Total (% increase)	0 (0%)	476 (7%)	305 (5%)

[a]Based on 6,800 ANL employees in 2002.

5.4.10.2.1 Electrical Service

As described in Section 3.2.3.4, the proposed SNS would require large supplies of electrical power for operation. The ANL site's existing 138-kV lines would not be adequate for SNS loads (Fornek 1998a). An actual capacity of 50 MW is available from substation 549A. It is expected that this would be adequate for the 63-MW connected load for the proposed 1-MW SNS. Based on ANL's experience with the APS power requirement estimates, this would probably also satisfy the 4-MW connected case.

The location of the proposed SNS at ANL would require a 6,600-ft (2,012-m) 138-kV overhead line to connect the SNS facility to substation 549A. The route for the 138-kV line would be from substation 549A to Southwood Drive, following Outer Circle Road west to Watertower Road and west to the 800 area. If additional capacity beyond the available 50 MW is required, it would be necessary to coordinate with Commonwealth Edison to determine the best way to provide power to the site. Environmental effects of the proposed SNS on electrical supply are expected to be negligible.

5.4.10.2.2 Steam

The proposed SNS would not necessarily require steam for facility heating, but at ANL heating would be provided by steam. ANL currently uses steam for central heating and steam turbine-driven emergency generators. Approximately 1,500 ft (457 m) of additional steam piping would be required to connect the proposed SNS facility with the current steam distribution system (Fornek 1998a). APS use is approximately 60,000 lb/hr. It is expected that the proposed SNS would use about the same amount. ANL can accommodate approximately 300,000 lb/hr of additional steam demand. Therefore, environmental effects on steam supply from the proposed SNS are expected to be inconsequential.

5.4.10.2.3 Natural Gas

Natural gas would provide energy for operational equipment such as boilers and localized unit heaters in the SNS heating system. As described in Section 4.2.10.2.2, natural gas at ANL is distributed from a nearby, high-pressure main and is used in laboratory areas, boilers, and furnaces not served by the central steam heating system. Natural gas lines at the ANL site are scheduled for upgrade in 1999. It is expected that any capacity increases and/or line extensions associated with the proposed SNS could be incorporated into the upgrade (Fornek 1998a). Thus, effects on natural gas supply and distribution are expected to be minor.

5.4.10.2.4 Water Service

The proposed SNS would require water supplies for the following systems: tower water cooling, deionized cooling, chilled water, building heating, process water, potable water, demineralized water, fire suppression, and target moderators.

The potable domestic water supply at the ANL is purchased from the local water district and is capable of meeting the proposed SNS demand. The remaining capacity of nonpotable water is approximately 2 mgpd (7.6 million lpd) (Fornek 1998a). Estimated peak use of water for the proposed SNS at 1 MW and the fully upgraded facility at 4 MW is expected to be 800 gpm (3,028 lpm) and 1,600 gpm (6,057 lpm), respectively. ANL has adequate existing capacity to treat process wastewater. ANL currently treats 300,000 gpd (1,135,620 lpd) in a treatment system with over a 1-mgpd (3.8-million-lpd) capacity. It is expected that ANL would be able to meet all water requirements for the proposed SNS facility with negligible environmental effects.

5.4.10.2.5 Sewage Treatment

ANL has approximately 500,000 gpd (1,892,700 lpd) of additional sanitary waste capacity. The proposed SNS project would require 12,500 gpd (473,175 lpd) for the 1-MW facility and 18,150 gpd (68,705 lpd) for the fully upgraded 4-MW facility. Therefore, ANL would be able to provide sewage treatment for the proposed SNS. Environmental effects of the proposed SNS on sewage treatment at ANL are expected to be inconsequential.

5.4.11 WASTE MANAGEMENT

All of the wastes generated during construction and operation of the proposed SNS would be transported to ANL for processing. The existing waste management systems at ANL have sufficient capacity to accommodate the proposed SNS waste streams. Therefore, DOE anticipates only minimal effects on ANL waste management systems.

Projections of construction and operations waste streams that would be generated at the proposed SNS include the following: hazardous waste, LLW, mixed waste, and sanitary/industrial waste, as listed in Table 3.2.3.7-1. A summarization of existing waste management facilities located at ANL, along with facility design and/or permitted capacities and remaining capacities, can be found in Table 5.4.11-1. Waste stream forecasts for ANL’s individual operations, the proposed SNS operations at 4 MW, and the aforementioned wastes are also included in Table 5.4.11-1. These forecasts cover the period from 1998 to 2040, unless otherwise noted. They are based on estimates provided by ANL Waste Management Operations and waste management documentation.

Before wastes from the proposed SNS facility would be accepted for TSD at ANL, they would be certified to meet the WAC of the receiving TSD facility. As mentioned earlier in Section 5.2.11, AEA, EPA, and NRC limits for LLLW treatment facility WAC would also need to be addressed for ANL.

Table 5.4.11-1. ANL waste management facility description and capacities.

Waste Disposition	Waste Type and Facility	Total Design Capacity for ANL Site	ANL Waste Projections for 1998-2040	Total Remaining Capacity for ANL Site (Excludes Proposed SNS Operations)	Proposed SNS Waste Operations Projections for 1998-2040	Potential Effect on Waste Management Facility
HAZARDOUS WASTE						
TREATMENT	None					
STORAGE	Solid/Liquid a) Bldg. 306 (Central Waste Management Facility) b) Bldg. 325C	Permitted Capacity a) 67 m^3 b) 6 m^3	115 m^3/yr	a) 67 m^3 new facility b) 6 m^3 new facility	40 m^3/yr	No effect anticipated. DOE has contracts in place for disposal of hazardous wastes.
LOW-LEVEL WASTE						
TREATMENT	Liquid a) LLLW Treatment Facility b) Process Waste Treatment Facility (PWTF)	a) LLLW Treatment Facility has two 3.5 m^3/day evaporators. (2,500 m^3/yr) b) PWTF – 1.38E5 m^3/yr	a) LLLWTF 57 m^3/yr b) PWTF 412,600 m^3/yr	a) One 3.5 m^3/day evaporator not currently used. b) 1.0E6 m^3/yr	a) Hazardous Liquid 175,600 gal/yr b) Process Liquid potentially hazardous 4.16E06 gal/yr	a) No effect anticipated. b) No effect anticipated. Tritium discharge would increase from 0.75 Ci/yr to 40 Ci/y.
	Solid Compaction Shredding Facility	Shredder Capacity HEPA filters only, 14 filters/day. Compactor Capacity 50 drums/day	Solid Low-Level Waste Projection at 232 m^3/yr	NA	Solid 1,026 m^3/yr	No effect anticipated. Treatment can be extended for greater capacity; personnel resources can be increased.
STORAGE	Solid Area 398	Permitted Capacity 30 m^3	232 m^3/yr	30 m^3	(Not compacted)	No effect anticipated. DOE has contracts in place for disposal of LLW as generated.

Table 5.4.11-1. ANL waste management facility description and capacities (continued).

Waste Disposition	Waste Type and Facility	Total Design Capacity for ANL Site	ANL Waste Projections for 1998-2040	Total Remaining Capacity for ANL Site (Excludes Proposed SNS Operations)	Proposed SNS Waste Operations Projections for 1998-2040	Potential Effect on Waste Management Facility
MIXED WASTE						
TREATMENT	Liquid a) Metal Precipitation Filtration Unit b) Chemical/Photo Oxidation Unit c) Mixed Waste Immobilization/ Macro-Encapsulation Unit	Permitted Capacities a) 0.4 m^3/day b) 0.2 m^3/day c) 2 m^3/day	Combined Liquid/Solid Mixed Waste Projection at 9 m^3/yr Combined Liquid/Solid Hazardous Waste Projection at 205 m^3/yr	NA	Liquid 10 m^3/yr (approximately 0.04 m^3/yr)	No effect anticipated. Design capacity is much greater than anticipated volumes. If necessary, permitted volumes can be increased. DOE has contracts in place to dispose of mixed waste as generated.
	Solid a) Alkali Metal Passivation Booth b) Dry Ice Pellet Decontamination unit	Permitted Capacity a) 40 pds/hr b) 500 pds/hr	0.1 m^3/yr 15,000 lb/yr	NA	Solid 7.3 m^3/yr	
STORAGE	Solid/Liquid a) Mixed Waste Storage Facility b) Bldgs. 306, 317; 329, 374A	Permitted Capacity a) 196 m^3 b) 182 m^3	215 m^3/yr	NA	NA	
SANITARY WASTE						
TREATMENT	Liquid Waste Water Treatment Facility	500,000 gpd	350,000 gpd	150,000 gpd	18,000 gpd	No effect anticipated.
DISPOSAL	Solid Offsite landfills	N/A	NA	NA	1,349 m^3/yr	No effect anticipated.

Sources: DOE-CH 1995; Grandy 1997; Fornek 1998a; Fornek 1998b.
NA - Not applicable.

Currently, no hazardous waste treatment or disposal facilities are located at ANL. Hazardous wastes are collected and sent quarterly to a commercial vendor. ANL handles about 30,000 gallons of chemical waste per year, excluding asbestos. The additional 10,800 gallons of hazardous waste generated by the SNS facility would not be a problem for the facility.

No LLW disposal facilities are located at ANL. These wastes are collected, certified, and shipped to permitted commercial disposal facilities or the DOE Hanford site (Fornek 1998b).

The mixed waste treatment and storage units for ANL are listed in Table 5.4.11-1. Currently, there are no mixed waste disposal facilities at ANL. Mixed wastes are collected and stored onsite pending treatment or shipment. Wastes are stored onsite until an offsite disposal facility can be determined (DOE-CH 1995).

ANL has a waste certification process in place to ensure that wastes meet the WACs for LLW disposal. However, because of the uncertainty of the composition of LLW and mixed wastes that may be generated from operation of the SNS, the waste may not meet the current WAC for waste management facilities at ANL. DOE would take action to ensure the proper disposition of these wastes. For example, pretreatment of the wastes may ensure that they meet the WAC. DOE may be able to amend the license at current waste disposal facilities to allow acceptance of wastes from the SNS.

Excess soil, construction wastes, and sanitary wastes would be generated during construction of the proposed SNS. Excavated soil and rock would be used for backfill, erosion control, or other environmental purposes. Construction debris would be sent to a Class IV landfill. Liquid sanitary wastes would be transported to the ANL sanitary wastewater treatment plant. Solid sanitary waste would be sent to a sanitary landfill (ORNL 1997b).

As stated in Section 5.2.11, in accordance with the *NSNS Waste Minimization and Pollution Prevention Plan*, considerations for minimizing the production of the SNS facility waste would be implemented.

5.5 BROOKHAVEN NATIONAL LABORATORY

This section describes the potential environmental effects or changes that would be expected to occur at BNL if the proposed action were to be implemented. Included in this discussion are the potential effects on the physical environment; ecological and biological resources; the existing social and demographic environment; cultural, land, and infrastructure resources; and human health.

5.5.1 GEOLOGY AND SOILS

Potential effects on geology and soils from construction and operation of the proposed SNS at BNL are described in this section.

5.5.1.1 Site Stability

The proposed SNS site at BNL is stable and would provide excellent foundation support for the SNS. Other large-scale buildings and structures such as the High Flux Beam Reactor (HFBR), the Alternating Gradient Synchrotron, the 200 MeV Linear Accelerator, and the

National Synchrotron Light Source have been built at BNL without encountering significant site stability problems. No effects are anticipated from site stability.

5.5.1.2 Seismicity

BNL is in an area of relatively quiet seismic activity (refer to Figure 4.3.1.4-1). The proposed SNS would be constructed at BNL to meet DOE Standard 1020-94 (DOE 1996a) and would be capable of withstanding maximum horizontal ground accelerations of 0.12 gravity for a return period of 500 years, of 0.15 gravity for a return period of 1,000 years, of 0.19 gravity for a return period of 2,000 years, and of 0.30 gravity for a return period of 10,000 years. The particle beam for the proposed SNS facility would be designed to shut down immediately in the event of an earthquake. As such, predictable seismicity at BNL would have no effect on construction, operation, or retirement of the proposed SNS.

5.5.1.3 Soils

Excavation required for construction of the proposed SNS would disturb native soils. Excavated soils would be stockpiled according to soil type and horizon. If the excavated soils possess the proper characteristics, they would be used to construct the shielding berm. Otherwise the soils would be placed in the spoils area (refer to Section 3.2.5.5). Topsoil removed during excavation would be used for grading and landscaping of the site at the finish of construction.

Construction of the SNS would require removal grading of the site and removal of vegetative cover. As a result, the potential exists for soil erosion and stream siltation, especially during periodic storm events. Best management practices would be followed to minimize the impacts of erosion during construction activities. Section 3.2.2.3, Site Preparation, discusses the elements (retention basin, silt fences, temporary storm water drainages, etc.) that would follow an erosion control plan to prevent erosion and siltation of the Peconic River.

The proposed SNS at BNL would most likely be designed with a cut-and-fill approach, providing sufficient amounts of fill material for the shield from within the proposed SNS site. If additional soils are needed, then fill would be obtained from firebreak areas around BNL. Excess spoil material would be stored in the BNL transfer station area. The future supply of fill material would not be affected by construction of the proposed SNS.

Operation of the proposed SNS would affect soils within the shield berm surrounding the linac tunnel (refer to Section 5.2.1.3). Site-specific calculations of nuclide concentrations and transport potential have not been performed for BNL. Importantly, the soils at BNL are primarily composed of quartz sand (SiO_2) and possess little of the retardation capacity normally seen in clay-rich soils or soils with high organic carbon content. The resultant migration rates offer a higher potential for exposure to nuclides.

5.5.2 WATER RESOURCES

Potential effects on water resources from construction and operation of the proposed SNS at BNL are described in this section. Best management practices would be employed to minimize any effects on surface water from erosion and siltation during construction (see Section 5.2.1.3).

5.5.2.1 Surface Water

No surface water resources would be used to support operations at the proposed SNS site. Potable water would be supplied by groundwater wells within BNL.

Conventional cooling tower blowdown for the proposed SNS facility would be discharged into the headwaters of the Peconic River. Because there is no sustained flow in this portion of the river, this release would be to the same headwaters reach as the sewage treatment plant (STP). Compared to an average daily contribution of 0.66 mgpd (2.5 million lpd) for the STP, the proposed SNS facility would add about 0.36 to 0.50 mgpd (1.4 to 1.9 million lpd) to the river flow depending upon the facility size (2 or 4 MW). Currently, flow within the headwaters of the Peconic River infiltrates into the subsurface before reaching the boundary of BNL. It is unlikely that the addition of SNS discharge would create sustained offsite flow.

Cooling tower discharges would be temporarily held within a retention basin before release to the Peconic River. This basin would be designed to allow sufficient residence time for the discharge to cool to ambient temperatures. If necessary, active cooling systems such as recirculating fountains may be employed. Polyphosphonates for antiscaling and ozone as a biocide would be used in the cooling towers. Discharge from the towers would be regulated to contain about four times the dissolved solids content of potable water (i.e., 1,000 to 1,200 mmhos/cm conductivity). Contributions of solids or chemical agents are not anticipated to significantly affect the stream. Flow at the BNL boundary is monitored under an existing NPDES permit and is required to meet permitted standards when it is present. Effects on surface water resources would be expected to be negligible.

5.5.2.2 Flood Potential and Floodplain Activities

The SNS at BNL would not encroach upon the 100-yr floodplain at the Peconic River. Additional flow of 0.36 to 0.50 mgpd (1.36 to 1.9 million lpd) would not impact the delineation of the floodplain within BNL. By comparison, a 1995 project to upgrade the STP would have involved the discharge of 1 mgpd (3.8 million lpd) into the onsite headwaters of the Peconic River. This project received New York State Department of Environmental Conservation (NYSDEC) approval and was found consistent with Executive Order 11988 (Floodplain Management) and all aspects of Executive Order 11990 (Protection of Wetlands). However, the project was eventually reengineered to exclude discharges to the Peconic River. This reengineering was prompted by concerns over the discharge of slightly contaminated groundwater and not floodplain delineation issues (Naidu et al. 1996: 2-45). The project has since been completed with no discharges to the Peconic River.

5.5.2.3 Groundwater

All of Long Island's drinking water supply comes from the Upper Glacial Aquifer, which underlies the island. BNL uses roughly 2,000 gpm (7,570 lpm) of groundwater to meet potable water needs plus heating and cooling requirements. Additional demands of up to 1,600 gpm (6,057 lpm) would be created by the proposed 4-MW SNS facility. Currently, three wells are in the vicinity of the proposed SNS site. Each well is capable of producing approximately 1,200 gpm (4,542 lpm). No effects on the supply or capacity of the water system at BNL are anticipated.

The SNS is proposed to be a high-energy linear accelerator potentially creating more abundant nuclides in the soil than the Alternating Gradient Synchrotron (AGS) Facility. Although transport calculations for BNL have not been performed, characteristics of the groundwater system at BNL would make this site more susceptible than the one at ORNL to effects on groundwater from radionuclide contamination. At the proposed location, the SNS would sit about 20 ft (6.1m) above the groundwater table, if built at natural grade. Using a cut-and-fill approach, the tunnel and ring structures, as well as the activated soils, would be in close proximity to the water table. Because of high permeability, vertical transport rates in these sandy soils can approach 17 ft/yr (5.2 m/yr). Thus, radionuclide contamination of groundwater would be an important potential effect of the proposed SNS facility operations.

At the AGS, only ^{3}H and ^{22}Na have sufficient half-life durations to pose a problem (DOE-BNL 1994b). Calculated dilution reduces exposure estimates to offsite receptors to below levels of concern. If comparable dilution factors can be applied to the SNS releases, then radionuclide concentrations would not be transported offsite at levels of concern. Limited effects may be expected for groundwater quality in the immediate vicinity of the proposed SNS.

Because BNL sits atop a sole source aquifer for Long Island's water supply, mitigation measures would include the construction of a multilayer shielding berm to reduce nuclide diffusion and migration (refer to Section 3.2.2.9). In addition, routine groundwater sampling at the proposed SNS facility would be implemented to ensure that radionuclide concentrations are within acceptable limits around the linac tunnel.

5.5.3 CLIMATOLOGY AND AIR QUALITY

Potential effects on the climate and air quality from construction and operation of the proposed SNS at BNL are described in this section.

5.5.3.1 Climatology

Construction and operation of the proposed SNS would not affect regional or localized climates within the BNL area.

5.5.3.2 Air Quality

Impacts on nonradiological air quality are presented in this section. Airborne radiological releases are evaluated under human health impacts (Section 5.5.9). Construction activities would create temporary effects in regard to particulate matter (PM_{10}) measurements during the construction phase of the proposed SNS project. This effect would be greatest during early clearing and excavation efforts but would decrease within a relatively short time period. This level is predicted to be minimal when weighted over the usual 24-hr averaging period.

The primary nonradiological airborne release during operations at the proposed SNS would be combustion products from the use of natural gas. Emission rates related to the maximum period of natural gas usage are listed in Table 5.2.3.2-1. This location is also considered flat, and projected air quality impacts from natural gas usage would be as shown in Table 5.5.3.2-1. Adding maximum background concentrations to maximum projected impacts from the SNS

Table 5.5.3.2-1. Impact of natural gas combustion at the proposed SNS.

NAAQS Compound	Period[a]	Estimate (μg/m³) at 984 ft (300 m)	Maximum Concentration[b]	Assumed Background (μg/m³) (Table 4.4.3.3-1)	Background + 300 m Location (μg/m³)	NAAQS Limits (μg/m³)
Sulfur dioxide	Annual[c]	0.03	0.05	—	—	80
(SO_2)	24-hr	0.30	0.60	77.0	77.3	365
	3-hr	0.70	1.40	225.7	226.4	1,300
Carbon	8-hr	21	40	6,738	6,759	10,000
monoxide (CO)	1-hr	30	57	8,016	8,046	40,000
Nitrogen dioxide (NO_2)[d]	Annual[c]	5.0	9.0	49.6	54.6	100
Particulate	Annual[c]	0.60	1.10	—	—	50
(PM_{10})	24-hr	6.80	13.30	57.0	63.8	150

[a] Factors used to convert from 1-hr averages to long periods taken from EPA 1977.
[b] Concentration at 984 ft (300 m) estimated boundary and maximum concentration [occurring at 174 ft (53 m)] estimated by EPA – Screen 3 Model (v. 96043). Maximum concentration location is expected to be "onsite."
[c] Annual concentrations reflect 33% estimated (conservative) annual usage factor.
[d] Estimated concentration in this table includes all NO_x compounds and not only NO_2 for NAAQS.

sources (a very conservative procedure because the two do not occur at the same location or time) also does not provide any violations of the NAAQS.

Five 200-kW generators would be tested for short durations several times a year. Emissions from these generators are rated at 1,450 cfm at 910 °F (487 °C). Periodic emissions from these generator testings would not affect overall air quality, and effects on air quality from construction or operation of the proposed SNS facility would be negligible.

5.5.4 NOISE

Noise levels emitted from construction of the proposed SNS at BNL would be very similar to those currently produced by Relativistic Heavy Ion Collider (RHIC) construction. The impacts of construction noise from the proposed SNS facility would be temporary and localized. The proposed SNS would be designed to operate within New York State Noise Standards and DOE criteria for safety and health. No significant noise effects are anticipated from construction of the facility at BNL.

Operations at the proposed SNS facility would generate some noise, caused particularly by traffic and cooling towers. In general, sound levels would be characteristic of a light industrial setting. Impacts to residential areas would be attenuated by the distance from the proposed SNS facility and by existing forested areas. Onsite, the level of noise from the proposed SNS facility would be typical of accelerator facilities, and any effects would be negligible when compared to ambient levels.

5.5.5 ECOLOGICAL RESOURCES

This section describes the potential effect construction and operation of the proposed SNS would have on ecological resources at BNL. It includes potential effects on terrestrial and aquatic resources, wetlands, and threatened and endangered species.

5.5.5.1 Terrestrial Resources

Construction of the proposed SNS facility would result in clearing vegetation, primarily oak and pine forest, from 110 acres (45 ha) of land at BNL. The entire proposed SNS site would be cleared during the first year of construction. The timber harvested during site preparation would be sold. Areas not immediately required for construction of proposed SNS facilities would be planted with grasses to minimize erosion.

Wildlife inhabiting the proposed SNS site includes white-tailed deer, gray squirrels, cottontail rabbits, and chipmunks. Construction of the proposed SNS would displace these species to surrounding areas. These areas have ample habitat for the displaced species, but one or more of the species populations may exceed the carrying capacity of the land because new individuals would be added to the existing offsite populations. This effect may result in a small but permanent reduction in these populations.

Clearing operations for construction of the SNS may cause the direct loss of small animals. Also, wildlife would be displaced from cleared areas and the surrounding habitat. Large mammals would be mostly excluded from controlled areas by access control fences. While additional forest-edge habitat would be created, cleared land would represent long-term loss of habitat.

Construction and operation activities and the associated noise and human presence would disturb wildlife occupying areas adjacent to the proposed site. This could result in emigration of some sensitive species from the surrounding area, although many of the species would adjust to the disturbance. To help minimize disturbance to wildlife, construction machinery would be kept in proper operating condition and workers would be prevented from entering undisturbed areas delineated before construction.

The proposed SNS site at BNL lies within the pine barrens area of Long Island, but the 110 acres (45 ha) of land on the site represents less than 2 percent of the legally established Pine Barrens Protection Area. Furthermore, the proposed SNS facility would be constructed entirely within the Compatible Growth Area rather than the more stringently protected Core Preservation Area (refer to Section 4.4.8.4). As a result, construction of the proposed SNS facility would have a minimal effect on the Pine Barrens.

The proposed SNS would operate on land where natural features have been largely removed or altered by construction activities. Consequently, the proposed SNS facility operations would have a minimal effect on terrestrial resources at this location and in immediately adjacent areas. Operation of the SNS would result in emissions to the atmosphere, composed primarily of CO_2, low levels of pollutants (see Section 5.5.3.2), and water vapor. These emissions would have no discernable effects on the surrounding Compatible Growth Area of the protected Pine Barrens.

5.5.5.2 Wetlands

No wetland areas are located within the proposed SNS site. However, three wetland areas are located in the vicinity of the site along the upper reaches of the Peconic River and at some points downstream.

The wetlands associated with the Peconic River would be protected from precipitation runoff and sedimentation during construction of the proposed SNS by establishing an uncleared zone of vegetation between the proposed SNS site and the river and by implementing erosion control measures such as silt fences. As a result, effects on wetland areas along the Peconic River would be minimal.

Runoff from most facilities and blowdown from the cooling towers would be discharged into a retention basin during operations at the proposed SNS. The outflow from the retention basin would be discharged into the Peconic River at about the same location as the current STP discharge. Therefore, none of the operational discharges from the proposed SNS facility would enter the wetland areas. Wetland areas downstream from the STP outfall would experience an increased flow of water. However, this flow would be less than that caused by a routine rain event. Consequently, construction and operation of the proposed SNS would have minimal effects on wetlands in the vicinity of the proposed SNS site.

5.5.5.3 Aquatic Resources

The proposed SNS site at BNL is adjacent to the headwaters area of the Peconic River. During land clearing and other construction activities, there would be a potential for increased surface water runoff and sediment loading in the river. A minimum 300-ft (91-m) buffer zone of uncleared vegetation would be established between the proposed SNS site and the Peconic River. This undisturbed zone would help limit runoff and preserve the vegetative cover of the river. Also, erosion control measures, including silt fencing and preservation of native vegetation, would be implemented to minimize the increased sediment load flowing to the river during construction. As a result of implementing these measures, effects on aquatic resources in the Peconic River would be minimal.

No effluents would be discharged to the upper reaches of the Peconic River during operation of the proposed SNS. All surface runoff from the site would be directed to the retention basin. Cooling tower blowdown would also be released into this basin. The basin would discharge 350 gpm (1,325 lpm) of water through a standpipe, and the discharge would be piped to the Peconic River. As previously noted, this discharge would empty into the river at about the same location as the current STP discharge. The river channel downstream from the STP outfall would experience an increased flow, but this flow would be less than that caused by a routine rain event. Thus, its effects on aquatic resources would be minimal.

The cooling tower blowdown would be elevated in temperature and contain chemical biocides and antiscaling agents. The source of the make-up water for the cooling towers would be the potable water supply system for the laboratory; therefore, the blowdown would contain chlorine. The blowdown would be dechlorinated prior to its release into the sediment retention basin. As described in Chapter 3, the sediment retention basin would be designed to reduce the temperature of the water to the ambient temperature of the Peconic River prior to discharge.

The foregoing assessment indicates that aquatic resources located on the proposed SNS site and in its vicinity would be minimally affected by the proposed action.

5.5.5.4 Threatened and Endangered Species

Spotted wintergreen, bayberry, and swamp azalea have been identified on the proposed SNS site at BNL (see Section 4.4.5.4). These species are protected under New York Environmental Conservation Law 9-1503 and New York State Regulation 193.3. Prior to the start of construction, DOE would consult with USFWS and the New York Department of Environmental Conservation to develop an appropriate mitigation plan to prevent adverse effects on these protected plants. Possible mitigation measures include placing a fence around the habitat containing protected plants so the construction workers and equipment could not cause damage. Consequently, the proposed action would result in minimal effects on known threatened and endangered species.

A systematic survey for protected species would be conducted in potential habitat areas prior to the start of land clearing and construction activities on the proposed SNS site. Because definitive identifications of many protected plants can only be made when they are flowering, this survey would extend over the spring, summer, and fall seasons to maximize the probability of finding them. If found, appropriate mitigation measures would be taken to protect these plants during construction and operation of the proposed SNS.

5.5.6 SOCIOECONOMIC AND DEMOGRAPHIC ENVIRONMENT

This section identifies whether construction and operation of the proposed project (and associated worker in-migration from outside the ROI) may adversely affect regional services and infrastructure. It also presents an estimate of the financial effects (employment, income, taxes, and economic output) that would be generated locally in the form of worker salaries, indirect effects, and induced effects. Unless otherwise noted, economic effects are described in escalated-year dollars.

The ROI associated with the BNL site includes Nassau and Suffolk Counties, New York. This 1,200-mi^2 region was selected because it forms the area within which at least 90 percent of BNL workers currently reside. It is, therefore, the region within which the majority of socioeconomic impacts are expected to occur. Socioeconomic effects beyond the ROI are generally expected to be minor.

The total local construction cost is estimated to be approximately $332 million (escalated dollars), and the peak construction year would be 2002, when 578 workers will be onsite (Brown 1998a). Of this total, about three-fourths (433 individuals) would likely be hired from the local area, and 144 will come from outside the ROI. An approximate average of 300 workers per year would be onsite, including all construction, management, and engineering design personnel and other technical and commissioning staff. Construction of the 1-MW SNS is the bounding case for analysis of construction effects. If the SNS is upgraded to 4 MW, additional construction would occur but this would be much less than the effects associated with the initial construction of the 1-MW SNS.

Operation of the proposed SNS facility at 1 MW would begin in 2006 with a staff of 250 persons. Later, if the proposed SNS is upgraded to 4 MW, 375 persons would be employed. The

4-MW case is used for this analysis as the bounding case, and the effects of the proposed 1-MW SNS on the ROI would be similar but slightly less than the 4-MW case.

5.5.6.1 Demographic Characteristics

It is assumed that approximately 75 percent of all construction workers would come from the local region (Brown 1998a). Most of the construction workers would be general craft laborers, and the specialized technical components would be contracted out and fabricated in places not yet known. All locally hired construction workers would commute to the job site from existing residences and would not relocate closer to the site. The experience with other past major construction projects has been that most in-migrating workers would temporarily move to the project area but would usually commute home on weekends or periodically. These individuals would generally not bring families to the ROI for the construction period. However, even if all of the in-migrating workers brought families into the ROI, the total (temporary) population increase would be less than 500 persons in the peak year, including spouses and children. This would be a temporary increase in population of much less than 0.01 percent and is, therefore, negligible.

People with the technical expertise needed to operate the proposed SNS facility currently reside in the ROI. However, it is also expected that some plant operators would come from outside the local region. It is assumed that about half of the 375-person operating workforce (for the bounding 4-MW case) would come from outside the area. It is further assumed that these households would be the same size as the national average because it is not known from where they would in-migrate. It is conservatively estimated that in 2006 the total population increase associated with operations would be about 600 individuals, including spouses and children. The facility operators would be "permanent" residents of the area, and little additional in-migration would occur in subsequent years. The population increase associated with construction and operations would represent less than 0.01 percent of the local population and is, therefore, negligible.

5.5.6.2 Housing

With about 71,000 vacant "dwelling units" (refer to Section 4.4.6.2) in the two-county ROI, workers should easily be able to find apartments to rent or houses to purchase. Some new houses would probably be constructed. However, existing vacancies and historical construction rates indicate that housing would be available for this small in-migration.

5.5.6.3 Infrastructure

Potential effects on infrastructure are closely tied to population growth. Because the expected permanent in-migration is only 600 individuals, effects on infrastructure would be relatively minor.

More than 600 schools with an enrollment of 666,000 students are located in the ROI. The addition of less than 300 children to the ROI would, therefore, be minor. Even if all 300 children attended schools in Nassau County, the current teacher-student ration of 1:13 would be unchanged. Effects would also be minor for police and fire protection, health care, and other services.

5.5.6.4 Local Economy

Design of the proposed SNS facility would begin in 1999, and the first construction managers and workers would begin work in FY 2000. The majority of the construction would occur from FY 2001 through FY 2004, with the peak construction employment occurring in FY 2002. Testing of the proposed SNS facility would be from FY 2003 through FY 2005. Operations are planned to begin by the end of FY 2005; FY 2006 would be the first full year of operations (see Figure 3.2.2-1).

Table 5.5.6.4-1 presents the results of the IMPLAN modeling for the period 1999 through 2006. Economic benefits in the form of jobs, wages, business taxes, and income would begin to accrue during the first year of the project in FY 1999. These economic benefits in the ROI would increase as construction and other associated project activities increase. Design and construction employment would be highest in FY 2002, and there would be an estimated 1,481 total (direct, indirect, and induced) new jobs created at BNL. This trend would begin to diminish in FY 2003 as design and construction employment decreased and would continue to decrease until construction is completed in FY 2004. Facility operations would begin in FY 2005. Operations would reflect substantial regional spending for operator salaries, supplies, utilities, and administrative costs.

The proposed SNS is planned to operate for 40 years. If the level of operation is the same as for the 4-MW case measured in the first full year (FY 2006), it is expected that facility operation would continue to support an estimated 1,551 jobs for each of the following years of operation, 873 of which would be indirect or induced. Other annual operations effects would include $71.6 million in local wages, $10.3 million in business taxes, $80.5 million in personal income, and $196 million in total output.

Construction of the facility would create new jobs and may potentially result in the region's unemployment rate dropping from 3.4 percent to 3.3 percent. During operations, the unemployment rate may decrease further to 3.2 percent, depending on whether construction workers and engineers (unemployed following project completion) stay in the ROI. The effects from operating the proposed 1-MW SNS would be similar but slightly lower.

5.5.6.5 Environmental Justice

As identified in Figures 4.4.6.5-1 and 4.4.6.5-2, minority populations and low-income populations reside within 50 mi (80 km) of the proposed SNS site. For environmental justice effects to occur, there must be high and adverse human health or environmental effects that disproportionately affect minority populations or low-income populations.

The human health and safety analyses show that hazardous chemical and radiological releases from normal operation of the proposed SNS at 1-MW and 4-MW power levels would be within regulatory limits. Annual radiological doses are given in Section 5.5.9, and the data show that normal air emissions from the proposed 1-MW SNS would be negligible and would not result in adverse human health or environmental effects on the public at offsite locations. Therefore, operation of the proposed SNS would not have disproportionately high and adverse effects on minority or low-income populations.

Radiation doses to the public from both normal operations and accident conditions would not

Table 5.5.6.4-1. BNL IMPLAN modeling results—construction and operations impacts.

	1999	2000	2001	2002	2003	2004	2005	2006
Employment								
Direct	102	202	473	573	404	272	37	678
Indirect	77	139	334	418	300	206	28	362
Induced	90	166	396	491	351	239	33	511
Total	269	507	1,203	1,481	1,055	717	98	1,551
Wages								
Direct	$7,549,066	$14,330,179	$34,733,467	$43,790,913	$31,881,709	$22,154,595	$3,101,162	$39,667,537
Indirect	$2,573,668	$4,754,553	$11,623,660	$14,801,201	$10,845,926	$7,585,138	$1,064,148	$14,888,863
Induced	$2,636,431	$4,961,149	$12,028,197	$15,173,970	$11,045,277	$7,674,012	$1,073,164	$17,016,618
Total	$12,759,165	$24,045,880	$58,385,324	$73,766,084	$53,772,913	$37,413,746	$5,238,474	$71,573,018
Business Tax								
Direct	$186,863	$461,190	$1,047,036	$1,210,987	$833,858	$547,796	$76,291	$4,457,596
Indirect	$451,002	$836,614	$2,032,627	$2,570,126	$1,871,913	$1,301,083	$181,647	$2,070,553
Induced	$597,104	$1,122,175	$2,717,000	$3,422,671	$2,487,629	$1,725,603	$240,913	$3,813,381
Total	$1,234,969	$2,419,979	$5,796,663	$7,203,784	$5,193,400	$3,574,482	$498,852	$10,341,531
Income								
Direct	$8,238,595	$15,629,937	$37,888,677	$47,779,063	$34,789,683	$24,178,269	$3,384,471	$42,795,649
Indirect	$2,996,030	$5,534,549	$13,546,035	$17,270,440	$12,669,442	$8,870,343	$1,245,647	$18,147,646
Induced	$3,016,283	$5,678,937	$13,775,646	$17,387,412	$12,662,937	$8,802,386	$1,231,580	$19,538,272
Total	$14,250,907	$26,843,423	$65,210,358	$82,436,916	$60,122,062	$41,850,998	$5,861,698	$80,481,565
Output								
Direct	$23,274,370	$44,327,898	$107,356,711	$135,192,079	$98,356,752	$68,302,617	$9,560,201	$102,443,763
Indirect	$7,082,311	$13,147,894	$32,089,130	$40,779,464	$29,841,783	$20,841,952	$2,922,516	$42,204,013
Induced	$7,888,100	$14,863,259	$36,082,068	$45,575,617	$33,215,117	$23,104,202	$3,234,652	$51,346,502
Total	$38,244,781	$72,339,050	$175,527,908	$221,547,159	$161,413,653	$112,248,772	$15,717,369	$195,994,276

Source: IMPLAN Pro.

create high and adverse effects. Less than two (1.5) LCFs are calculated at the 4-MW power level over a 40-year operations period. If the facility operated for 10 years at 1 MW and 30 years at 4 MW, the calculated number of LCFs would be reduced. An LCF is a cumulative measure from the entire regional population (within a 50-mi or 80-km radius) of almost 5,000,000 used for comparing alternatives and does not necessarily indicate that a fatality would occur (refer to Section 5.2.9.2.1). Twenty-five accident scenarios for the proposed SNS at BNL would result in airborne releases. The consequences of most of these accidents would be negligible at power levels of both 1 MW and 4 MW. Four accidents are calculated to result in LCFs at 4 MW. The prevailing ground-level winds are from the southwest during the summer, from the northwest during the winter, and about equal from these two directions in the spring and fall (refer to Figure 4.4.3.2-1). Figures 4.4.6.5-1 and 4.4.6.5-2 show that the closest concentrations of minority and low-income populations are southwest of the proposed site. However, the site is mostly surrounded by non-minority, higher-income populations, especially in the path of the predominant wind direction. The public, including minority and low-income persons, could be in the path of an offsite airborne release. However, the analysis has shown that there would not be high and/or adverse effects on any of the population; therefore, there would be no disproportionate risk of significantly high and adverse effects on minority and low-income populations.

A number of uncertainties are associated with the evaluation of potential effects due to subsistence consumption. ANL developed an article reviewing the literature on subsistence consumption (Elliot 1994) and found that (1) "the majority of the studies that have been conducted to date are focused on site- or region-specific exposure concerns. At present, it is unclear whether the findings of these studies are representative of consumption and exposure levels among minority populations at a national level"; (2) "a large number of risk assessment studies focusing on fish and wildlife consumption examined whole populations without distinguishing between consumption and exposure patterns of specific ethnic (or other) subpopulations"; (3) "the vast majority of studies have focused on fish consumption as an exposure pathway. Few examined wildlife consumption and contamination, and even in such cases the studies were not motivated by minority exposure concerns"; and (4) "the majority populations were not significantly higher than for the population as a whole." Specific data on subsistence living are not available for the BNL region. However, DOE is unaware of any subsistence populations residing in the vicinity of the proposed SNS site. Therefore, no adverse effects on such populations are expected.

In order to assemble and disseminate information on subsistence hunting and fishing, DOE began publishing *A Department of Energy Environmental Justice Newsletter: Subsistence and Environmental Health* in the spring of 1996. The newsletter is available in the public reading rooms. Three goals of the newsletter are (1) "to provide useful information about the health implications of consuming contaminated fish, wildlife, livestock products, or vegetation"; (2) "to provide information about projects and programs at DOE and other Federal and State agencies that address the problems associated with consuming contaminated fish, wildlife, livestock products, or vegetation"; and (3) "to receive relevant information from readers." In addition to the newsletter, DOE has a new project under way to identify what information is being collected on subsistence consumption by other federal agencies and to serve as a clearinghouse for such information (DOE 1996e).

No discharges of radioactive water to surface water would occur because all of the wastes generated during construction and operation of the proposed SNS facility would be transported to BNL facilities for processing. These facilities and the management process for these wastes are described in Section 5.5.11. All chemical releases would be regulated by NPDES permits and would be in compliance with federal and state regulations. As such, there would be no incremental effects on fish or other edible aquatic life in areas surrounding the proposed SNS site.

The analyses indicate that socioeconomic changes resulting from implementing the proposed SNS would not lead to environmental justice effects. The proposed SNS project would provide economic benefits through generating additional employment and income in the affected region (refer to Table 5.5.6.4-1). There would be increased traffic congestion; however, this effect would not disproportionately affect minority or low-income communities because traffic patterns would not be different between low-income and minority populations and the rest of the surrounding population (refer to Section 5.5.10.1). Overall, nothing from construction or operation of the proposed SNS facility would pose high and adverse human health or environmental effects that disproportionately affect minority or low-income populations.

5.5.7 CULTURAL RESOURCES

The potential effects of the proposed action on cultural resources located on and adjacent to the proposed SNS site at BNL are assessed in this section. These assessments involve prehistoric archaeological sites; structures, features, and archaeological sites dating to the Historic Period; and TCPs.

The SNS design team has not established the areas where construction or improvement of utility corridors and roads would be necessary to support the proposed SNS at BNL. In addition, the locations of ancillary structures such as a retention basin and a switchyard have not been determined. As a result, the effects of the proposed action on any cultural resources that may occur in these areas cannot be assessed at this time. If the proposed SNS site at BNL were chosen for construction, a cultural resources survey and an assessment of potential effects would be conducted prior to the initiation of construction-related activities in these areas. Appropriate measures would be implemented to mitigate any identified effects on cultural resources. These measures would include avoidance, where possible, or data recovery operations, including detailed recording of surface features and/or archaeological excavation.

5.5.7.1 Prehistoric Resources

No prehistoric cultural resources have been identified on or adjacent to the proposed SNS site at BNL. Consequently, implementation of the proposed action would have no effect on prehistoric cultural resources listed on or eligible for listing on the NRHP.

5.5.7.2 Historic Resources

Large earthen features such as berms, linear trenches, pits, and mounds have been found at survey Stations 2, 4, 8, and 10 on the proposed SNS site at BNL. These features may have been used for trench warfare training at Camp Upton during World War I. The features at Station 2 may have been a command post associated with adjacent trenches. If these features were associated with World War I training activities, they would date to approximately 1917–1918.

The earthen features at Stations 2, 4, 8, and 10 are considered to be potentially eligible for listing on the NRHP, based on the results of the 1998 cultural resources survey of the proposed SNS site at BNL. All of these features would be destroyed by site preparation activities under the proposed action. These effects would be mitigated through data recovery operations, including detailed recording of surface features and archaeological excavation.

5.5.7.3 Traditional Cultural Properties

No Native American tribal representatives have been identified in the BNL area, and no Native American lands are located on the proposed BNL site. Because no Native American groups have been identified, it has not been possible for DOE to consult with such groups concerning the potential occurrence of TCPs on and near the proposed SNS site. A survey of the proposed site and limited surveys of other areas at BNL have encountered no evidence of prehistoric occupations. In addition, no Native American TCPs have been identified in the BNL area. Based upon these results, it has been concluded that no TCPs occur on the proposed SNS site or anywhere else on laboratory land. Therefore, implementation of the proposed action on the SNS site at BNL would have no effect on such resources.

5.5.8 LAND USE

The potential effects of the proposed action on land use in the vicinity of BNL, within the boundaries of BNL, and on the proposed SNS site are assessed in this section. The assessments cover potential effects on current land uses and zoning for future land use. Furthermore, the potential effects of the proposed action on parklands, nature preserves, major recreational resources, and visual resources are assessed.

5.5.8.1 Current Land Use

Current land use in the area surrounding BNL is driven by the relationship between existing land characteristics and socioeconomic forces acting at the local and regional levels. Similarly, current land use within the boundaries of BNL results from selectively using the existing characteristics of the land to meet various DOE mission requirements. The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the basic land characteristics and other forces that influence land use. Consequently, implementation of the proposed action on the SNS site at BNL would have no reasonably discernible effects on land use in the vicinity of BNL and throughout most of the laboratory. However, current use of the land within and near the proposed SNS site would be more subject to effects.

The current land use within the proposed SNS site is Open Space. Construction of the proposed SNS facility would introduce development to 110 acres of SNS site land, utility corridors, and rights-of-way. The current use of proposed SNS site land would be changed to Commercial/Industrial. Considering the large areas of undeveloped Open Space that would still be available at BNL (refer to Figure 4.4.8.2-1), these effects would be minimal.

DOE has a federally mandated role as trustee of the natural and cultural resources on its lands. The use of undeveloped trusteeship land for the SNS is proposed only because no previously developed BNL lands that meet project requirements are available.

The land on and in the vicinity of the proposed SNS site is not being used for environmental research projects. As a result, the proposed action would have no effects on the use of land by such projects.

5.5.8.2 Future Land Use

Two versions of zoning for future land use at BNL have been developed. Each is based on the possible construction of a major scientific research facility at the laboratory in the future. One is the muon-muon collider version, and the other is the new linear accelerator version.

As much as 20 percent of the BNL land now used as Open Space is zoned for future Industrial/Commercial use. In the muon-muon collider and new linear accelerator versions, the proposed SNS site is located on land zoned as Open Space and Commercial/Industrial. In each version, most of the land within the proposed SNS site is zoned Commercial/Industrial. Construction and operation of the proposed SNS facility is consistent with this zoning. The use of Open Space would appear to be at variance with this current zoning, but one of the guiding principles behind the zoning of BNL land is to expand other land uses into Open Space.

Portions of the proposed SNS site would become contaminated with pollutants from operations. Current plans call for in situ decommissioning of the SNS when its operational life cycle is completed. As a result of in situ decommissioning, some contaminated components would remain in place on the SNS site. This could limit the future use of land on the site for other purposes. Construction and operation of the SNS could also limit the future use of land areas adjacent to the SNS site.

No future uses of proposed SNS site and vicinity land for environmental research are planned. As a result, effects of the proposed action on specific future research projects cannot be assessed.

The end-use zoning of BNL was completed before the laboratory became an alternative site for the proposed SNS facility. With the exception of a small area of Commercial/Industrial land, the land on the proposed SNS site was zoned for end use as Open Space. However, if the proposed SNS facility were eventually constructed and operated on this site, its presence would probably influence a change of end-use zoning to Commercial/Industrial for both the site and some adjacent land.

5.5.8.3 Parks, Preserves, and Recreational Resources

The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics that support park, nature preserve, and recreational land uses in the vicinity of BNL. Consequently, implementation of the proposed action on the proposed SNS site at BNL would have no reasonably discernible effects on the following specific land uses: Brookhaven State Park, Rocky Point State Park, Wildwood State Park, recreational use of the Peconic and Carmens rivers, Calverton Naval Weapons Plant (recreational areas), Cathedral Pines County Park, South Haven County Park, Wertheim National Wildlife Refuge, and Randall Road Hunting Station.

5.5.8.4 Visual Resources

Most of the visual panoramas in the area immediately surrounding BNL and within the laboratory contain features indicative of development. The proposed action would add the SNS facilities to this visual environment, and they would be compatible with it. Consequently, implementation of the proposed action on the proposed SNS site at BNL would have a minimal effect on visual resources.

5.5.9 HUMAN HEALTH

Construction and operation of the proposed SNS at BNL could pose a potential risk of adverse effects on the health of workers and of the public living in the vicinity of the facility. Potential adverse effects include

- Traffic-related fatalities and injuries to workers and the public.
- Occupational fatalities and injuries to workers.
- Exposure of workers and the public to radiation or radioactive materials.
- Exposure of workers and the public to toxic or hazardous materials.

This section evaluates the potential magnitude of these effects and the likelihood that they would occur during three phases or conditions:

- construction,
- normal operations, and
- accident conditions.

5.5.9.1 Construction

The potential effects on the health of construction workers, other BNL workers, and members of the public would be essentially the same for any of the proposed locations, because the size of the construction work force would be the same. Potential effects of construction of the SNS include construction accidents and traffic accidents.

On the basis of national traffic accident rates (1.74×10^{-8} fatalities per vehicle mile and 1.05×10^{-6} disabling injuries per vehicle mile) and the anticipated total mileage of commuting construction workers (2,074 person-years × 250 work days/person-year × 0.806 daily round-trips/worker × 20 miles/round-trip), less than one additional fatality and nine additional disabling injuries could occur as a result of increased commuter traffic during the 7-year construction period of the proposed SNS.

On the basis of national construction accident rates, 0.31 fatality (0.00015 fatalities/worker-year × 2,074 worker-years) and 110 disabling injuries (0.053 disabling injuries/worker-year × 2,074 worker-years) could occur as the result of occupational accidents during construction of the proposed SNS.

The existing BNL workforce of 3,100 is smaller than that at the other proposed locations, so the relative increase in traffic-related injuries and fatalities would be greater during construction of the proposed SNS facility at BNL. Based on traffic data shown in Section 5.5.10.1 and the approach described in Section 5.2.9.1, traffic-related disabling injuries and fatalities would be expected to increase by approximately 19 percent during the peak year of construction relative to existing injury and fatality rates at BNL.

No known construction activities or requirements would place SNS construction workers and the public at BNL at a different risk of occupational injury or fatalities than the risk posed to these same groups by construction at any of the proposed locations.

The previous discussion is based on construction of the 1-MW proposed SNS facility. At this stage of design, estimates of the number of workers that would be required to upgrade the facility for 4-MW operation are not available. Because the amount of construction required for upgrade to 4 MW would be less than that required for construction of the original facility, injuries and fatalities for traffic-related and construction accidents for the 4-MW facility would be less than those for construction of the original facility regardless of where the SNS is located.

5.5.9.2 Normal Operations

The number of SNS workers is independent of the location of the facility. The absolute number of industrial accidents and traffic-related injuries and fatalities would be expected to be essentially the same as at the other proposed locations.

On the basis of national traffic accident rates (0.0174 fatalities per million vehicle-mile and 1.05 disabling injuries per million vehicle-mile) and the anticipated total mileage of 60 million miles (375 commuting workers × 20 miles/trip × 0.806 trips/day × 250 days/year × 40 years), 1 additional fatality and 63 additional disabling injuries could occur as the result of increased commuter traffic during the 40-year operational life of the proposed SNS.

National industrial workplace accident rate data applied to the work force for the proposed SNS would yield less than 1 fatality (3.4 deaths annually/100,000 workers × 375 workers × 40 years) and 500 disabling injuries (3,400 disabling injuries annually/100,000 workers × 375 workers × 40 years) occurring over the 40-year operational life of the proposed SNS.

The relative increase would be greater at BNL than at the other proposed locations because of its smaller existing workforce. Based on data shown in Section 5.5.10.1, the addition of the maximum of 375 SNS workers to the daily BNL traffic flow could increase the number of disabling injuries and fatalities in traffic accidents by approximately 12 percent relative to existing rates.

The proposed SNS facility would generate and release direct radiation, radioactive materials, and toxic materials. Members of the public and workers at the proposed SNS facility and other adjacent facilities would be exposed to such radiation and emissions. The quantities and release rates of these materials would be the same as for any of the proposed locations. The impact of the BNL site-specific meteorology, distances to site boundaries, and population density and distribution are discussed in the following sections.

5.5.9.2.1 Radiation and Radioactive Emissions

This section assesses the potential effects of direct radiation and airborne emissions of radioactive materials from the proposed SNS based on the methods and dose-to-risk conversion factors discussed in Section 5.1.9.

Direct Radiation

Exposure of SNS workers to direct radiation from the proposed SNS facility at BNL would be expected to be the same as the other proposed locations because the SNS Shielding Design Policy is applicable regardless of location.

The proposed SNS at BNL is near existing facilities that emit small amounts of direct radiation. As a result, dose to SNS workers at BNL could be slightly different than at the other proposed locations. The difference, if any, would be on the order of a few mrem annually. The average total EDE to all BNL workers was 81 mrem in 1996 (DOE 1996f).

The proposed SNS site at BNL is also relatively close to the site boundary at several points. Based on BNL monitoring results for 1995 that reflect the contributions of direct radiation from several major accelerator facilities (Naidu et al. 1996), the potential increase in direct radiation levels at the BNL boundary, if any, would not be expected to be more than a few mrem/yr.

Radioactive Emissions

Radioactive emissions from routine operations of the proposed SNS facility would consist of releases to the atmosphere from two stacks: the Tunnel Confinement Exhaust Stack and the Target Building Exhaust Stack. Radionuclide activities in these emissions are listed in Table F-1 of Appendix F and are the same regardless of the facility location. Existing EPA-permitted commercial disposal facilities servicing BNL have sufficient capacity to accommodate LLLW and process waste from the proposed SNS facility, and these wastes would be processed in accordance with existing permits for these facilities.

The estimated annual doses to workers and the public from routine SNS airborne emissions are shown in Table 5.5.9.2.1-1. The methods and assumptions used in the calculation of doses are discussed in Section 5.1.9 and in greater detail in Appendix F.

Even under the conservative assumptions regarding the exposure pathways, these estimated doses would be in compliance with applicable regulations. The dose to the maximally exposed individual member of the public from operation at a 1-MW beam power (0.91 mrem) is 9 percent of the 10-mrem annual limit (40 CFR Part 61); the maximally exposed individual dose for operation at a 4-MW beam power (3.4 mrem) is 34 percent of the annual dose limit. Because the reported annual dose from existing operations at BNL is very low, only 0.06 mrem to the maximally exposed individual and 3.2 person-rem to the offsite population in 1995 (Naidu et al. 1996), BNL would remain in compliance when the emissions from the proposed SNS are included.

Dose at the BNL boundary because of emissions from the Tunnel Confinement Exhaust is 0.024 mrem and is dominated by radionuclides in activated concrete dust. Dose at the BNL boundary because of emissions from the Target Building Exhaust is dominated by ^{3}H (55 percent) with smaller contributions from

Table 5.5.9.2.1-1. Estimated annual radiological dose from proposed SNS normal emissions at BNL.[a]

	1-MW Power Level		4-MW Power Level	
Receptor	Target Building[b]	Tunnel Confinement[c]	Target Building[b]	Tunnel Confinement[c]
Maximum Individuals (mrem)				
Offsite Public[d]	0.89	0.024	3.4	0.029
Uninvolved Workers[d]	0.093	0.050	0.19	0.062
Populations (person-rem)				
Offsite Public[e] (4,940,116 persons)	20	0.41	76	0.41
Uninvolved Workers[e] (2,007 persons)	0.032	0.006	0.096	0.009

[a] Doses shown include the contributions from inhalation, immersion, and "ground shine" for workers and the offsite public and ingestion for the offsite public.
[b] Target Building emissions include hot offgas exhaust, primary confinement exhaust, secondary confinement exhaust from the target building, and activated air from the beam dump buildings.
[c] Tunnel Confinement emissions include activated air and concrete dust from the linac tunnel, high-energy beam transport (HEBT) tunnel(s), ring tunnel(s), and ring-to-target beam transport tunnel(s).
[d] The maximally exposed individuals are hypothetical receptors. The member of the public is assumed to occupy a position at the BNL site boundary for 8,760 hr/yr and to produce their entire food supply at this location. The maximally exposed uninvolved worker is assumed to occupy a position within 1.2 mi (2 km) of the stack for 2,000 hr/yr.
[e] The offsite population consists of all individuals residing outside the BNL site boundary within 50 mi (80 km) of the site and is assumed to be present for 8,760 hr/yr. The involved/uninvolved worker population consists of all workers normally within 1.2 mi (2 km) of the facility. These workers are assumed to be present for 2,000 hr/yr.

^{14}C, ^{125}I, and ^{203}Hg. These radionuclides are listed in order of decreasing dose and account for 99 percent of this component of the total dose.

To estimate the total consequence from SNS emissions of radioactive materials over the entire life of the facility, annual population dose is multiplied by operating life of the facility and by the dose-to-risk factor of 0.0005 LCFs/ person-rem. For 40 years of operation at 1 MW, 0.4 excess LCFs would be projected. For 40 years at 4 MW, 1.5 excess LCFs would be projected. If the facility operated for 10 years at 1 MW and 30 years at 4 MW, 1.2 excess LCFs would be projected. These projected excess LCFs do not mean that any actual fatalities would occur as the result of the proposed SNS operations but provide a quantified magnitude for comparison to excess LCFs estimated for the other alternatives.

5.5.9.2.2 Toxic Material Emissions

As discussed in Section 5.2.9.2.2, elemental mercury vapor is the only toxic material expected to be released from the proposed SNS facility under normal conditions. Based on the continuous annual release rate of 0.0171 mg/s and atmospheric dispersion factors specific to BNL, the maximum mercury concentration in areas that could be occupied by uninvolved workers would be 2.71×10^{-6} mg/m^3 in any 2-hr period and 6.05×10^{-7} mg/m^3 in any 8-hr period. These concentrations are at least 1/100,000th of the OSHA ceiling limit (0.1 mg/m^3) and the ACGIH recommended TLV-TWA (0.05 mg/m^3) for workers. The maximum average annual airborne mercury concentration at the site boundary would be 1.60×10^{-8} mg/m^3, 1/20,000th of the EPA Reference concentration for members of the public (0.0003 mg/m^3).

5.5.9.3 Accident Conditions

This section assesses the effects on human health of accidents that could potentially occur during operation of the proposed SNS at BNL.

5.5.9.3.1 Accident Scenarios

The accident scenarios and source terms for accidents that could potentially occur at the proposed SNS are the same for all alternative sites and are summarized in Table F-2 (refer to Appendix F). The details of these scenarios and source terms are provided in Appendix A. Table 3.2 in Appendix A defines the terminology used to describe the likelihood that a given accident could occur.

5.5.9.3.2 Direct Radiation

The frequencies of occurrence and consequences of accidents involving exposure to direct radiation have not been specifically analyzed. DOE's Shielding Design Policy for the proposed SNS is such that for the worst-case design-basis accident, the dose to the maximally exposed individual in an uncontrolled area would be limited to 1 rem and for a worker in a controlled area would be limited to 25 rem. The risks of this category of accidents would be the same for all alternative sites.

5.5.9.3.3. Radioactive Materials Accidents

DOE has performed a hazard analysis of potential accidents at the proposed SNS facility, and for those that could result in release of radioactive material, it has estimated source terms. The DOE analysis is included as Appendix A. Accident scenarios, estimated frequencies of occurrence, and source terms are summarized in Table F-2 and are the same for all proposed SNS alternative sites. The methods used to evaluate the consequences of these accidents are discussed in Section 5.1.9 and in more detail in Appendix F.

Doses for these accidents, should they occur at the proposed SNS facility at BNL, are listed in Table 5.5.9.3.3-1. With the exception of accident ID 16, all doses are for accidents at a 1-MW facility and would be four times higher at a 4-MW facility. This is not the case for ID 16, the beyond-design-basis mercury spill, because of differences in the source term model (refer to Exhibit F of Appendix A). At 4 MW (ID 16b), some boiling of mercury is assumed, releasing a larger quantity of mercury than at 1 MW (ID 16a), where only evaporation is assumed.

The pattern of accident doses for the proposed SNS at BNL is similar to that for the other proposed locations. That is, the same accidents and releases are postulated to occur independent of facility location. However, doses to individuals and populations reflect the relative proximity of the proposed SNS to the BNL boundary, and population doses reflect the proximity to a major metropolitan area.

At a power level of 1 MW, the design-basis mercury spill (ID 16a) has the highest dose of accidents involving the target. The maximum individual doses would be 24 mrem for the

Table 5.5.9.3.3-1. Radiological dose for SNS accident scenarios at BNL.

ID	Event	Frequency[b]	Source Term[c]	Maximum Individual (mrem) [a] Offsite Public 1 MW Beam	Maximum Individual (mrem) [a] Offsite Public 4 MW Beam	Maximum Individual (mrem) [a] Uninvolved Workers 1 MW Beam	Maximum Individual (mrem) [a] Uninvolved Workers 4 MW Beam	Population (person-rem) [a] Offsite Public 1 MW Beam	Population (person-rem) [a] Offsite Public 4 MW Beam	Population (person-rem) [a] Uninvolved Workers 1 MW Beam	Population (person-rem) [a] Uninvolved Workers 4 MW Beam
A. Accidents Involving Proposed SNS Target or Target Components											
2	Major loss of integrity of Hg Target Vessel or piping (Appendix A, Section 3.3)	a) Unlikely	Percent Inventory Mercury Iodine 0.142 0.142	3.4	13.6	4.0	16.0	210	840	2.9	11.6
		b) Extremely Unlikely	Percent Inventory Mercury Iodine 0.243 100	14	56	9.4	37.6	950	3,800	6.7	26.8
8	Loss of integrity in Target Component Cooling Loop (Appendix A, Section 3.9)	a) Anticipated	Bounded by annual release limits[d]	<10	<10	NA	NA	NA	NA	NA	NA
		b) Anticipated	Gases + Mist + 150 L of D_2O	1.5	6.0	0.26	1.04	1.9	7.6	0.13	0.52
		c) Anticipated	18 L of D_2O	<0.001	0.003	0.001	0.004	0.039	0.156	<0.001	0.004
		d) Anticipated	Gases + Mist + 150 L of H_2O	1.4	5.6	0.22	0.88	4.6	18.4	0.094	0.376
16	Beyond-Design-Basis Hg Spill (Appendix A, Section 3.17)	a) Beyond Extremely Unlikely	1 MW Percent Inventory Mercury Iodine 1.11 100	24		29		1,500		21	
		b) Beyond Extremely Unlikely	4 MW Percent Inventory Mercury Iodine 1.28 100		2,200		920		170,00 0		660

Table 5.5.9.3.3-1. Radiological dose for SNS accident scenarios at BNL - (continued).

				Maximum Individual (mrem) [a]				Population (person-rem) [a]			
				Offsite Public		Uninvolved Workers		Offsite Public		Uninvolved Workers	
ID	**Event**	**Frequency[b]**	**Source Term[c]**	**1 MW Beam**	**4 MW Beam**	**1 MW Beam**	**4 MW Beam**	**1 MW Beam**	**4 MW Beam**	**1 MW Beam**	**4 MW Beam**
	B. Accidents Involving proposed SNS Waste Systems										
17	Hg Condenser Failure (Appendix A, Section 4.1.1)	Anticipated	13.7 g mercury	0.007	0.028	0.005	0.02	0.41	1.64	0.003	0.012
18	Hg Charcoal Absorber Failure.[e] (Appendix A, Section 4.1.2)	Unlikely	14.8 g mercury	0.002	0.008	0.003	0.012	0.077	0.308	0.002	0.008
19	He Circulator Failure (Appendix A, Section 4.2.1)	Anticipated	1 day tritium production	<0.001	<0.001	<0.001	<0.001	0.009	0.036	<0.001	<0.001
20	Oxidation of Getter Bed (Appendix A, Section 4.2.2)	Unlikely	1 day tritium production	<0.001	<0.001	<0.001	<0.001	<0.009	0.036	<0.001	<0.001
21	Combustion of Getter Bed (Appendix A, Section 4.3.1)	Extremely Unlikely	1 year tritium production, 200 g depleted uranium	4.0	16.0	0.99	3.96	320	1,280	0.71	2.84
22	Failure of Cryogenic Charcoal Absorber [f] (Appendix A, Section 4.4.1)	Unlikely	1 day production of xenon	0.13	0.52	0.019	0.076	8.0	32.0	0.014	0.056
23	Valve sequence error in Tritium Removal System (Appendix A, Section 4.5.1)	Unlikely	1 year tritium production	3.8	15.2	0.95	3.8	300	1,200	0.68	2.72
24	Valve sequence error in Offgas Decay System (Appendix A, Section 4.5.2)	Anticipated	7 days xenon accumulation (1 decay tank)	10	40	2.4	9.6	770	3,080	1.7	6.8

Table 5.5.9.3.3-1. Radiological dose for SNS accident scenarios at BNL - (continued).

				Maximum Individual (mrem) [a]				Population (person-rem) [a]			
				Offsite Public		Uninvolved Workers		Offsite Public		Uninvolved Workers	
ID	**Event**	**Frequency[b]**	**Source Term[c]**	**1 MW Beam**	**4 MW Beam**	**1 MW Beam**	**4 MW Beam**	**1 MW Beam**	**4 MW Beam**	**1 MW Beam**	**4 MW Beam**
25	Spill during filling of tanker truck for LLLW Storage Tanks[g] (Appendix A, Section 4.5.3)	Anticipated	0.00005% of contents of LLLW Tank	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001
26	Spray during filling of tanker truck for LLLW[g] (Appendix A, Section 4.5.4)	Anticipated	1.9 ml of LLLW	<0.001	<0.001	<0.001	<0.001	0.002	0.008	<0.001	0.001
27	Spill during filling of tanker truck for Process Waste Storage Tanks[g] (Appendix A, Section 4.5.5)	Anticipated	51,100 L Process Waste to surface water + 57 L to atmosphere	See footnote “h”		See footnote “h”		See footnote “h”		See footnote “h”	
28	Spray during filling of tanker truck for Process Waste[g] (Appendix A, Section 4.5.6)	Anticipated	28.4 L of Process Waste	See footnote “h”		See footnote “h”		See footnote “h”		See footnote “h”	
29	Offgas Treatment pipe break (Appendix A, Section 4.6.1)	Unlikely	24 hrs xenon production	1.6	6.4	0.15	0.6	4.7	18.8	0.12	0.48
30	Offgas Compressor Failure (Appendix A, Section 4.6.2)	Unlikely	1 hr xenon production	0.23	0.92	0.019	0.076	7.4	29.6	0.015	0.06
31	Offgas Decay Tank Failure (Appendix A, Section 4.6.3)	Extremely Unlikely	7 days xenon accumulation	10	40	2.4	9.6	770	3,080	1.7	6.8
32	Offgas Charcoal Filter Failure (Appendix A, Section 4.6.4)	Unlikely	7 days iodine production	0.15	0.6	0.020	0.080	1.5	6.0	0.012	0.0048

Table 5.5.9.3.3-1. Radiological dose for SNS accident scenarios at BNL - (continued).

				Maximum Individual (mrem) [a]				Population (person-rem) [a]			
				Offsite Public		Uninvolved Workers		Offsite Public		Uninvolved Workers	
ID	Event	Frequency[b]	Source Term[c]	1 MW Beam	4 MW Beam	1 MW Beam	4 MW Beam	1 MW Beam	4 MW Beam	1 MW Beam	4 MW Beam
33	LLLW System piping failure. (Appendix A, Section 4.6.5)	Unlikely	0.00005% of contents of LLLW Tank	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001
34	LLLW Storage Tank Failure (Appendix A, Section 4.6.6)	Extremely Unlikely	0.00005% of contents of LLLW Tank	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001
37	Process Waste Storage Tank Failure (Appendix A, Section 4.6.9)	Extremely Unlikely	57 L to atmosphere	See footnote "h"		See footnote "h"		See footnote "h"		See footnote "h"	

[a] Unless otherwise indicated, radiological doses are based on radiological source terms for a 1-MW power level and would be four times greater if the facility is operating at 4 MW. These doses are total EDEs and include dose from inhalation and immersion. "Offsite" means outside the site boundary rather than outside the proposed SNS facility boundary. Individual receptors are hypothetical and do not correspond to any actual person. Population receptors are based on the actual number of people residing outside the site boundary and within 50 mi (80 km) of the facility and the number of site workers normally within 1.2 mi (2 km) of the facility and not involved in facility operation.

[b] Refer to Table 5.2.9-2 for the numerical ranges associated with accident frequencies categories.

[c] Source terms are expressed in units that are independent of power level. Except for beyond-design-basis accidents (IDs 16a, 16b), the radioactivity released in accidents at 4 MW is four times that released at 1 MW.

[d] 40 CFR 61 limits dose to members of the public from airborne emissions from DOE facilities to 10 mrem/yr.

[e] Installation of sulfur-impregnated charcoal filters is being considered to serve as a "polishing filter" for the mercury condenser (refer to Event 17).

[f] Cryogenic charcoal absorbers are being considered as an alternative to the offgas compressor, decay storage tanks, and ambient temperature charcoal filters (refer to Events 24, 30, 31, and 32).

[g] Accidents involving tanker trucks may not be applicable for an proposed SNS facility at this site. It has not been determined how LLLW and process waste would be treated and disposed.

[h] Process waste accidental airborne releases occur at ground level. Only atmospheric dispersion factors for elevated releases were calculated for this site. Based on the radionuclide contents of LLLW and process waste source terms and results for BNL, doses for process waste accidents at this site are anticipated to be approximately 0.001 mrem or less for individuals and to be less than approximately 0.050 person-rem for the offsite population.

NA - Not available.

maximally exposed individual and 29 mrem for the uninvolved worker. These doses are approximately 10 percent of the 300 mrem received annually by the average person from background radiation. The offsite population dose of 1,500 person-rem corresponds to 0.75 excess LCFs.

At a power level of 1 MW, accidents involving the off-gas decay system (IDs 24 and 31) would result in the highest individual and population doses of potential accidents involving the waste handling systems. The dose to the maximally exposed member of the public for these two accidents is 10 mrem and 2.4 mrem for the maximally exposed uninvolved worker. The dose to the maximally exposed member of the public is approximately 3 percent of the 300 mrem received annually by the average person from natural background. The uninvolved worker dose is 3 percent of the average dose received by workers from normal operations at BNL (DOE 1996f). The population dose of 770 person-rem corresponds to 0.4 excess LCFs.

At a power level of 4 MW, the potential consequences of all accidents, except ID 16, would increase by a factor of 4 but would still represent quantified dose of less than 10 mrem to maximally exposed individuals. For the “beyond extremely unlikely” mercury spill (ID 16b), dose to the maximally exposed member of the public would be 2,200 mrem and 920 mrem to the maximally exposed uninvolved worker. The dose to the maximally exposed member of the public is slightly more than 7 times the annual dose from natural background radiation and corresponds to an individual excess risk of LCF of about 1 in 910 chances (0.0011 LCFs).

The dose to the maximally exposed individuals from the off-gas decay system accidents (IDs 24 and 31) would be 41 mrem for the public individual, about 15 percent of the 300-mrem annual dose for natural background, and 9.6 mrem for the uninvolved worker.

Because of the large offsite population and the conservative assumptions underlying the use of dose-to-risk factors, the quantified adverse effects are large for four accidents should they occur at a power level of 4 MW. The accident with the greatest potential consequences is the beyond-design-basis mercury spill (ID 16b). The population dose of 170,000 person-rem corresponds to 85 excess LCFs. The probability that this accident would occur in a given year is less than 1 chance in 1,000,000. Another mercury spill accident (ID 2b) also has quantified adverse health effects in the offsite population. The population dose for this accident of 3,800 person-rem corresponds to 1.9 excess LCFs. The probability that this “extremely unlikely” accident would occur in a given year is between 1 chance in 10,000 and 1 chance in 1,000,000.

The two accidents involving the offgas decay system (ID 24 and ID 31) have the same emission source term and also would have the potential for adverse effects in the offsite population quantified with a magnitude greater than 1.0. The population dose from either accident of 3,100 person-rem corresponds to 1.6 excess LCFs. Accident ID 31 is “extremely unlikely”; Accident ID 24 is “anticipated.” Section 5.2.9.3.3 discusses several simple mitigation actions that could be taken that would reduce the frequency of occurrence of Accident ID 24 to “unlikely.”

As discussed in Section 5.2.9.2.1, LCF values of 1.0 or greater do not mean that fatalities would actually occur in the offsite population but provide a quantified value for use in comparison between alternatives.

5.5.9.3.4 Hazardous Materials Accidents

Accidents involving potential exposure to toxic materials are discussed in Section 5.2.9.3.4. All involve spills of irradiated mercury. Accident IDs 2b, 16a, and 16b could result in the OSHA ceiling concentration of 0.1 mg/m^3 being exceeded for a few minutes in locations accessible to workers during the initial stages of these accidents, but it would not be exceeded at or beyond the BNL site boundary. Thus for only a few minutes at the start of the accident, mercury concentrations at or beyond the site boundary might exceed TEEL-1 limit (0.075 mg/m^3) but would not exceed the TEEL-2 limit (0.10 mg/m^3); individuals at the boundary at the precise occurrence of the initial emission might perceive an odor but would not experience or develop irreversible health effects or symptoms that could impair the ability to take protective action.

The secondary and tertiary stages of these accidents are conservatively assumed to last from 7 to 30 days, while in reality, administrative and emergency response actions would more probably terminate the release in a shorter time period. During these stages, airborne concentrations of mercury would remain two to three orders of magnitude below the TEEL-0 limit of 0.05 mg/m^3, and no observable detrimental effects would be expected to occur.

5.5.10 SUPPORT FACILITIES AND INFRASTRUCTURE

This section summarizes the facilities and infrastructure effects on BNL transportation and utility systems from construction and operation of the proposed SNS facility.

5.5.10.1 Transportation

As described in Section 3.2.5, Alternative Sites, construction of the proposed SNS, related infrastructure, and support systems would occur at BNL, located in Suffolk County on Long Island in the state of New York. The wooded and largely undeveloped BNL site is bordered on the south by I-495, on the west by the William Floyd Parkway, on the north by State Highway 25, and on the east by County Route 25. Primary access to BNL is provided via Princeton Avenue from the William Floyd Parkway.

A recent BNL traffic study indicated that the current site population is approximately 3,100 with approximately 2,500 daily round-trips. In 1990, a transportation master plan was completed for BNL. The transportation plan evaluated traffic circulation effects for a future site population of 3,800 employees. At that time, the BNL site population was approximately 3,400 (Vollmer Associates, 1990).

Construction vehicles would transport necessary concrete, steel, and related building materials. Construction employee and vehicle activity would increase during the first years of construction, peaking in 2002, and would decrease significantly during the last year (2004) of construction. The estimated total of 578 construction employees in the peak construction year (2002) is expected to add approximately 466 daily round-trips and 10 material/service trucks. This represents a 16 percent increase. This increase is considered to be below a level of significance and, therefore, would not result in significant traffic impacts to the site or surrounding area. However, the nature of the construction vehicles, given their size and speed, would affect traffic composition, and they may affect the flow of vehicles approaching and within BNL during construction. The implementation of mitigation measures, as described in Section 5.10, would minimize such adverse effects.

After construction, operation of the proposed SNS would result in an additional 250 resident/visiting scientists by 2006 and another 125 employees during future facility upgrades. The long-term total of an additional 375 people and 3 service trucks/day (approximately 305 daily round-trips) is not expected to exceed the 1990 Traffic Master Plan's projection of 3,800 employees for the entire BNL facility. Therefore, no significant effects would be expected from operation of the proposed SNS facility at BNL.

Table 5.5.10.1-1 compares the No-Action Alternative with the proposed action at BNL. The table provides the percentage increase in traffic resulting from the proposed SNS facility during construction and operation, as compared to that of the No-Action Alternative. The table also provides the percentage increase using existing site data, as well as projected data for the site. Potential effects of these modest traffic increases could be reduced by having craft and non-craft workers report to work at different times, thus reducing the adverse effects on traffic flow during rush hours. Additionally, this analysis assumed there would be no transferring of personnel from within BNL. If some of the workers were previously working at BNL, the impact on traffic would be reduced.

5.5.10.2 Utilities

This section assesses the potential consequences of the proposed SNS on utilities and utilities infrastructure at BNL.

5.5.10.2.1 Electrical Service

As described in Section 3.2.3.4, the proposed SNS facility would require large supplies of electrical power for operation. In order to accommodate the 4-MW proposed SNS, a new

Table 5.5.10.1-1. BNL traffic increases compared to No-Action Alternative.

	Baseline No-Action	(Peak Year) SNS Construction	(4 MW) SNS Operation
Passenger vehicle trips[a]/day	2,500	466	302
Material transport trucks/day	0	7	0
Service trucks/day	0	3	3
Total (% increase)	0 (0%)	476 (16%)	305 (11%)

[a]Based on BNL site population of 3,100.

69-kV transmission line would be required. This line would extend to the Long Island Lighting Company's (LILCO) 138-kV grid, located on the southeast corner of BNL. The length of the line would be approximately 1 mi (1.6 km) and would parallel BNL's existing 69-kV transmission line. The LILCO grid would require a new 138- to 69-kV substation. Required upgrades to the electrical system would occur within existing infrastructure corridors or alignments. Therefore, environmental effects resulting from this upgrade in electrical service at BNL are expected to be minor.

5.5.10.2.2 Steam

The proposed SNS facility does not necessarily require steam for facility heating; however, steam is available at BNL. The present steam load peaks at 170,000 lb/hr. The existing steam plant has a firm capacity of 295,000 lb/hr. It would be necessary to extend the existing steam pipeline approximately 4,000 ft (1,219 m) to service the proposed SNS facility. The existing steam capacity would be sufficient to meet the 1,500 lb/hr required by the proposed SNS to deal with the Long Island climate. Environmental effects on steam resulting from the proposed SNS facility at BNL would be expected to be inconsequential.

5.5.10.2.3 Natural Gas

Natural gas would provide energy for operational equipment such as boilers and localized unit heaters in the proposed SNS facility's heating system. As described in Section 4.4.10.2.3, natural gas at BNL is distributed from an existing main located near the electrical substation at the southeast corner of the laboratory. Natural gas is distributed to the Central Steam Facility for steam production. Current usage peaks at approximately 200,000 ft^3/hr, and 40,000 ft^3/hr would be available for the proposed SNS. Thus, environmental effects on natural gas distribution to the proposed SNS facility at BNL are expected to be inconsequential.

5.5.10.2.4 Water Service

The proposed SNS facility would require water supplies for the following systems: tower water cooling, deionized cooling, chilled water, building heating, process water, potable water, demineralized water, fire suppression, and target moderators.

The water supply at BNL is obtained from six onsite wells. As described in Section 4.4.10.2.4, the total pumping capacity of the wells is approximately 7,200 gpm (27,255 lpm). Average daily water usage at BNL is approximately 1 mgpd (3.8 million lpd). Given the available supply of water, onsite water treatment, and the water storage capacity at BNL, it is expected that the laboratory can provide the proposed SNS facility with water supplies from existing sources. Environmental effects on water service resulting from the proposed SNS are expected to be minor.

5.5.10.2.5 Sewage Treatment

The STP at BNL was recently renovated, bringing the hydraulic capacity of the plant to 3 mgpd (11.4 million lpd). Its peak use during a recent 10-year storm was 2.2 mgpd (8.3 million lpd). Therefore, sufficient capacity exists to accommodate the additional flow from the proposed SNS facility. Regarding the processing of biodegradable mass, the plant capacity is 250 to 500 lb/day. Approximately

40 lb enters the sewage plant daily. The addition of biodegradable mass from the proposed SNS is expected to improve the efficiency of the existing plant. Therefore, the BNL site would be able to provide sewage treatment for the proposed SNS facility, and environmental effects are expected to be negligible.

5.5.11 WASTE MANAGEMENT

All of the wastes generated during construction and operation of the proposed SNS would be transferred to BNL waste operations for processing. The existing waste management systems for sanitary wastes and liquid low-level radioactive wastes would have sufficient capacity to accommodate wastes from the proposed SNS facility. However, storage capacity for hazardous wastes, liquid low-level and solid LLWs, and mixed wastes would have to be expanded to accommodate SNS wastes.

Projections of construction and operations waste streams that would be generated at the proposed SNS facility include the following: hazardous waste, LLW, mixed waste, and sanitary/industrial waste, as listed in Table 3.2.3.7. A summarization of existing waste management facilities located at BNL, along with facility design and/or permitted capacities and remaining capacities, can be found in Table 5.5.11-1. Waste stream forecasts for BNL's individual operations, proposed SNS operation at 4 MW, and the aforementioned wastes are also included in Table 5.5.11-1. These forecasts cover the period from 1998 to 2040, unless otherwise noted. They are based on estimates given by waste management facility contacts and waste management documentation.

Before SNS wastes would be accepted for TSD at BNL, they would be certified to meet the WAC of the receiving TSD facility. As mentioned earlier in Section 5.2.11.1, AEA, EPA, and NRC limits for LLLW treatment facility WAC would also need to be addressed for BNL.

Currently, no hazardous waste treatment or disposal facilities are located at BNL. Hazardous wastes are collected, certified, and shipped to EPA-permitted commercial treatment or disposal facilities (Petschauer 1998a).

No LLW disposal facilities are located onsite at BNL. These wastes are collected, certified, and shipped to EPA-permitted commercial disposal facilities (Petschauer 1998a).

No mixed waste treatment or disposal facilities are located at BNL. These wastes are collected, certified, and shipped to permitted disposal facilities (Petschauer 1998a).

BNL has a waste certification process in place to ensure that wastes meet the WACs for LLW disposal. However, because of the uncertainty of the composition of LLW and mixed wastes that may be generated from operation of the SNS, the waste may not meet the current WAC for waste management facilities at BNL. DOE would take action to ensure the proper disposition of these wastes. For example, pretreatment of the waste may ensure that they meet the WAC. DOE may be able to amend the license at current waste disposal facilities to allow acceptance of wastes from the SNS.

Sanitary/industrial waste disposal facilities are not present at BNL. These wastes would be sent to a licensed disposal facility offsite (DOE 1997a).

Table 5.5.11-1. BNL waste management facility description and capacities.

Waste Disposition	Waste Type and Facility	Total Design Capacity for BNL Site	BNL Waste Projections for 1998-2040	Total Remaining Capacity for BNL Site (Excludes Proposed SNS Operations)	Proposed SNS Waste Operations Projection for 1998–2040	Potential Effect of Waste Management Facility
HAZARDOUS WASTE						
STORAGE	Liquid/Solid RCRA Hazardous Waste Storage Building	Drum storage bays (30,800 gal); chemical storage rooms (5,000 gal) 650 drums/yr	25 tons/yr (Estimate includes both liquids and solids) 100 drums/yr	NA	Hazardous Liquid 10,800 gal/yr (200 drums/yr)	No effect anticipated. DOE has contracts in place to dispose of hazardous waste.
LOW-LEVEL WASTE						
TREATMENT	Liquid Waste Concentration Facility	120,000 gal/yr	50,000 gal/yr	80,000 gal/yr	175,600 gal/yr LLLW 4.15E06 gal/yr process waste potentially LLLW	SNS volume exceeds capacity–waste can be processed at higher rate, if necessary.
	Solid None					
STORAGE	Solid Radioactive Waste Storage Building (Reclamation Building)	270 m^3	283 m^3/yr	270 m^3 – new facility	1,026 m^3/yr	Additional storage may be necessary; however, DOE has contracts in place for offsite disposal of LLW.
MIXED WASTE						
STORAGE	Solid/Liquid Mixed Waste Storage Building	22.70 m^3	2 m^3/yr	20.70 m^3 – new facility	Liquid 10.8 m^3/yr Solid 7 m^3/yr	No effect anticipated. Wastes are collected, certified, and shipped to permitted facilities.

Table 5.5.11-1. BNL waste management facility description and capacities (continued).

Waste Disposition	Waste Type and Facility	Total Design Capacity for BNL Site	BNL Waste Projections for 1998-2040	Total Remaining Capacity for BNL Site (Excludes Proposed SNS Operations)	Proposed SNS Waste Operations Projection for 1998-2040	Potential Effect on Waste Management Facility
SANITARY WASTE						
TREATMENT	<u>Liquid</u> Waste Water Treatment Facility	2.3 mgd	800,000 gpd	1.5 mgd	18,750 gpd	No effect anticipated.
	<u>Solid</u> None					
DISPOSAL	<u>Solid</u> Offsite landfills		<u>Trash</u> 842.4 ton/yr <u>Construction Waste</u> 844 ton/yr	NA Offsite landfills	1,349 m³/yr	No effect anticipated.

Sources: DOE 1997a; Naidu et al. 1996; Petschauer 1998a; Petschauer 1998b.
NA – Not applicable.

Excess soil, construction wastes, and sanitary wastes would be generated during construction of the proposed SNS. Excavated soil and rock would be used for backfill, erosion control, or other environmental purposes. Construction debris would be sent to a Class IV landfill. Liquid sanitary wastes would be transported to the sanitary wastewater treatment plant at BNL. Solid sanitary waste would be sent to a sanitary landfill (ORNL 1997b).

As stated in Section 5.2.11, in accordance with the *NSNS Waste Minimization and Pollution Prevention Plan*, considerations for minimizing the production of SNS waste would be implemented.

5.6 NO-ACTION ALTERNATIVE

The No-Action Alternative, as described in Section 3.4, is the alternative under which the proposed SNS facility would not be constructed. This section describes the effects on the existing environment that would result from implementation of this alternative.

5.6.1 GEOLOGY AND SOILS

If the proposed SNS facility is not constructed, there would be no disturbance of geological formations or soils. In addition, there would be no possibility of soil activation. Consequently, the No-Action Alternative would have no effects on geology and soils.

5.6.2 WATER RESOURCES

If the proposed SNS facility is not constructed, there would be no effects on surface water or groundwater resources. Because no soils would be activated, there would be no chance of activation products reaching groundwater. Without operation of the proposed SNS facility, there would be no discharges of cooling water to surface waters. Consequently, implementation of the No-Action Alternative would have no effects on water resources.

5.6.3 AIR QUALITY

No excavation would occur under the No-Action Alternative; thus, there would be no increase in fugitive dust. There would be no deterioration of air quality from construction or operation of the proposed SNS. As a result, implementation of this alternative would have no effects on air quality.

5.6.4 NOISE

No increases in noise levels would occur under the No-Action Alternative because no facility construction or operations would occur. Consequently, its implementation would have no effects on the noise environment.

5.6.5 ECOLOGICAL RESOURCES

This section describes the potential effects implementation of the No-Action Alternative would have on ecological resources. It includes potential effects on terrestrial and aquatic resources, wetlands, and threatened and endangered species.

5.6.5.1 Terrestrial Resources

The proposed SNS facility would not be constructed on any area of land under the No-Action Alternative. As a result, implementation of this alternative would have no effects on terrestrial resources.

5.6.5.2 Wetlands

No area of land would be used for construction of the proposed SNS under the No-Action Alternative. As a result, no wetland areas would be filled, excavated, or otherwise disturbed. Consequently, implementation of this alternative would have no effects on wetlands.

5.6.5.3 Aquatic Resources

The proposed SNS facility would not be constructed on any area of land under the No-Action Alternative. As a result, this alternative would have no effects on aquatic resources.

5.6.5.4 Threatened and Endangered Species

No area of land would be used for construction of the proposed SNS under the No-Action Alternative. No habitats for endangered or threatened plant or animal species would be affected. Consequently, implementation of this alternative would have no effects on endangered or threatened species.

5.6.6 SOCIOECONOMIC AND DEMOGRAPHIC ENVIRONMENT

This section describes the potential effects on the socioeconomic and demographic environment that would result from implementation of the No-Action Alternative.

5.6.6.1 Demographic Characteristics

Under the No-Action Alternative, there would be no in-migrating construction or operations workers. Therefore, there would be no effects on population growth trends or projections or the race or ethnicity of populations. Consequently, implementation of this alternative would have no effects on the demographic environment.

5.6.6.2 Housing

Under the No-Action Alternative, there would be no in-migrating construction or operations workers who would need housing. Therefore, there would be no effects on numbers of housing units, vacancy rates, housing sales, or apartment vacancy rates. Consequently, implementation of this alternative would have no effects on housing.

5.6.6.3 Infrastructure

Under the No-Action Alternative, there would be no in-migrating construction or operations workers who would need community services. There would be no effects on schools, health care, police protection, or fire protection services. Consequently, implementation of this alternative would have no effects on infrastructure.

5.6.6.4 Local Economy

The proposed SNS facility would not be constructed or operated under the No-Action Alternative. Therefore, no communities would receive additional benefits from increased construction or operations jobs at the proposed SNS. Consequently, the No-Action Alternative would have no effects on local economies.

5.6.6.5 Environmental Justice

Under the No-Action Alternative, there would be no proposed SNS facility, and as such, it would not cause any disproportionately high and adverse human health or environmental effects on minority populations or low-income populations, including Native Americans. Consequently, implementation of the No-Action Alternative would have no effects on environmental justice.

5.6.7 CULTURAL RESOURCES

This section assesses the potential effects on cultural resources that would result from implementation of the No-Action Alternative.

5.6.7.1 Prehistoric Resources

The No-Action Alternative would involve no disturbance of ancient archaeological sites, artifacts, structures, or features at any location. As a result, implementation of this alternative would have no effects on prehistoric cultural resources.

5.6.7.2 Historic Resources

This alternative would involve no disturbance of historic archaeological sites, artifacts, objects, structures, features, or written records. Consequently, implementation of the No-Action Alternative would have no effects on cultural resources dating to the Historic Period.

5.6.7.3 Traditional Cultural Properties

The No-Action Alternative would involve no disturbance of significant places or objects associated with the historical and cultural practices or beliefs of a living community. Consequently, its implementation would have no effects on TCPs.

5.6.8 LAND USE

This section assesses the potential effects on land use that would result from implementation of the No-Action Alternative.

5.6.8.1 Current Land Use

No existing parcel of land would be used for construction of the proposed SNS under the No-Action Alternative. Consequently, implementation of this alternative would have no effects on current land use.

5.6.8.2 Future Land Use

No existing parcel of land would be used for construction of the proposed SNS under the No-Action Alternative. Consequently, implementation of this alternative would have no effects on future land use.

5.6.8.3 Parks, Preserves, and Recreational Resources

No existing parcel of land would be used for construction of the proposed SNS under the No-Action Alternative. Consequently, implementation of this alternative would have no effects on parks, nature preserves, or recreational resources.

5.6.8.4 Visual Resources

No existing parcel of land would be used for construction of the proposed SNS under the No-Action Alternative. Consequently, implementation of this alternative would have no effects on visual resources.

5.6.9 HUMAN HEALTH

This section assesses the potential effects on human health that would result from implementation of the No-Action Alternative.

5.6.9.1 Construction

There would be no risk of adverse effects on the health of SNS workers or the public due to injury or exposure to radioactive or toxic materials since no construction would take place. Consequently, implementation of the No-Action Alternative would have no effects on the health of construction workers or the public.

5.6.9.2 Normal Operations

There would be no risk of adverse effects on the health of workers or the public from exposure to direct radiation or to emissions of radioactive or toxic materials during normal operations of the proposed SNS facility since the SNS would not operate. Consequently, the No-Action Alternative would have no effects on the health of workers or the public.

5.6.9.3 Accident Conditions

There would be no risk of adverse effects on the health of workers or the public from exposure to direct radiation or to emissions of radioactive or toxic materials as the result of accidents during operations of the proposed SNS since the SNS would not operate. Consequently, implementation of the No-Action Alternative would have no effects on the risk of accidents for workers or the public.

5.6.10 SUPPORT FACILITIES AND INFRASTRUCTURE

There would be no additional demands on support facilities and infrastructure because the proposed SNS facility would not be constructed or operated. Consequently, implementation of the No-Action Alternative would have no effects on support facilities or infrastructure.

5.6.11 WASTE MANAGEMENT

No wastes would be generated under the No-Action Alternative. Consequently, this alternative would have no effects on waste management.

5.7 CUMULATIVE IMPACTS OF THE ALTERNATIVES

The Council on Environmental Quality (CEQ) regulations that implement the procedural provisions of the National Environmental Policy Act (NEPA) define cumulative impacts as effects on the environment that result from the addition of the incremental effect of the proposed action to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes the other actions (40 CFR 1508.7). This chapter describes cumulative impacts for geology and soils, water resources, air quality, ecological resources, socioeconomic and demographic characteristics, cultural resources, land use, human health, infrastructure, and waste management facilities.

In the earlier discussions in this chapter, the potential environmental effects of the proposed SNS facility were evaluated with respect to existing conditions or "background." This takes into account past and present actions on the alternative sites and in the vicinity of the alternative sites. Therefore, discussions in this section will center on the potential effects of reasonably foreseeable future actions in the vicinity of the alternative sites in conjunction with the potential effects from construction and operation of the proposed SNS. The reasonably foreseeable future actions included in the discussions for each alternative site were determined from planning documents and through communications with each site to identify potential actions that may contribute to cumulative impacts on or in the vicinity of the laboratory.

No reasonably foreseeable future actions by nonfederal agencies or persons that might contribute to cumulative impacts were identified.

5.7.1 ORNL ALTERNATIVE (PREFERRED ALTERNATIVE)

The actions that DOE considers reasonably foreseeable and pertinent to the analysis of cumulative impacts for the ORNL Alternative are described in this section. The proposed locations of these actions are shown in Figure 5.7.1-1. These actions are as follows.

Parcel ED-1. DOE completed an environmental assessment (DOE-ORO 1996) for the proposed lease of 957.16 acres of land within the ORR to the East Tennessee Economic Council, a non-profit organization, for a period of 10 years with an option for renewal. The East Tennessee Economic Council proposes to develop an industrial park on the leased site to provide employment opportunities for DOE and contractor employees affected by decreased federal funding. DOE has determined that this action is not a major federal action that would significantly affect the quality of the human environment. However, Parcel ED-1 is included in the discussions of cumulative impacts.

Upgrades to the High Flux Isotope Reactor. DOE is planning several upgrades to the High Flux Isotope Reactor (HFIR) at ORNL. These upgrades include a new Users Facility, a Neutron Science Support Building, and Accelerator and Reactor Improvements and Modifications. Based on the NEPA documentation for these actions (Hall, 1989; Hall, 1996; and Hall, 1997), no environmental effects that would contribute to cumulative impacts with the proposed SNS are anticipated.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Waste Disposal Facility. DOE has published a Remedial Investigation/Feasibility Study for the disposal of ORR CERCLA wastes (DOE-ORO 1998). Alternatives in the Remedial Investigation/Feasibility Study include disposal of CERCLA wastes offsite and in a new disposal facility to be constructed on the ORR. Three alternative sites on the ORR have been considered; two just north of Bear Creek Road and the third along State Highway 95 at the interchange with State Highway 58. The Proposed Plan and Record of Decision (ROD) for the CERCLA Waste Disposal Facility have not been published, so no decisions concerning the construction of this facility on the ORR have been made.

Joint Institute for Neutron Science. This is a facility being funded by the State of Tennessee.

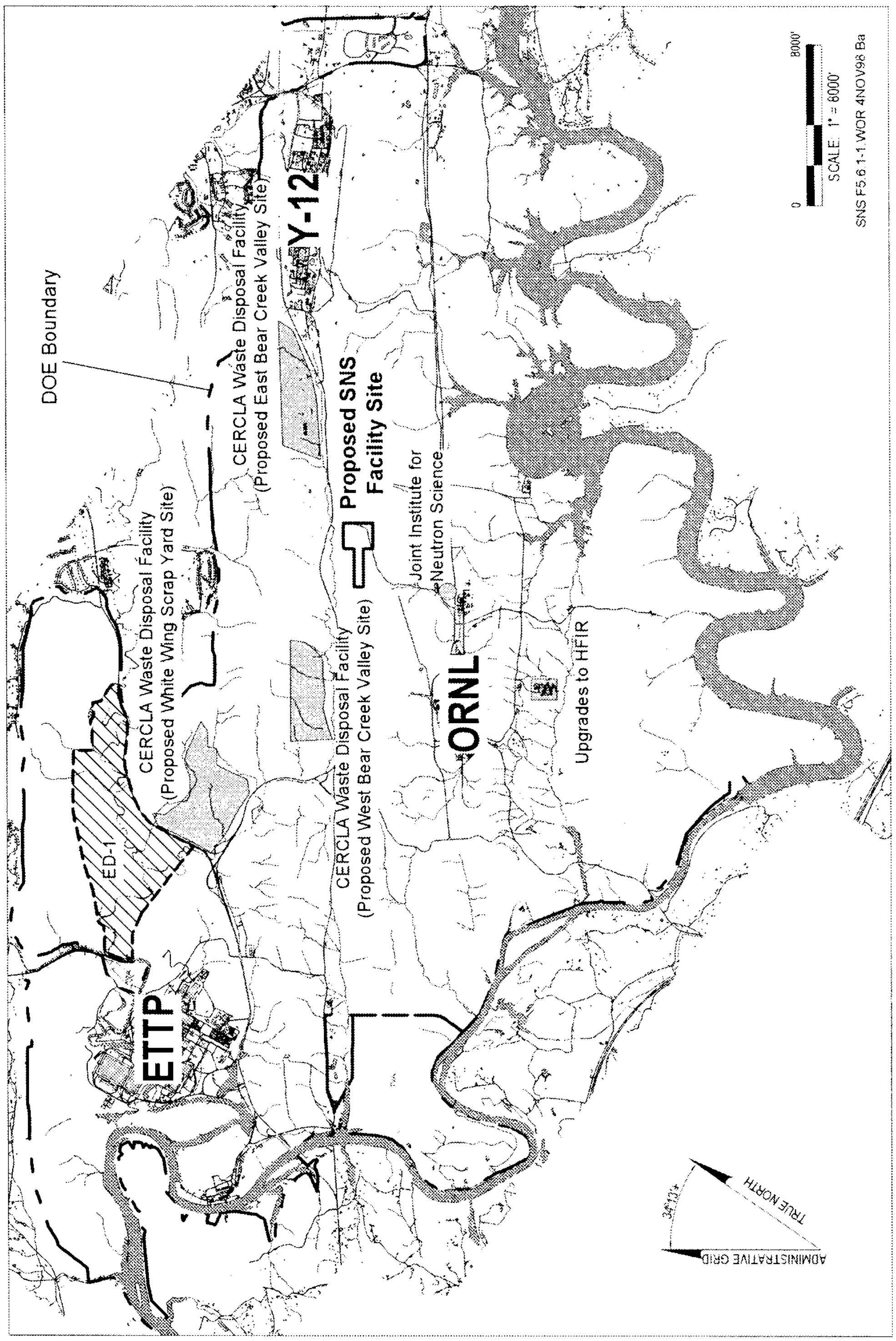

Figure 5.7.1-1. Locations of actions used in the ORNL cumulative impacts analysis.

It would be constructed near the intersection of Bethel Valley Road and Chestnut Ridge Road on the ORR. Because this would be a state-funded project, Joint Institute for Neutron Science (JINS) would not be a DOE facility. The facility would provide accommodations, including hotel rooms, offices, and meeting rooms, for scientists visiting the neutron science facilities at ORNL. The Division of Facilities Planning, University of Tennessee, is designing the facility. Construction is expected to begin in the summer of 1999, and occupancy would begin in the summer of 2000. NEPA documentation for this facility would be completed in 1999.

5.7.1.1 Geology and Soils

Construction and operation of the proposed SNS facility would not contribute to the cumulative impact on the geology or soils of the ORR or surrounding communities. The proposed SNS would be designed as a stand-alone facility that is physically removed from the main plant area of ORNL. No significant problems have been identified in regard to site stability, seismic risk, or the soil medium that would constitute impacts by themselves (refer to Section 5.2.1) or combine with existing or future conditions to create cumulative impacts.

5.7.1.2 Water Resources

Construction and operation of the proposed SNS would not contribute to the cumulative impact on the surface water and groundwater of the ORR or surrounding communities. Increased surface water flow due to the discharge from the proposed SNS facility would have temporary effects on the erosion patterns of WOC and would increase the flow over White Oak Dam by a small amount (refer to Section 5.2.2). However, information to date shows no future activities within ORNL that would add to the current or proposed SNS discharge to further increase flows within WOC, thereby creating cumulative impacts.

The primary effect of the proposed SNS facility operations on the groundwater of the site would be the activation and leaching of radionuclides (refer to Section 5.2.2.3.2). Since no other radiological source exists in close proximity to the proposed SNS site and radionuclides from the SNS linac tunnel would decay prior to significant transport away from the site, no cumulative impacts would occur. Similarly, no current or planned activities would affect the groundwater supply at the proposed SNS site on Chestnut Ridge.

5.7.1.3 Air Quality

Potential cumulative impacts on air quality are discussed with reference to the air quality in Roane County. Table 5.2.3.2-2 provides collective effects of the ten small boiler stacks at the proposed SNS facility by adding the model-projected maximums for those stacks for each pollutant to an assumed background concentration developed from ambient monitoring maximums measured near the site. These values were then compared to appropriate NAAQS, and no exceedances were noted.

Table 5.7.1.3-1 indicates total hourly emission rates from the ten stacks and compares these values to county-wide average hourly emission rates. The very small percentage increase attributed to the proposed SNS facility is also shown.

No effects from the emission of air pollutants were identified in the NEPA documentation for the development of Parcel ED-1, the CERCLA

Table 5.7.1.3-1. Comparison of SNS boiler emission rates to county-wide emission totals.

	SNS Emissions (lb/hr)[a]	Roane County Total Average Emission Rate (lb/hr)	% Increase from SNS Emissions
SO_2	0.02	26,947	0.000074
NO_x	3.49	8,634	0.04
CO	0.73	394	0.18
Particulate matter (PM_{10})	0.42	246 (TSP)[b]	0.17

[a] Based on cumulative output of 10 boilers at the proposed SNS with total heat load of 34,870,000 Btu/hr. Boilers do not operate at total heat load continuously.
[b] TSP - total suspended particulates

Waste Disposal Facility, JINS, or the upgrades to HFIR. Similarly, the emissions from the proposed SNS would have a minimal effect on air quality because they would not exceed regulatory standards. The addition of these low SNS emissions to those of the other facilities would be expected to result in a minimal cumulative impact on the air quality of the ORR.

5.7.1.4 Noise

The anticipated future actions would generate additional levels of noise, especially during construction periods. However, these projects would be constructed at different time periods and on different ORR locations. As such, the noise levels would only be additive to existing background noises. Noise effects from the proposed SNS at ORNL are described in Section 5.2.4. It is anticipated that the highest levels would occur during construction and would approach a typical noise level of approximately 86 dBA for such activities. However, the proposed SNS at ORNL would be located in a remote portion of the ORR and would not contribute to other noise sources to increase the overall noise amplitude at the site. Hence, no cumulative impacts are predicted for noise on the ORR.

5.7.1.5 Ecological Resources

This section presents the potential cumulative impacts on ecological resources at ORNL.

5.7.1.5.1 Terrestrial Resources

The ORR has a total of 34,516 acres (13,794 ha) of land. About 80 percent of this land is covered with forest. Approximately 110 acres (45 ha) of forest would be cleared for the proposed SNS. The other planned actions for the ORR would also require the clearing of forests. Parcel ED-1 would require clearing of approximately 500 acres (202 ha) of land (Medley 1998:1). The site for the CERCLA Waste Disposal Facility has not been selected; however, the largest area of land that would have to be cleared is approximately 126 acres (51 ha), if the White Wing Scrap Yard site is selected (Jacobs 1998). Construction of the JINS would require clearing approximately 4 acres (1.6 ha). The HFIR upgrades would occur in developed areas; no forests would be cleared. Thus, the total amount of forest to be cleared, including forest on the proposed SNS site, would be 740 acres (300 ha). This would reduce the total acreage of forest on the ORR by approximately 2.5 percent.

This reduction in forested land may reduce the overall population of terrestrial wildlife utilizing the forest habitat. However, this reduction would be minimal, as the reduction in forest habitat is minimal.

5.7.1.5.2 Wetlands

The proposed SNS facility would cause an incremental impact to wetlands on the ORR. Depending on the site selected for the CERCLA Waste Disposal Facility, up to 0.7 acres (0.3 ha) of wetlands would be destroyed. No impacts on wetlands were identified for construction of the JINS or in the environmental assessment for development of Parcel ED-1. Thus, a cumulative total of approximately 1 acre (0.4 ha) of wetlands would be destroyed in the ORR. Each wetland is less than 1 acre (0.4 ha); thus, they do not fall under USACOE jurisdiction. However, the Tennessee Department of Environment and Conservation (TDEC) does not recognize a *de minimis* size for protection of wetlands. Before construction, DOE would secure regulator approval of the mitigation plan to minimize these impacts. Therefore, cumulative impacts on ORR wetlands would be minimal.

5.7.1.5.3 Aquatic Resources

As stated in Section 5.2.5.3, construction of the proposed SNS on the Chestnut Ridge site would have minimal effects on WOC. None of the other projects proposed for the foreseeable future would impact WOC; thus, no cumulative impacts are anticipated.

5.7.1.5.4 Threatened and Endangered Species

As stated in Section 5.2.5.4, the effects of construction of the proposed SNS on the Chestnut Ridge site can be mitigated and would be expected to be minimal. The CERCLA Waste Disposal Facility is also expected to have minimal effects on protected species at any of the three alternative sites (Jacobs 1998). Areas within Parcel ED-1 that may contain protected species or habitat for protected species would be protected during the development of this parcel (DOE-ORO 1996). No effects on protected species have been identified for the HFIR upgrade projects, and enough flexibility exists in siting of the JINS to avoid effects on protected species. Therefore, cumulative impacts on protected species on the ORR would be expected to be minimal.

5.7.1.6 Socioeconomic and Demographic Characteristics

Service sector businesses, government operations (federal, state, and local), retail trade, and manufacturing dominate the economics of the ORNL ROI. Activities included in operation of the ORR are estimated to account for more than 7 percent of the employment, wage and salary, and business activities in the four-county ROI. The effects from upgrades to the HFIR and construction and operation of the JINS would be minimal. The existing onsite workforce would accomplish construction of the upgrades to HFIR, and the current operations staff would operate it. No new jobs would be created, and there would be no effects on housing or community services. JINS is a small facility that would be constructed in less than one year and would be operated by a few people. Construction and operations jobs are expected to be filled by current residents, and there would be no additional effects on housing or community infrastructure.

The goal of the Parcel ED-1 project is to create 1,500 new jobs over the next 10 years. Given the number of persons displaced by DOE downsizing at the ORR facilities in the past five years and the number of unemployed persons in the ROI, it is likely that almost all the direct and indirect jobs created by the development of Parcel ED-1 would be filled by current residents of the ROI. Thus, it is expected that worker in-migration resulting from the proposed action and the effects on housing and community services would be insignificant (DOE-ORO 1996).

The incremental effects from locating the proposed SNS facility on the economy and community infrastructure of the ROI would be minimal. There would be some positive economic benefits in the form of new jobs created by construction and operation of the proposed SNS. Construction of the proposed SNS facility would require 578 full-time employees during the peak year and from 250 to 375 (1 MW to 4 MW) during operations. Most of the construction workforce and about half of the operations workforce would come from the ROI, and as such, the effects on housing and community services would be minimal. The details of these effects are given in Section 5.2.6.

No effects to environmental justice were identified from the upgrades to the HFIR, the construction and operation of the JINS, the construction of a CERCLA Waste Disposal Facility, or the development of Parcel ED-1. The proposed SNS facility would also not have any effects on environmental justice at ORNL. Therefore, there would be no cumulative impacts on environmental justice.

5.7.1.7 Cultural Resources

The cumulative impacts of the proposed action and other actions on the cultural resources of the ORR are assessed in this section.

5.7.1.7.1 Prehistoric Resources

No prehistoric sites listed on or considered to be eligible for listing on the NRHP have been identified on the proposed SNS site at ORNL or in its vicinity. As a result, the proposed action would have no effects on prehistoric cultural resources. Therefore, the proposed action would not contribute to cumulative impacts on the prehistoric cultural resources of the ORR.

5.7.1.7.2 Historic Resources

No Historic Period sites, structures, or features listed on or considered to be eligible for listing on the NRHP have been identified on the proposed SNS site at ORNL or in its vicinity. As a result, the proposed action would have no effect on Historic Period cultural resources. Therefore, the proposed action would not contribute to cumulative impacts on the Historic Period cultural resources of the ORR.

5.7.1.7.3 Traditional Cultural Properties

No TCPs of special sensitivity or concern to the Cherokee are known to exist on the proposed SNS site at ORNL or anywhere else on the ORR. As a result, no TCPs would be affected by implementation of the proposed action. Therefore, the proposed action would not contribute to cumulative impacts on the TCPs of the ORR.

5.7.1.8 Land Use

The cumulative impacts of the proposed action and other actions on ORR land use are assessed in this section.

5.7.1.8.1 Current Land Use

The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the basic characteristics of the land that influence land use in the vicinity of the ORR and on most of the ORR. This would also be true of the effects from industrial development of Parcel ED-1, the CERCLA Waste Disposal Facility, upgrades to HFIR, and JINS. Therefore, these would have no reasonably discernible cumulative impacts on current land use outside the ORR or throughout most of the reservation.

The proposed action would introduce large-scale development to approximately 110 acres (45 ha) of proposed SNS site land on the ORR. The Parcel ED-1 industrial park would introduce development to about 500 acres (202 ha) of ORR land (Medley 1998: 1). If the White Wing Scrap Yard is selected for the onsite CERCLA Waste Disposal Facility, 126 acres (51 ha) of undeveloped land would be affected by the project (Jacobs 1998: 7-14 and 8-17). The JINS would introduce development to no more than 4 acres (1.6 ha) of ORR land. The HFIR upgrades would occur in developed and disturbed areas of the 7900 complex at ORNL (Hall 1989: 1; Hall 1996: 1 and 3; Hall 1997: 1 and 4).

The ORR has approximately 22,490 acres (8,903 ha) of undeveloped land (Medley 1998: 1). Cumulatively, the foregoing facilities would introduce development to about 740 acres (294 ha), which is only 3.3 percent of the undeveloped land on the ORR. Therefore, this cumulative impact on undeveloped ORR land would be minimal.

The proposed action would effectively change the current use of 110 acres (45 ha) of land on the proposed SNS site from Mixed Research/Future Initiatives to Institutional/Research. The current use of CERCLA Waste Disposal Facility land [White Wing Scrap Yard (high-end scenario)] is Mixed Research/Future Initiatives. If this new waste management facility is built at the scrap yard location, the use of approximately 126 acres (51 ha) of land would change to the Industrial use designation. If JINS is built, approximately 4 acres (1.6 ha) of current Mixed Research/Future Initiatives land would change to Institutional/Research. Current use of the 500 acres (202 ha) slated for development in Parcel ED-1 would have been designated as Mixed Research/Future Initiatives at one time, but, in anticipation of industrial development, its current designation has become Mixed Industrial. No changes in current land use would result from the HFIR upgrades.

The current use of approximately 20,000 acres (8097 ha) of ORR land is Mixed Research/Future Initiatives. In addition, approximately 957 acres (387 ha) of land on Parcel ED-1 would have been designated as Mixed Research/Future Initiatives prior to its reclassification in anticipation of industrial development. For the purposes of this cumulative impacts assessment, these figures are summed to obtain a total of 20,957 acres (8,485 ha) of Mixed Research/Future Initiatives land. Cumulatively, the facilities in the foregoing paragraph would change the current use of about 740 acres (300 ha) of Mixed Research/Future Initiatives land. This is only 3.5 percent of the Mixed Research/Future Initiatives land on the ORR. Therefore, this cumulative impact on current land use would be minimal.

National Environmental Research Park

Pollutant emissions from the proposed SNS facility (CO_2 and possibly H_2O vapor) would adversely affect the NOAA TDFCMP and ORNL-ESD ecological research projects in the nearby Walker Branch Watershed (refer to Section 5.2.8.1.1). Construction and operation of the SNS would reduce the current environmental research potential on the approximately 241 acres (98 ha) of land that comprise the Walker Branch Watershed research area (Hanson 1998: 1). Construction of the proposed SNS facility would reduce the current environmental research potential of a minimum 110 acres (45 ha) of NERP land on the proposed SNS site. The CERCLA Waste Disposal Facility [White Wing Scrap Yard (high-end scenario)] would effectively reduce the current environmental research potential of 126 acres (51 ha) of NERP land. The CERCLA documentation for this project indicates that NERP activities, such as research, could be affected by this facility but does not specify any particular environmental monitoring or research projects that would be clearly affected by this facility (Jacobs 1998: 8-32). Industrial construction and operations on Parcel ED-1 would reduce the current environmental research potential of up to 500 acres (202 ha) of NERP land. However, the NEPA documentation for this project does not indicate specific, current environmental monitoring or research projects that would be affected (DOE-ORO 1996: F-3 and 4-1). The HFIR upgrades would have no effect on the current use of ORR land for environmental monitoring or research. JINS would reduce the current environmental research potential of 4 acres (1.6 ha) of NERP land. However, it is not expected to affect current environmental monitoring or research projects on ORR land.

The ORR NERP contains approximately 21,980 acres (8,899 ha) of land. Cumulatively, the proposed action, CERCLA Waste Disposal Facility, Parcel ED-1, and JINS would reduce the current environmental research potential of 981 acres (391 ha) of NERP land. However, this would be only 4.5 percent of the NERP land on the ORR. Therefore, this cumulative impact on the current research potential of NERP land would be minimal. The cumulative impacts of the foregoing actions on environmental research projects would be uncertain.

5.7.1.8.2 Future Land Use

The proposed action would be compatible with DOE zoning of ORR land on the proposed SNS site. Therefore, it would not contribute to cumulative impacts involving the future use of land for purposes other than those for which it is zoned.

Walker Branch Watershed

Future operation of the proposed SNS facility over a 40-year period would have continuing adverse effects on CO_2 and possibly H_2O vapor monitoring under the TDFCMP in the Walker Branch Watershed unless effective mitigation measures are implemented to minimize these effects. Future ORNL-ESD ecological research projects in this area would also be adversely affected by CO_2 and H_2O vapor emissions from the proposed SNS. However, the NEPA/

CERCLA documentation for the CERCLA Waste Disposal Facility, Parcel ED-1, and HFIR upgrades does not indicate effects from these actions on future environmental research projects. No such effects are anticipated from JINS. Therefore, the cumulative impacts of the foregoing actions on future environmental research projects would be uncertain.

Common Ground Process and End Uses of ORR Land

The proposed action and CERCLA Waste Disposal Facility [White Wing Scrap Yard (high-end scenario)] would be cumulatively at variance with the Common Ground recommendations for future land use on the ORR (refer to Section 4.1.8.3). They are within areas designated for Conservation Area Uses.

The siting of the proposed action on a greenfield site would appear to be at variance with the draft End Use Working Group recommendation to locate new DOE facilities on brownfield sites. However, as noted in Section 5.2.8.2.2, use of the proposed SNS site would be necessary because no brownfield sites of the required size and configuration could be available by the proposed start date for SNS construction. The other actions considered in this cumulative impacts analysis would not clearly be at variance with the End Use Working Group draft recommendation. Two of the alternative locations for the CERCLA Waste Disposal Facility would include brownfield sites. However, the White Wing Scrap Yard (high-end scenario) would also contain a large greenfield area. The HFIR upgrades would occur in a developed area of the ORR that could be technically defined as a brownfield. The private sector industrial facilities in Parcel ED-1 would not be DOE facilities. Because JINS would be constructed using State of Tennessee funds, it would not be a DOE facility

5.7.1.8.3 Parks, Preserves, and Recreational Areas Resources

The proposed action would have minimal effects on the following parks, preserves, and recreational resources on and in the vicinity of the ORR: University of Tennessee Arboretum, University of Tennessee Forest Experiment Station, TVA recreation areas on Melton Hill Lake and Watts Bar Lake, and Clark Center Recreation Park. The NEPA/CERCLA documentation for the CERCLA Waste Disposal Facility, Parcel ED-1, and the HFIR upgrades do not identify effects on these specific land uses. JINS would not be expected to affect these uses of the land. The cumulative effect of these actions on parks, preserves, and recreational land use is uncertain, however, it is expected that construction and operation of the SNS would not contribute to cumulative impacts on parks, preserves, or recreational land uses on or in the vicinity of the ORR.

The proposed action would reduce the area of ORR land open to hunting by approximately 110 acres (45 ha). Industrial development of Parcel ED-1 could reduce the area open to recreational hunting by approximately 500 acres (202 ha) (DOE-ORO 1996: 4-18). JINS would reduce the area open to hunting by up to 4 acres (1.6 ha). The NEPA/CERCLA documentation for the CERCLA Waste Disposal Facility and the HFIR upgrades does not identify any effects of these actions on recreational hunting.

Recreational hunting is restricted on approximately 8,000 acres (3,238 ha) of the 34,516 acres (13,968 ha) of land on the ORR (DOE-ORO 1996: 4-18). Thus, approximately

26,516 acres (10,731 ha) are open for hunting. Cumulatively, the proposed action, development of Parcel ED-1, and JINS would reduce the ORR land open to deer hunting by 614 acres (248 ha), or 2.3 percent. Therefore, the cumulative impact of these actions on recreational hunting would be minimal.

5.7.1.8.4 Visual Resources

The SNS, CERCLA Waste Disposal facility (three proposed locations), industrial development on Parcel ED-1, JINS, or HFIR upgrades would not be visible to the public from one vantage point. This would result from a combined function of the distance between facilities, restricted public access to reservation land, topography, and vegetation cover. Therefore, the proposed action would not contribute to cumulative impacts on visual resources.

5.7.1.9 Human Health

None of the reasonably foreseeable actions on the ORR have effluents containing radioactive materials. Therefore, they would not contribute to cumulative impacts with the proposed SNS facility. During normal operations, all SNS effluents containing radioactive or toxic materials would be gaseous. The dose from all ORR airborne emissions in 1996 was 9.9 person-rem to the offsite population and 0.45 mrem to a hypothetical maximally exposed individual. If it is conservatively assumed that the ORR and proposed SNS maximally exposed individuals are in the same location, SNS emissions at 1-MW power would increase these doses to 0.84 mrem for the maximally exposed individual and 26 person-rem for the offsite population. The cumulative dose to the maximally exposed individual would be only 8 percent of the applicable limit. At a power level of 4 MW, these doses would become 2.0 mrem for the maximally exposed individual and 36 person-rem for the offsite population. The cumulative dose to the maximally exposed individual would be 20 percent of the applicable limit. If the same population received these doses for 40 years, 0.52 LCFs could occur from operations on the ORR with a 1-MW SNS facility and 0.72 LCFs could occur for operations on the ORR with a 4-MW SNS facility. LCFs of 1.0 or greater do not mean that any actual deaths would occur. Rather, LCFs provide a common and conservative basis for comparisons of alternatives.

Airborne concentrations of mercury would be approximately 10,000 times less than applicable standards for workers and the public and would not contribute to cumulative toxic health impacts.

5.7.1.10 Infrastructure

This section discusses the cumulative impacts on transportation and utility systems from the upgrades to HFIR, development of Parcel ED-1, and construction and operation of JINS and the proposed SNS facilities on the ORR.

5.7.1.10.1 Transportation

No effects on traffic would result from upgrading the HFIR because the construction upgrades and operation would be performed by the existing workforce. There would be a small increase in traffic during the construction of JINS, but this would only be for less than 1 year. The operation of JINS would add only a few automobiles to the local traffic, and the effects would be minimal.

The development of Parcel ED-1 could eventually generate as many as 7,000 trips per day. The development of this industrial park is intended to provide employment opportunities for DOE and contractor employees affected by decreased federal funding. As such, the vast majority of these employees would be expected to already live in the region and utilize the roads. Therefore, no significant change in levels of service on or nearby roads is expected. The LOS for some roadway segments nearby the proposed SNS site would also be expected to be marginally reduced, especially during construction.

5.7.1.10.2 Utilities

Incremental increases in utilities usage by addition of the reasonably foreseeable future projects would be minimal. Utilities required for the HFIR are not expected to increase noticeably after the upgrades are made. There would be a small incremental increase in the utilities used by JINS but this would be minimal. The development of Parcel ED-1 would occur over a 10-year period. These developments would gradually require more electric power, water, and wastewater treatment, but the DOE water treatment and City of Oak Ridge sewer system are currently operating at about 50 percent capacity. Electrical energy consumption for the whole ORR is about 726,000 MW hr/yr, and availability from the TVA is 13,880,000 MW hr/yr. The proposed SNS facility would require substantial electric power (62 MW for the 1-MW beam and 90 MW for the 4-MW beam), but there is sufficient excess capacity to accommodate the demand. Capacities for other utilities needed to support the proposed SNS are well above the required demands. Details on the impacts to utilities are given in Section 5.2.10.2.

5.7.1.11 Waste Management Facilities

All of the waste generated during construction and operation of the proposed SNS facility would be transferred to ORNL for processing. The existing waste management facilities at ORNL have sufficient capacity to accommodate the known waste streams from the proposed SNS facility (refer to Section 5.2.11). DOE would take the appropriate action necessary to dispose of any waste streams that have unknown composition. The evaluation of potential effects on the waste management systems include projected volumes of waste. These projections include wastes from future activities; thus no cumulative impacts on ORNL wastes systems would be anticipated.

Wastes generated by the development of Parcel ED-1 would not enter the ORNL Waste Management system. These wastes would remain the responsibility of the companies utilizing Parcel ED-1. Small volumes of wastes that do not meet the WAC for the CERCLA Waste Disposal facility may enter the ORNL waste system. Small amounts of solid low-level radioactive wastes, hazardous wastes, and mixed wastes would be generated during modifications to HFIR. These wastes have been accounted for in the waste projections used to evaluate the potential cumulative impacts of the SNS wastes.

5.7.2 LANL ALTERNATIVE

DOE recently published the *Draft Site-Wide Environmental Impact Statement for Continued Operations of the Los Alamos National Laboratory* (DOE-AL 1998). This site-wide analysis in large measure is, by its scope, an analysis of cumulative impacts. This document formed the basis for analyzing the cumulative environmental impacts of constructing the proposed SNS at LANL.

The site-wide EIS addresses several proposed alternative actions that are pertinent to the analysis of cumulative impacts. The locations of these actions are shown in Figure 5.7.2-1. These actions are as follows.

Expansion of Low-Level Waste Disposal Capacity. The existing disposal capacity for low-level radioactive waste at LANL is projected to be filled by 2000. Five alternatives for expanding this disposal capacity are described in the LANL site-wide EIS. In the EIS, they are included under the Expanded Operations Alternative for continued LANL operations. They are as follows: (1) develop Zone 4 at TA-54, (2) develop Zone 6 at TA-54, (3) develop both Zones 4 and 6 at TA-54 in stepwise fashion (preferred alternative), (4) develop the north site at TA-54, and (5) develop an undisturbed site at another LANL TA (TA-67) [DOE-AL 1998: Vol. II, 1-8]. The proposed locations for implementation of these alternatives are shown in Figure 5.7.2-1.

Road Construction to Support Pit Production. The Expanded Operations Alternative for continued LANL operations includes construction of a proposed road between TA-55 (Plutonium Facility) and TA-3 (Chemical and Metallurgy Research Building). This road would support pit production operations at the laboratory. Approximately 7 acres (3 ha) of LANL land would be used for this project (DOE-AL 1998:5-99).

In addition to the site-wide EIS, the EIS for the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility (DOE-AL 1995a) was also examined. The construction of the DARHT facility is nearing completion. The DARHT facility would provide dual-axis, multiple-exposure radiographs for the study of devices and materials under hydrodynamic conditions. This facility would be used primarily in support of DOE’s Stockpile Stewardship and Management Programs. For the most part, the environmental effects discussed in the DARHT EIS are included in the discussion in the LANL site-wide EIS. However, specific information from the DARHT EIS is included in the following discussion when necessary for clarity.

5.7.2.1 Geology and Soils

The proposed SNS facility would not contribute to the cumulative impact on the geology and soils of LANL or surrounding communities. The proposed SNS would be designed as a stand-alone facility at TA-70, which is physically removed from the main area of LANL. No significant problems have been identified in regard to site stability, seismic risk, or the soil medium that would constitute impacts by themselves (refer to Section 5.3.1) or combine with existing or future conditions to create cumulative impacts.

5.7.2.2 Water Resources

Surface water discharge by the proposed SNS facility would enter a dry arroyo and infiltrate into the arid soils of the site. No other discharges are planned for this area; hence, no cumulative impacts on surface water would occur at the TA-70 site.

LANL and the surrounding local communities are dependent on groundwater for their water supply. The main aquifer in the area is the only groundwater source capable of serving as a municipal water supply. Although not classified

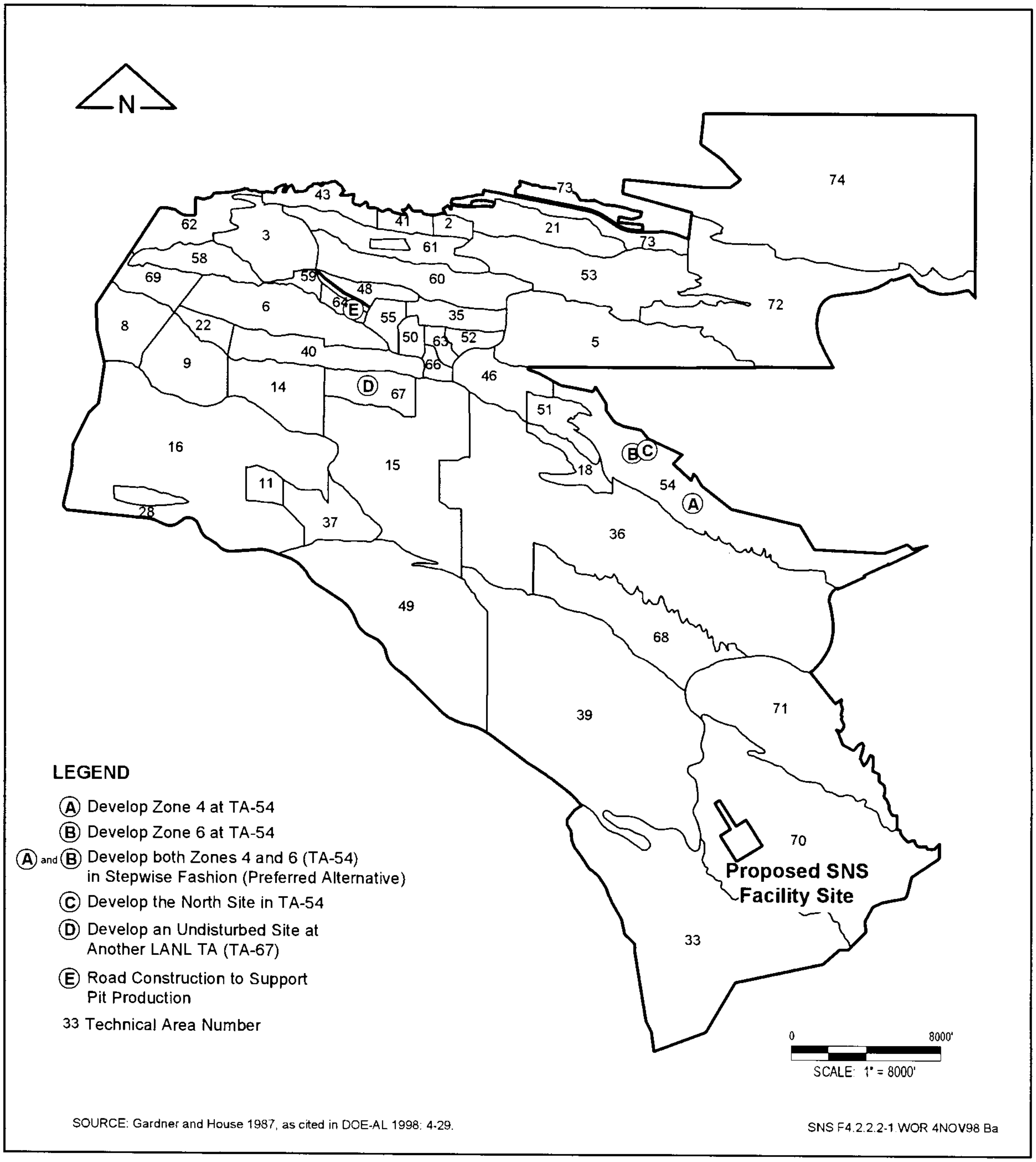

Figure 5.7.2-1. Locations of actions used in the LANL cumulative impacts analysis.

as such, it could be considered a sole-source aquifer. An additional 1.2 to 2.3 mgpd (4.5 to 8.7 million lpd) above current demand would be required to support the proposed SNS operations. Water supply studies specific to SNS demand have not been conducted, but it can be reasonably predicted that increased production of 36 to 70 percent from the main aquifer would impact water levels and create competition with private and local users for water resources.

5.7.2.3 Air Quality

Table 5.3.3.2-1 provides collective effects of the ten small boiler stacks at the proposed SNS facility by adding the model-projected maximums for those stacks for each pollutant to an assumed background concentration developed from ambient monitoring maximums measured near the site. These values were then compared to appropriate NAAQS, and no exceedances were noted.

Table 5.7.2.3-1 indicates total hourly emission rates from the ten stacks and compares these values to county-wide average hourly emission rates. The percentage increase to this total from addition of the SNS minimal sources is also shown.

If future facilities were to be located near the proposed SNS, they would have a cumulative impact on air quality in the immediate vicinity of the SNS. The potential cumulative impact of incremental emissions from such facilities would be evaluated and permitted on a case-by-case basis by the state and federal air quality agencies at the appropriate juncture in order to protect public health and welfare.

5.7.2.4 Noise

Noise impacts of the proposed SNS facility at LANL are described in Section 5.3.4. It is anticipated that the highest levels would occur during construction and would approach a typical noise level of approximately 86 dBA for such activities. However, the proposed SNS facility would be located in a remote portion of LANL and would not combine with other noise sources to increase the overall amplitude of the laboratory. Hence, no cumulative impacts are predicted for noise at LANL.

5.7.2.5 Ecological Resources

This section presents the potential cumulative impacts to ecological resources at LANL.

Table 5.7.2.3-1. Comparison of SNS boiler emission rates to county-wide emission totals.

	SNS Emissions (lb/hr)[a]	Los Alamos County Total Average Emission Rate (lb/hr)	Increase from SNS Emissions (%)
SO_2	0.02	2.1	0.95
NO_x	3.49	84.3	4.1
CO	0.73	22.1	3.3
Particulate matter (PM_{10})	0.42	8.5	4.9

[a] Based on cumulative output of 10 boilers at the proposed SNS facility with total heat load of 34,870,000 Btu/hr. Boilers do not operate at total heat load continuously.

5.7.2.5.1 Terrestrial Resources

A total of 12,770 acres (5,108 ha) of piñon-juniper woodland is present at LANL, representing 46.2 percent of the total land area at LANL. The proposed SNS facility would remove approximately 110 acres (45 ha), or less than 1 percent, of piñon-juniper woodland. LANL is relatively large and undeveloped. Therefore, construction and operation of the proposed SNS facility at LANL would have a minimal contribution to cumulative impacts on terrestrial resources.

5.7.2.5.2 Wetlands

No wetlands are located on or near the proposed site for the SNS, and no cumulative impacts on wetlands were identified in the LANL site-wide EIS. Thus, the SNS would not be expected to contribute to cumulative impacts on wetlands at LANL.

5.7.2.5.3 Aquatic Resources

No aquatic resources are located on or near the proposed SNS site in TA-70. Construction and operation of the proposed SNS would not be expected to affect aquatic resources. Thus, the proposed SNS would not contribute to cumulative impacts on these resources at LANL.

5.7.2.5.4 Threatened and Endangered Species

Impacts on protected species are identified in the LANL site-wide EIS. DOE will soon complete the Threatened and Endangered Species Habitat Management Plan. This plan provides long-range planning information for all future projects at LANL, and develops long-range mitigation actions to protect the habitat of protected species at LANL. This plan will be integrated with the LANL Natural Resource Management Plan, providing policies, methods, and recommendations for long-term management of LANL facilities, infrastructure, and natural resources (DOE-AL 1998). Construction and operations activities associated with the proposed SNS facility would be subject to the restrictions and protective measures defined in these plans, thus minimizing any cumulative impacts on threatened and endangered species at LANL.

5.7.2.6 Socioeconomic and Demographic Characteristics

Government operations (federal, state, local, and tribal) and service sector businesses dominate the economics of the LANL ROI. Activities included in the continued operation of LANL are estimated to directly and indirectly account for more than one third of the employment, wage and salary, and business activity in the three county ROI. In addition to continued operations covered under the LANL site-wide EIS, the DARHT facility is estimated to add about 253 new jobs to the economy. About 106 of these new jobs would be directly supported by project construction and operating expenditures. There would be no impacts to housing or community infrastructure (DOE-AL 1995b). The majority of the new jobs would most likely be filled by existing residents.

The incremental effects of the proposed SNS facility on the economy and community infrastructure of the ROI would be minimal. There would be some positive economic benefits in the form of new jobs created by construction and operation of the proposed SNS. Construction of the proposed SNS facility would require 578 full-time employees during the peak year and from 250 to 375 (1 MW to 4 MW) during operations. Most of the construction workforce and about half of the operations workforce would come from the ROI. As such, the effects on housing and community services would be minimal. The details of these effects are given in Section 5.3.6.

No effects on environmental justice would result from continued operation of LANL or the construction or operation of the DARHT or the proposed SNS facilities. Therefore, there would not be any cumulative effects to environmental justice.

5.7.2.7 Cultural Resources

This section assesses the cumulative impacts of the proposed action and other actions on the cultural resources at LANL.

5.7.2.7.1 Prehistoric Resources

The proposed action would result in the destruction of five prehistoric archaeological sites on the 65 percent of the proposed SNS site and adjacent buffer zone that have been surveyed for cultural resources. These sites are eligible for listing on the NRHP. In the unsurveyed area of the proposed SNS site, any prehistoric sites listed on or eligible for listing on the NRHP would also be destroyed. However, the remaining 35 percent of the proposed SNS site and buffer zone have not been surveyed for prehistoric cultural resources. As a result, the potential effects of the proposed action on specific cultural resources in this unsurveyed area cannot be assessed at this time. Therefore, the contribution of such effects to cumulative impacts on prehistoric cultural resources at LANL cannot be accurately assessed. If the proposed SNS site at LANL were selected for construction of the SNS, this area would be surveyed for prehistoric cultural resources. The effects of the proposed action on specific prehistoric cultural resources, including contributions to cumulative impacts, would be assessed prior to the initiation of construction-related activities within this area.

The alternative to construct a new Low-Level Waste Disposal Facility in TA-67 at LANL could potentially destroy 15 prehistoric archaeological sites. All of these sites are eligible for listing on the NRHP. The effects on these cultural resources would be mitigated through archaeological data recovery (DOE-AL 1998: 5-118). The other alternatives for expanding LLW disposal capacity and the road construction to support pit production are not expected to affect prehistoric cultural resources.

Cumulatively, 20 prehistoric cultural resources at LANL would be impacted by the foregoing actions. This is approximately 3 percent of the 770 prehistoric sites at LANL that are eligible for listing on the NRHP. This percentage would probably be much smaller in light of another 322 prehistoric sites that are considered potentially eligible for listing on the NRHP. These low percentages and the mitigation of impacts through archaeological data recovery indicate that the cumulative impacts of the proposed action (65 percent survey area only) and the Area G LLW disposal facility on prehistoric cultural resources at LANL would be minimal.

5.7.2.7.2 Historic Resources

No archaeological sites, structures, or features dating to the Historic Period have been identified within the 65 percent survey area at the proposed SNS site. As a result, the proposed action would have no effect on Historic Period cultural resources within this area. None of the other LANL actions considered in this analysis would affect historic cultural resources. Therefore, implementation of the proposed action within the surveyed area would not contribute to cumulative impacts on Historic Period cultural resources at LANL.

Site preparation activities in the unsurveyed portion of the proposed SNS site would destroy any historic sites, structures, or features listed on or eligible for listing on the NRHP. However, the remaining 35 percent of the proposed SNS site and an adjacent buffer zone have not been surveyed for Historic Period cultural resources. As a result, the potential effects of the proposed action on specific historic resources in this area cannot be assessed at this time. Therefore, the potential contribution of these effects to cumulative impacts on Historic Period cultural resources at LANL cannot be accurately assessed at this time. If the proposed SNS site at LANL were selected for construction of the SNS, this area would be surveyed for specific Historic Period cultural resources. The effects of the proposed action on Historic Period cultural resources, including contributions to cumulative impacts, would be assessed prior to the initiation of construction-related activities within this area.

5.7.2.7.3 Traditional Cultural Properties

Five prehistoric archaeological sites have been identified within the 65 percent survey area on and adjacent to the SNS site at LANL. These TCPs would be destroyed by site preparation activities associated with construction of the SNS. If any prehistoric archaeological sites are located within the unsurveyed 35 percent of the proposed SNS site, these TCPs would also be destroyed by site preparation. However, because the occurrence of such TCPs in this area is unknown, such potential effects cannot be reasonably factored into the analysis of cumulative impacts.

Fifteen prehistoric archaeological sites would be destroyed by expansion of the LLW disposal facility in TA-54. Cumulatively, construction of the SNS and the new LLW disposal facility would affect 20 prehistoric archaeological sites eligible for listing on the NRHP. Although these 20 sites are only 1.5 percent of the 1,295 prehistoric archaeological sites identified at LANL, any losses or damage involving these TCPs would probably be viewed by tribal groups as an adverse cumulative effect.

Some tribal groups have identified the water resources at LANL as TCPs. Sections 5.7.2.2 and 5.7.2.10.2 discuss cumulative effects on water resources at LANL. The cumulative effects identified in these sections would probably be viewed by tribal groups as adverse cumulative effects on water resource TCPs.

The specific identities and locations of other TCPs on and adjacent to the SNS site are not known and cannot be reasonably estimated (refer to Section 4.2.7.3). As a result, the specific effects of the proposed action on such TCPs would be uncertain. The expansion of LLW disposal capacity at LANL and the road construction to support pit production could affect TCPs, but this is uncertain due to a lack of specific information on TCPs at the alternative construction sites and other locations on laboratory land. Therefore, the potential cumulative effects of these proposed actions on TCPs would be uncertain.

5.7.2.8 Land Use

This section assesses the cumulative impacts of the proposed action and other actions on land use at LANL.

5.7.2.8.1 Current Land Use

The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the basic characteristics of the land that influence land use in the vicinity of LANL or across the laboratory as a whole. The same would be true of the alternatives for future expansion of LLW disposal capacity and the proposed road construction to support pit production. Therefore, these actions would have no reasonably discernible cumulative impacts on current land use outside LANL or throughout most of the laboratory.

The proposed action would introduce development to approximately 110 acres (45 ha) of undeveloped land in TA-70. Construction of a new LLW Disposal Facility in TA-67 (worst-case alternative for area of land used) would introduce development to approximately 60 acres (24 ha) of land at LANL (DOE-AL 1998: 5-99). Under the Expanded Operations Alternative for continuing LANL operations, a new road would be constructed to support pit production (DOE-AL 1998: 5-99). This would introduce development to 7 acres (3 ha) of land.

The proposed action and the other foregoing actions would introduce development to about 177 acres (72 ha) of LANL land. This would be only 1.1 percent of the approximately 16,000 acres (6,478 ha) of undeveloped land within the laboratory boundaries. However, only about 2,000 acres (810 ha) out of these 16,000 acres (6,478 ha) of undeveloped land are considered to be suitable for development. The proposed action and other actions would consume about 8.8 percent of the currently undeveloped land that is considered to be suitable for development. However, future building on LANL land that has been previously developed would reduce additional effects on undeveloped land. Therefore, the overall cumulative impacts on undeveloped land at LANL would be minimal.

The proposed action would change the current use of approximately 110 acres (45 ha) of proposed SNS site land from Environmental Research/Buffer to Experimental Science. Construction of the road to support pit production would change 7 acres (3 ha) of Environmental Research/Buffer land to another land use category. The alternatives for expanding LLW disposal capacity would not appear to involve changes in the current use of Environmental Research/Buffer land.

The proposed action and the road construction would reduce the current Environmental Research/Buffer land at LANL by approximately 117 acres (47 ha). Considering the extremely large areas of LANL in current use as Environmental Research/Buffer land (see Figure 4.2.8.2-2), this cumulative impact on current land use would be minimal.

The proposed action, construction of a new LLW Disposal Facility in TA-67, and construction of a new road to support pit production would reduce the environmental research potential of 177 acres of NERP land. This cumulative impact would be minimal because only 0.6 percent of the NERP land at LANL would be affected.

The land on and in the vicinity of the proposed SNS site is not being used for environmental research projects. As a result, the proposed action would not contribute to cumulative impacts on the use of land by such projects.

5.7.2.8.2 Future Land Use

The proposed action would be compatible with DOE zoning for the land on the proposed SNS site at LANL. Therefore, it would not contribute to cumulative impacts involving the future use of land for purposes other than those for which it is zoned.

No future uses of proposed SNS site and vicinity land for environmental research are planned. As a result, the cumulative impacts of the proposed action on specific future research projects cannot be assessed.

5.7.2.8.3 Parks, Preserves, and Recreational Resources

The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics or other factors that support park, nature preserve, or recreational land uses outside the LANL boundaries. Consequently, implementation of the proposed action on the proposed SNS site would have minimal effects on the use of Santa Fe National Forest and Bandelier National Monument as recreational areas. However, on LANL land, the public use of hiking trails near the proposed SNS site could be potentially restricted or eliminated. The draft EIS covering the continued operation of LANL does not identify potential effects of the considered alternatives on parks, preserves, or recreational land uses. Thus, the cumulative effect of these actions on parks, preserves, and recreational land use is uncertain. However, it is expected that construction and operation of the SNS would not contribute to cumulative impacts on parks, preserves, or recreational land uses on and in the vicinity of LANL.

5.7.2.8.4 Visual Resources

Construction and operation of the proposed SNS facility on the TA-70 site would change views in the area of the site from that of an undeveloped piñon-juniper woodland to industrial development. During the night hours, facility lighting would be visible to travelers on State Route 4 and the access road to the proposed SNS site. No other large, lighted facilities would be present in this remote area of the laboratory. Under the Expanded Operations Alternative for continuing LANL operations, the alternative involving construction of a new LLW Disposal Facility in TA-67 would change views of the Pajarito mesa top in its area from forest to industrial development (DOE-AL 1998: 5-99). Nighttime lighting of this facility would be potentially noticeable to offsite viewers because there are currently no areas along the mesa that are similarly lit (DOE-AL 1998: 5-100). If the proposed action, one of the alternatives for expanding LLW disposal capacity, and the road construction to support pit production were implemented, a slight increase in overall levels of light pollution from LANL could occur. However, from a cumulative impacts perspective, the proposed action and these other actions would have a minimal impact in terms of expanding the overall daytime and nighttime visibility of LANL across the Rio Grande Valley.

5.7.2.9 Human Health

During normal operations, all SNS effluents containing radioactive or toxic materials would be gaseous. Doses from the airborne pathways for the alternatives considered in the LANL site-wide EIS range from lows of 1.88 mrem/yr for the maximally exposed individual and 11 person-rem/yr for the offsite population for the reduced operations alternative to highs of 5.44 mrem/yr for the maximally exposed individual and 33 person-rem/yr for the offsite population for the expanded operations alternative. The annual doses for airborne pathways for the DARHT facility are estimated to be 0.02 mrem for the maximally exposed individual and 0.9 person-rem for the offsite population. The annual doses for the proposed SNS facility would be 0.47 mrem for the maximally exposed individual and 2.0 person-rem for the offsite population for a 1-MW facility and 1.8 mrem for the maximally exposed individual and 5.3 person-rem for the offsite population for a 4-MW facility.

If it is conservatively assumed that (1) the MEI is in the same location for each case; (2) LANL implements the expanded operations alternative as described in the SWEIS; (3) the DARHT is operational; and (4) the SNS operates for 40 years at the 4-MW power level, the maximum cumulative radiological impacts of these activities would be 7.26 mrem/yr for the maximally exposed individual and 39.2 person-rem/yr for the offsite population. Based on a risk conversion factor of 0.0005 LCFs, 0.78 LCFs could occur if all of these facilities operated together for 40 years. LCFs of 1.0 or greater do not mean that any actual deaths would occur. Rather, LCFs provide a common and conservative basis for comparisons of alternatives.

Airborne concentrations of mercury would be approximately 10,000 times less than applicable standards for workers and the public and would not contribute to cumulative toxic health impacts.

5.7.2.10 Infrastructure

This section discusses the cumulative impacts on transportation and utility systems from the continued operation of LANL and construction and operation of the DARHT and proposed SNS facilities.

5.7.2.10.1 Transportation

Continued operation of LANL is not expected to increase the population of Los Alamos significantly, although future land transfers could potentially increase traffic. The construction of the DARHT facility is now nearing completion, and there would not be much of an increase in traffic once the facility is operational. The effects of SNS construction and operation are discussed in Section 5.3.10.1. No other planned activity would result in increased traffic on this road. Thus, minimal cumulative impacts would be expected.

5.7.2.10.2 Utilities

Within the electric power pool that serves LANL, direct use by LANL is about 80 percent of the total. The system serving LANL is near capacity, and projections of future electric power use by LANL under continued operations indicate that demand would exceed capacity. Some solutions are being evaluated, but no specific proposals have been fully developed to remedy this situation. The operation of the DARHT facility would be expected to add another 2,500 MW hr/yr of demand to the existing system. The incremental addition of the proposed SNS facility to the current electric system would be significant. In addition to bringing in a new 115-kV line, strategies for supplying 62 MW to meet the demands for a 1-MW beam and the 90 MW for the 4-MW beam would have to be addressed.

Current and future natural gas capacities would be able to meet the needs for continued operation of LANL, the DARHT, and the proposed SNS facilities. However, there are no existing gas lines or distribution systems in the vicinity of the proposed SNS site, and this infrastructure would have to be installed.

Under the current 3.3 mgpd (12.5 million lpd) demand for potable water from LANL and the surrounding communities, it would be difficult to meet the additional demands of 1.2 to 2.3 mgpd from the proposed SNS facility. Moreover, accommodating the proposed SNS facility would require delivery system upgrades, including many new lines, lift stations, and storage tanks to increase the existing 3.86-mgpd capacity of the system.

Sanitary sewage treatment capacity is more than adequate to meet the current and projected future demands from the continued operation of LANL, DARHT, and the proposed SNS facilities. However, there is no infrastructure in place at the proposed SNS site; the waste would likely have to be trucked to the nearest lift station, which is several miles away, or a treatment and discharge system would have to be installed. The details of the effects on utilities are given in Section 5.3.10.2.

5.7.2.11 Waste Management Facilities

All of the waste generated during construction and operation of the proposed SNS facility would be transferred to LANL for processing. The existing waste management facilities for hazardous wastes, solid low-level radioactive waste, mixed waste, and sanitary waste at LANL have sufficient capacity to accommodate the waste streams from the proposed SNS. The LANL treatment facility for liquid low-level radioactive waste cannot accommodate wastes with tritium. An alternative disposal method would be necessary for these wastes from the proposed SNS facility (refer to Section 5.3.11). The evaluation of potential effects on the waste management systems include projected volumes of waste. These projections include wastes from future activities. Thus, no cumulative impacts on LANL waste systems would be anticipated.

5.7.3 ANL ALTERNATIVE

DOE did not identify any reasonably foreseeable future actions at ANL for inclusion in the analysis of cumulative impacts. However, DOE did include the NEPA documentation for the APS in the analysis of cumulative impacts, although this facility has been completed and is operating. The APS (Figure 5.7.3-1) provides high-brilliance X-rays for use by researchers from industry, universities, and national laboratories. The bright X-ray beams are produced by accelerating positrons (particles like electrons, but positively charged) in a circular path to nearly the speed of light. When the beam is bent by magnets, it emits energy in the form of X-rays.

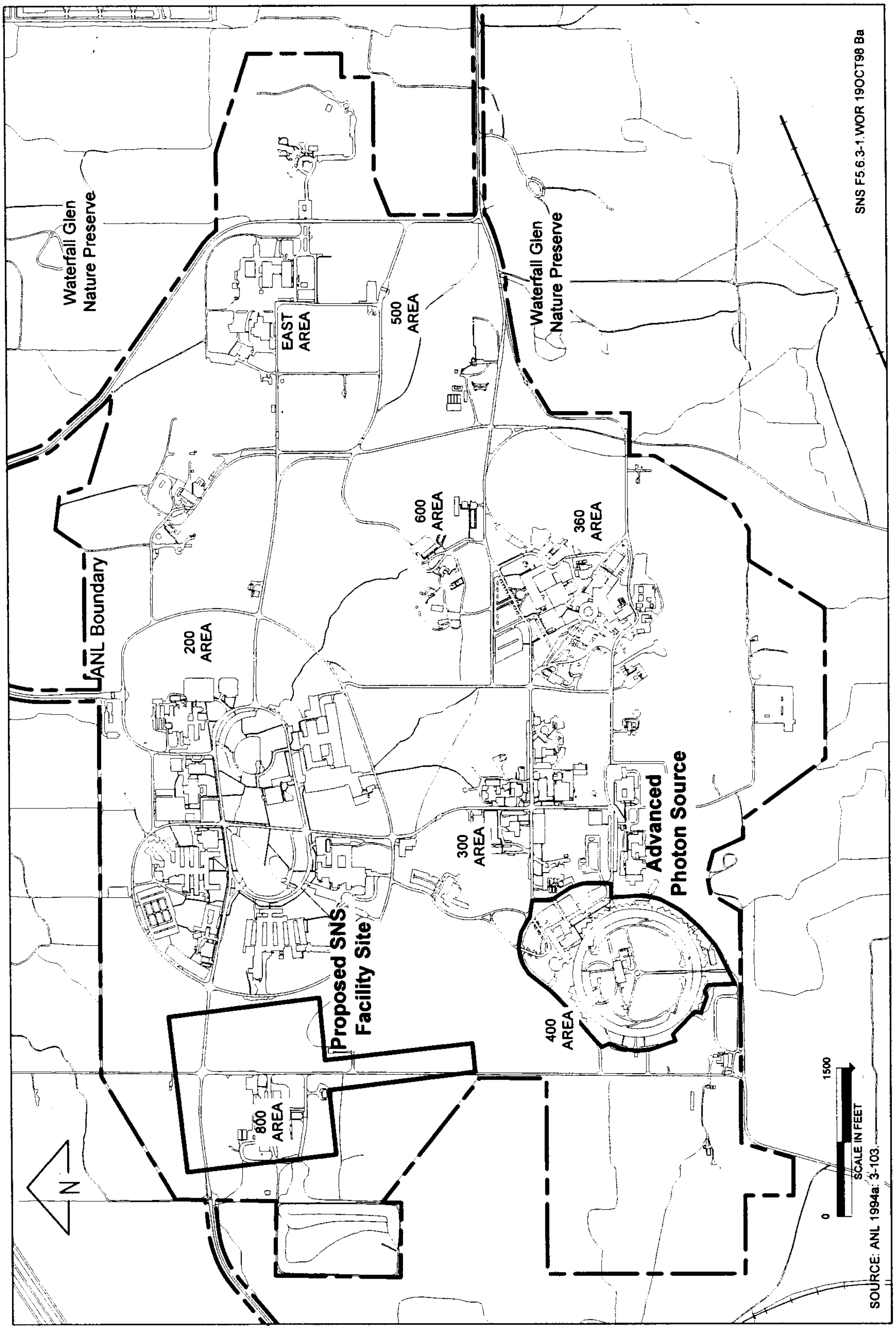

Figure 5.7.3-1. Locations of ANL actions used in the ANL cumulative impacts analysis.

5.7.3.1 Geology and Soils

Construction and operation of the proposed SNS facility would not contribute to the cumulative impact on the geology or soils of ANL or surrounding communities. The proposed SNS facility will be designed as a stand-alone facility in the 800 Area, which is adjacent to the main portion of the proposed SNS site. No significant problems have been identified with regard to site stability, seismic risk, or the soil medium (refer to Section 5.4.1), and no existing or future conditions would provide cumulative impacts.

5.7.3.2 Water Resources

Construction and operation of the proposed SNS facility would not contribute to the cumulative impact on the surface water and groundwater at ANL or in surrounding communities. A portion of the proposed SNS facility would encroach on the 100-year floodplain. The surface grade of the site within this area would be elevated above the 100-year flood stage. However, the buildup of a small area of the floodplain would not impact downstream flow. The floodplain does not extend above the proposed SNS site, and no cumulative impacts occur from nearby facilities.

The primary effect of SNS operations on groundwater at the site would be the activation and leaching of radionuclides. This impact would be localized to an area immediately adjacent to the proposed SNS facility and limited to the upper soil horizon. Potable aquifers that occur at depths of over 100+ feet in this region would not be impacted. No other radiological sources exist in close proximity to the proposed SNS site, and radionuclides generated at the SNS linac tunnel would decay prior to transport from the site. Therefore, no cumulative impacts would occur. Similarly, no current or planned activities would affect groundwater resources from the potable aquifers since Lake Michigan currently supplies water for ANL.

5.7.3.3 Air Quality

Information on the emission of air pollutants from specific facilities included in this discussion was not available. Therefore, potential cumulative impacts on air quality are discussed with reference to the air quality in DuPage County. Table 5.4.3.2-1 provides collective effects of the ten small boiler stacks at the proposed SNS facility by adding the model-projected maximums for those stacks for each pollutant to an assumed background concentration developed from ambient monitoring maximums measured near the site. These values were then compared to appropriate NAAQS, and no exceedances were noted.

Table 5.7.3.3-1 indicates total hourly emission rates from the ten stacks and compares these values to county-wide average hourly emission rates. The very small percentage increase attributed to the proposed SNS facility is also shown.

If future facilities were to be located near the proposed SNS, they would have a cumulative impact on air quality in the immediate vicinity of the SNS. The potential cumulative impacts from such facilities would be evaluated and permitted on a case-by-case basis by the state and federal air quality regulatory agencies at the appropriate juncture in order to protect public health and welfare.

Table 5.7.3.3-1. Comparison of SNS boiler emission rates to county-wide emission totals.

	SNS Emissions (lb/hr)[a]	DuPage County Total Average Emission Rate (lb/hr)	% Increase from SNS Emissions
SO_2	0.02	100.4	0.02
NO_x	3.49	406.8	0.86
CO	0.73	195.7	0.37
Particulate Matter (PM_{10})	0.42	27.2	1.54

[a] Based on cumulative output of 10 boilers at the proposed SNS facility with total heat load of 34,870,000 Btu/hr. Boilers do not operate at total heat load continuously.

5.7.3.4 Noise

Noise impacts of the proposed SNS facility at ANL are described in Section 5.4.4. It is anticipated that the highest levels would occur during construction and would approach a typical noise level of approximately 86 dBA for such activities. There are no other large construction activities in the vicinity of the proposed SNS site. Thus, no cumulative impacts on noise levels are anticipated. Both the proposed SNS and the APS would be in operation at the same time. Both facilities generate noise from their mechanical draft cooling towers. However, there would be sufficient distance between the two sources of noise to prevent a cumulative impact.

5.7.3.5 Ecological Resources

This section presents the potential cumulative impacts on ecological resources at ANL.

5.7.3.5.1 Terrestrial Resources

The construction of APS required the clearing of 70 acres (28 ha) of land. The total undeveloped land area that would be affected by both the APS and the proposed SNS would be approximately 160 acres (65 ha). This represents approximately 15 percent of the undeveloped land on ANL. This total decrease in undeveloped land would cause a decrease in terrestrial wildlife inhabiting ANL proper. The Waterfall Glen Nature Preserve may provide a refuge for the displaced wildlife. However, applying the argument of Kroodsma (refer to Section 5.4.5.1), the population levels would be permanently reduced by an amount generally proportional to the amount of habitat lost. As stated in Section 5.4.5.1, this would be a minor effect because, except for the fallow deer, the species that would be affected are typical of the surrounding region and are not particularly rare or important as game animals.

5.7.3.5.2 Wetlands

During 1993, a site-wide wetlands delineation was completed for ANL in accordance with the *1987 U.S. Army Corps of Engineers Wetlands Delineation Model.* This delineation identified 45 acres (18 ha) of natural and man-made wetlands. These range from small stormwater ditches that are overgrown with cattails to natural depressions, beaver ponds, and man-made ponds. Construction of the APS resulted in the destruction of 1.8 acres (0.73 ha) of wetlands. The current DOE policy is for no net decrease in the amount of wetlands as a result of DOE activities. Therefore, DOE obtained a permit for construction in wetlands from the

USACOE in accordance with Section 404 of the CWA. The lost wetlands were replaced with an equivalent amount of wetland habitat created in the vicinity of the APS facility within the same watershed of the impacted wetlands.

Construction of the proposed SNS facility at ANL would result in the destruction of approximately 3.5 acres (1.4 ha) of wetland (refer to Section 5.4.5.2). DOE would obtain a permit for construction in these wetlands as well. Creation of replacement wetlands or enhancement of existing wetlands would be the most likely mitigation for this loss. These replacement wetlands would be designed to normally contain saturated soils to support wetland vegetation similar to that in the lost habitat. Thus, the cumulative impact to wetlands at ANL would be mitigated.

5.7.3.5.3 Aquatic Resources

No permanent streams are located on the site of the APS. Only temporary effects on surface water biota were identified in the Environmental Assessment for the APS. As presented in Section 5.4.5.3, construction of the proposed SNS facility at ANL is expected to cause minimal effects on surface waters. Sawmill Creek currently receives many of the discharges from ANL. However, because of the nature of the aquatic discharges from the proposed SNS, these discharges would be expected to result in minimal contributions to cumulative impacts on Sawmill Creek.

5.7.3.5.4 Threatened and Endangered Species

Construction and operation of the proposed SNS facility would not affect known protected species at ANL. Therefore, there would be no contribution to cumulative impacts on threatened and endangered species at ANL.

5.7.3.6 Socioeconomic and Demographic Characteristics

Service sector businesses constitute one third of the economics of the ANL ROI. Activities included in the operation of ANL account for much less than one percent (0.01) of the employment, wage and salary, and business activity in the four-county ROI. The APS facility created up to 250 jobs during peak construction. As this number decreases, as it has done during the last three years of construction, the APS technical and administrative staff were projected to gradually increase to a stable operations work force of about 300 persons. Some of these new workers could be expected to have in-migrate with their families from outside the ROI, but the effects on housing and community infrastructure would have been minimal.

The incremental effects from the proposed SNS facility on the economy and community infrastructure of the ROI would be minimal. There would be some positive economic benefits in the form of new jobs created by the construction and operation of the proposed SNS. Construction of the proposed SNS facility would require 578 full-time employees during the peak year and from 250 to 375 (1 MW to 4 MW) during operations. Most of the construction workforce and about half of the operations workforce would come from the ROI, and as such, the effects on housing and community services would be minimal. The details of these effects are given in Section 5.4.6.

No effects on environmental justice were identified from the operation of ANL or the construction and operation of the APS. The proposed SNS would also have no effects on environmental justice at ANL. Therefore, there would be no cumulative impacts on environmental justice.

5.7.3.7 Cultural Resources

The cumulative impacts of the proposed action and other actions on cultural resources at ANL are assessed in this section.

5.7.3.7.1 Prehistoric Resources

One prehistoric archaeological site (40DU207), which might be eligible for listing on the NRHP, may be disturbed or destroyed by construction of the proposed SNS facility (refer to Section 5.4.7.1). After the Environmental Assessment for the proposed APS was completed, the remains at 40DU189 (formerly ANL-6) were assessed as ineligible for listing on the NRHP (DOE-CH 1990: 80-81; Wescott 1998b). As a result, the APS would have no impact on prehistoric cultural resources. Therefore, the proposed SNS would not contribute to cumulative impacts on prehistoric cultural resources at ANL.

5.7.3.7.2 Historic Resources

None of the Historic Period structures or features on the proposed SNS site or in its vicinity are listed on or considered to be eligible for listing on the NRHP. As a result, the proposed action would have no effect on Historic Period cultural resources. Therefore, the proposed action would not contribute to cumulative impacts on Historic Period cultural resources at ANL.

5.7.3.7.3 Traditional Cultural Properties

No TCPs are known to exist on the proposed SNS site at ANL or anywhere else on laboratory land. As a result, no TCPs would be affected by implementation of the proposed action. Therefore, the proposed action would not contribute to cumulative impacts on TCPs at ANL.

5.7.3.8 Land Use

The cumulative impacts of the proposed action and other actions on land use at ANL are assessed in this section.

5.7.3.8.1 Current Land Use

The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the basic characteristics of the land that influence land use in the vicinity of ANL and throughout most of the laboratory. This would also be true of the effects from construction and operation of the APS. Therefore, these actions would have no reasonably discernible cumulative impacts on land use outside ANL and throughout most of the laboratory.

The proposed action would introduce development to approximately 90 acres (36 ha) of undeveloped Open Space and Ecology Plot land on the proposed SNS site. Construction of the APS resulted in the development of 70 acres (28 ha) of previously undeveloped land. Cumulatively, these two actions would introduce development to 160 acres (65 ha) of undeveloped ANL land. This would represent an approximately 15 percent reduction in the combined Open Space and Ecology Plot land available for additional development. Considering the already limited space available for development at ANL, this would be a fairly substantial cumulative impact.

Construction of the proposed SNS would displace any remaining support services operations in the 800 Area at ANL, and it would result in demolition of the remaining buildings and features in this area. The current use designations for land on the proposed SNS site (Ecology Plots 6, 7, and 8; Support Services; and Open Space) would change to a programmatic use category specific to the new facility or the Programmatic Mission-Other Areas category. Construction of the APS resulted in a current land use change from Open Space to Programmatic Mission-APS Project. These changes in current land use would involve approximately 75 (30 ha) acres of Open Space land on the proposed SNS site and 70 acres (28 ha) of Open Space land on the APS site. Cumulatively, the proposed action and the APS would reduce the Open Space land at ANL by approximately 145 acres (59 ha). This would represent an approximately 15 percent reduction in the Open Space land available for additional development at ANL. Considering the already limited space available for development, this would be a fairly substantial cumulative impact.

No NERP land is present at ANL. Consequently, the proposed action would not reduce the environmental research potential of NERP land.

The land on and in the vicinity of the proposed SNS site, including Ecology Plot Nos. 6, 7, and 8, is not being used by environmental research projects. As a result, the proposed action would not contribute to cumulative impacts on the use of land by such projects.

5.7.3.8.2 Future Land Use

An extremely small area of land zoned for future use in Support Services is located barely inside the west boundary of the proposed SNS site at ANL. The remainder of the proposed SNS site would be compatible with DOE zoning of this land for future use. The APS site does not contain Support Services zoning and is already dedicated to APS facilities. Therefore, the proposed action would not contribute to cumulative impacts involving the future use of land for purposes other than those for which it is zoned.

No future uses of proposed SNS site and vicinity land for environmental research are planned. This includes Ecology Plot Nos. 6, 7, and 8. As a result, the cumulative impacts of the proposed action on specific future research projects cannot be assessed.

5.7.3.8.3 Parks, Preserves, and Recreational Resources

The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics that support park, nature preserve, and recreational land uses outside the ANL boundaries. Consequently, implementation of the proposed action would have minimal effects on the following land uses on and in the vicinity of ANL: Forest Preserve District of Cook County (recreation on Saganashkee Slough, McGinnis Slough, and small lakes), hunting and fishing in Sawmill Creek and the Des Plaines River, recreational use of an area adjacent to the southwest boundary of ANL, Waterfall Glen Nature Preserve, and ANL Park. The NEPA environmental assessment covering construction and operation of the APS indicates that these actions would have no significant, long-term effects on the Waterfall Glen Nature Preserve (DOE-CH 1990: 65). The environmental assessment does not identify effects on the other previously listed land uses. Thus, the cumulative effect of these actions on these other uses would be uncertain. However, it is expected that construction and operation of the SNS would not contribute to cumulative impacts on these uses.

5.7.3.8.4 Visual Resources

The proposed SNS site is located in close proximity to the west perimeter of ANL, and the APS site is similarly located near the proposed SNS site and the west perimeter of the laboratory. These facilities would not be visible from points outside the surrounding Waterfall Glen Nature Preserve because the preserve is heavily forested. Both facilities would be visible from deep interior points in the Waterfall Glen Nature Preserve, especially during late autumn, winter, and early spring. Cumulatively, the proposed SNS and APS would degrade natural views from interior points within the west side of the nature preserve.

5.7.3.9 Human Health

During normal operations, all SNS effluents containing radioactive or toxic materials would be gaseous. Based on 1996 emissions for all existing ANL facilities, the hypothetical maximally exposed individual received a dose of 0.053 mrem via air pathways, while the offsite population received a dose of 2.64 person-rem. DOE includes the APS in the analysis of cumulative impacts for the proposed SNS facility at ANL. The principal potential health impact from the APS would be exposure to direct radiation. Estimated dose at the ANL site boundary would be 6 mrem/hr due to direct radiation plus an additional 0.06 mrem/yr from the emission of activated air.

Estimates of direct radiation are not available for the proposed SNS, and analysis of cumulative impacts is based on the air pathways. For the proposed 1-MW SNS facility, the air pathway dose to the maximally exposed individual would be 3.1 mrem/yr and 20 person-rem/yr to the offsite population. For the proposed 4-MW SNS facility, the corresponding doses are 12 mrem/yr for the maximally exposed individual and 79 person-rem/yr for the offsite population. The ingestion component of the air pathway dose for the proposed SNS has been conservatively estimated based on the inhalation component of the air pathways. The maximum cumulative dose at the site boundary for the 4-MW facility is 12.1 mrem/yr. Maximally exposed individuals for determining compliance with the 10-mrem/yr limit for exposures based on the air pathway are receptors located only where people actually reside. Maximally exposed individuals in this EIS are hypothetical receptors located at the site boundary and, at ANL, are much closer to the site than the nearest actual resident. The cumulative affects of SNS emissions at locations where people actually reside would not exceed to limit of 10 mrem/yr. The limit for all pathways including air and direct radiation is 100 mrem/yr.

Based on a risk conversion factor of 0.0005 LCFs/person-rem, the cumulative impacts of ANL emissions with the proposed SNS could result in fatalities at both 1 MW (0.45 LCFs) and 4 MW (1.6 LCFs). LCFs of 1.0 or greater do not mean that any actual deaths would occur. Rather, LCFs provide a common and conservative basis for comparisons of alternatives.

Airborne concentrations of mercury would be approximately 10,000 times less than applicable standards for workers and the public and would not contribute to cumulative toxic health impacts.

5.7.3.10 Infrastructure

This section discusses the cumulative impacts on transportation and utility systems from construction and operation of the APS and proposed SNS facilities at ANL.

5.7.3.10.1 Transportation

ANL is bordered on the north by I-55, on the east by State Highway 83, and on the south by State Highway 171. As of 1994, no marked difficulties were apparent for onsite traffic at any location, either during peak periods of arrival and departure or midday (ANL 1994b). Also, according to Illinois DOT standards, vehicle accumulation at intersections and gates is minimal, even during peak hours. Operating the APS was projected to increase traffic by about 240 trips per day. Locating the proposed SNS at ANL would increase traffic by 466 round-trips during the peak construction year and by 302 round-trips during operations. The addition of the SNS to the existing APS would increase traffic, but the existing transportation infrastructure could accommodate this increase. However, the location within ANL that most closely matches the siting criteria for the SNS overlays Westgate Road. Approximately 1 mi (1.6 km) of the existing Westgate Road would be relocated to the north in order to circumvent the proposed SNS site and replace the existing Westgate Road access. The details of the effects from the proposed SNS are given in Section 5.4.10.1.

5.7.3.10.2 Utilities

Electric power was provided from an existing substation to the APS by two 13-kV feeder circuits that originally serviced the ANL Zero Gradient Synchrotron accelerator facility, which was shut down in 1979 (DOE-CH 1990). ANL's existing 138-kV lines would not be adequate for the SNS loads. A new 138-kV overhead line would be needed to connect the proposed SNS facility to substation 549A to meet the power requirements of the SNS. If additional capacity beyond the available 50 MW is required, it would be necessary to coordinate with Commonwealth Edison to determine the best way to provide power to the site.

The APS was expected to use approximately 60,000 lb/hr of steam. It is expected that the proposed SNS facility would use about the same amount. ANL can accommodate approximately 300,000 lb/hr of additional steam demand.

The potable domestic water supply at ANL is purchased from the local water district. The APS was estimated to use an average of 30,000 gpd (113,562 lpd) of domestic water. The proposed SNS facility would probably use about the same amount, which is four percent of the excess capacity at ANL. Cooling tower water demand for the APS was projected to average 400,000 gpd (1,514,160 lpd) and would come from the Chicago Sanitary and Ship Canal. The proposed SNS is expected to use 800 gpm (3,028 lpm) for the 1-MW beam and 1,600 gpm (6,057 lpm) for the 4-MW beam. ANL has the capacity to provide approximately 2 mgpd (7.6 million lpd), and it is expected that ANL would be able to meet the APS and proposed SNS water requirements with minimal environmental effects. The details of the effects on utilities are given in Section 5.4.10.2.

5.7.3.11 Waste Management Facilities

All of the waste generated during construction and operation of the proposed SNS facility would be transferred to ANL for processing. The existing waste management facilities have sufficient capacity to accommodate the SNS waste streams (refer to Section 5.4.11). The evaluation of potential effects on the waste management systems included projected volumes of waste. Since the APS is an operational facility, wastes from this facility are included in these projections, thus no cumulative impacts on ANL wastes systems would be anticipated.

5.7.4 BNL ALTERNATIVE

The actions that DOE considers reasonably foreseeable and pertinent to the analysis of cumulative impacts for the BNL alternative are described in this section. The locations of these actions are shown in Figure 5.7.4-1. These actions are as follows:

Programmed Improvements of the Alternating Gradient Synchrotron (AGS) Complex. DOE prepared an Environmental Assessment for the proposed action to improve the efficiency of the AGS and upgrade the environment, safety, and health systems of the facility. The AGS began operation in 1960 as a proton accelerator supporting research in high-energy physics. The AGS was adapted to accelerate heavy ions in 1986.

Relativistic Heavy Ion Collider. DOE prepared an environmental assessment for the construction and operation of the Relativistic Heavy Ion Collider (RHIC) facility at BNL. The proposed action is to utilize existing facilities at BNL and construct new facilities to complete the RHIC. The RHIC facility would provide a unique, world-class heavy ion research facility.

5.7.4.1 Geology and Soils

The SNS would be designed and constructed as a stand-alone facility. Because of its relative isolation from other BNL facilities, activated soil around the linac tunnel would not combine with other radioactively contaminated soils to create cumulative impacts. No potential conditions have been identified in regard to site stability or seismic risk that would constitute impacts by themselves (refer to Section 5.5.1) or combine with existing or future conditions to create cumulative impacts. Therefore, construction and operation of the SNS would not contribute to cumulative impacts on the soils and geology of BNL or the surrounding area.

5.7.4.2 Water Resources

Operation of the proposed SNS facility would create limited amounts of radionuclides in the soils and groundwater surrounding the linac tunnel. Site-specific studies have not been conducted to determine the specific concentrations of radionuclides that would be produced at BNL, but the types of nuclides would be very similar to those predicted for ORNL.

Any SNS contribution of radionuclides would add to those from currently operating and planned radiological sources at BNL. These potential sources include the Brookhaven LINAC Isotope Production Facility, the Alternating Gradient Synchrotron, and the National Synchrotron Light Source. In addition, the HFBR is reported to have released ^{3}H to the groundwater at BNL, and RHIC is predicted to

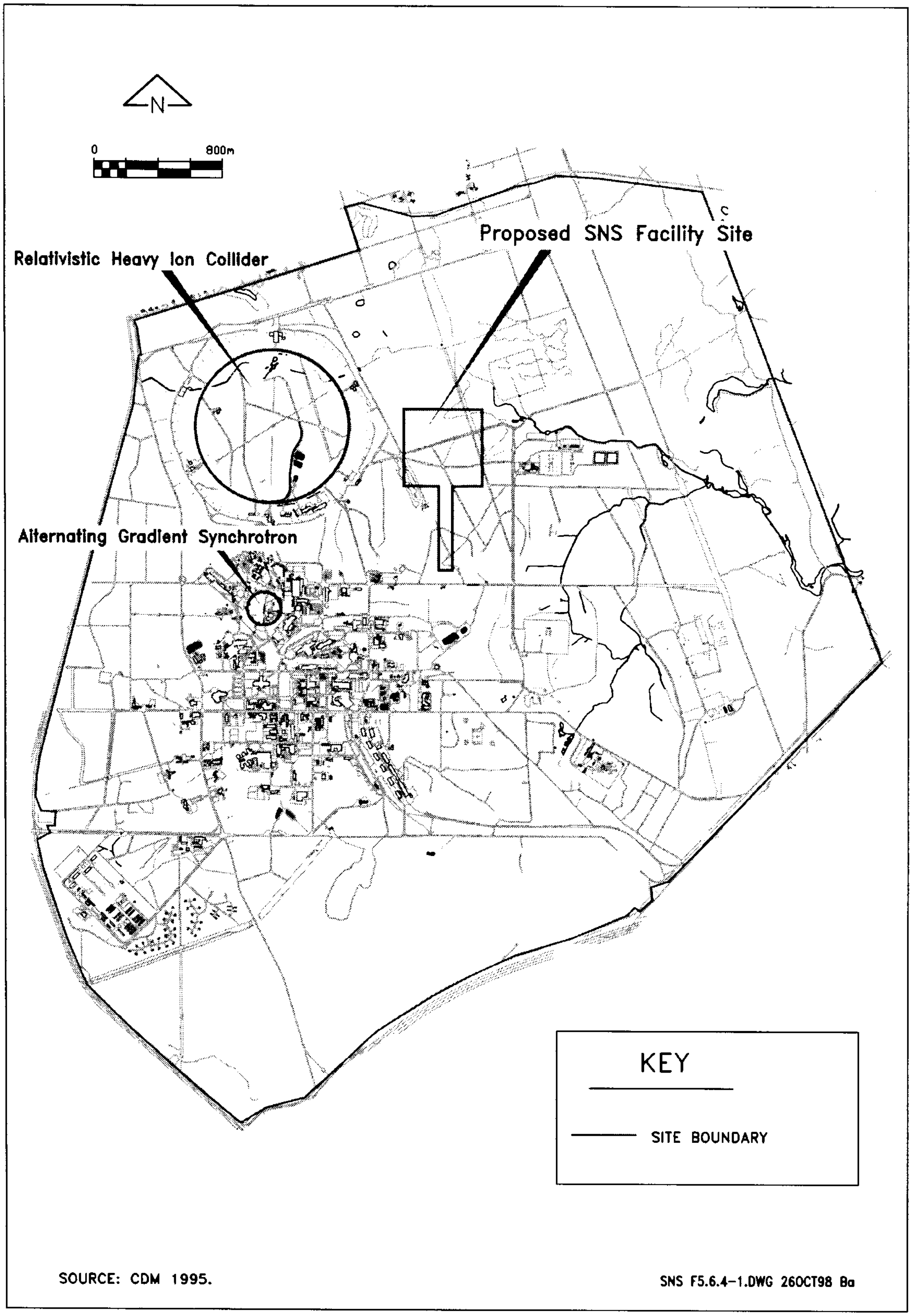

Figure 5.7.4-1. Locations of actions used in the BNL cumulative impacts analysis.

add quantities of several radionuclides, including ^{3}H and ^{22}Na, to the groundwater.

Similar to the SNS, a study of the RHIC (currently under construction at BNL) has indicated that secondary particles created by beam interactions would escape into the soil surrounding the tunnel on all sides (DOE-CH 1991). From the interaction with the silicon and oxygen atoms in the soil, RHIC is predicted to produce the following radionuclides: ^{3}H, ^{22}Na, ^{7}Be, ^{11}C, ^{13}N, and ^{15}O.

Since the leaching and transport of nuclides is relatively slow, only the longer-lived isotopes such as ^{3}H and ^{22}Na would exist for potential human exposure. An annual total of 11 mCi of ^{3}H and 14 mCi of ^{22}Na are expected to be produced by RHIC. These concentrations would yield a human exposure through the water pathway several orders of magnitude below the Safe Drinking Water Act (SDWA) limit of 4 mrem per year. Assuming a person's intake would consist of 100 percent of water at the BNL boundary, the maximum offsite dose to an individual would be about 0.07 mrem per year.

Due to the proximity of the proposed SNS site and RHIC, the potential exists for commingling of radionuclides from the two facilities. Cumulative impacts, however, would be minimal because of the small amounts generated by each facility, the natural dilution by groundwater, and the isotopic decay over time.

BNL has also identified a groundwater ^{3}H plume derived from the Spent Fuel Pool at the HFBR (BNL 1998). This plume has been the focus of a remedial investigation/feasibility study under the CERCLA process, and immediate remedial actions are being taken to remove the ^{3}H sources, mitigate the plume's migration, and characterize the human health exposure at the BNL boundary. The plume trends roughly south from HFBR about 4,200 ft and is approximately 750-ft wide at its greatest dimension. The leading edge of the plume (20,000-pCi/L contour line) would require about 16.4 years to reach the BNL boundary. By that time, natural radioactive decay alone would reduce the ^{3}H concentration to less than half of its current level. Considering the combined effects of groundwater flow, nuclide dispersion, and radioactive decay, groundwater modeling indicates that ^{3}H concentrations above the SDWA level of 20,000 pCi/L would never cross the BNL boundary.

The SNS site is located about 1,500 to 2,000 ft northeast of the HFBR. Due to the configuration of the groundwater gradient within BNL (refer to Figure 4.4.2.2-3), any migration of radionuclides from the SNS site would not intersect the HFBR plume. Hence, cumulative groundwater impacts from the SNS and HFBR would not occur.

The overall picture of cumulative groundwater impacts that might result from operation of the SNS and all the foregoing BNL facilities remains somewhat unclear. However, it is possible that localized groundwater conditions may be affected at BNL, while minimal effects would occur at the laboratory boundary due to the dilution and decay of radionuclides.

It is possible that localized groundwater conditions may be affected at BNL, while minimal effects would occur at the laboratory boundary due to the dilution and decay of radionuclides.

5.7.4.3 Air Quality

Information on the emission of air pollutants from the specific facilities included in this discussion was not available. Therefore, potential cumulative impacts on air quality are discussed with reference to the air quality in Suffolk County. Table 5.5.3.2-1 provides the collective effects of the ten small boiler stacks at the proposed SNS facility by adding the model-projected maximums for those stacks for each pollutant to an assumed background concentration developed from ambient monitoring maximums measured near the site. These values were then compared to appropriate NAAQS, and no exceedances were noted.

Table 5.7.4.3-1 indicates total hourly emission rates from the ten stacks and compares these values to county-wide average hourly emission rates. The very small percentage increase attributed to the proposed SNS facility is also shown.

If future facilities were to be located near the proposed SNS, they would have a cumulative impact on air quality in the immediate vicinity of the SNS. The potential cumulative impacts from such facilities would be evaluated and permitted on a case-by-case basis by the state and federal air quality regulatory agencies at the appropriate juncture in order to protect public health and welfare.

5.7.4.4 Noise

Noise impacts of the proposed SNS facility at BNL are described in Section 5.5.4. It is anticipated that the highest levels would occur during construction and would approach a typical noise level of approximately 86 dBA for such activities. However, the proposed SNS facility would be located west of the main BNL office complex and would be removed from any discernable source of noise produced by that area. No cumulative noise impacts are expected from the two sources.

5.7.4.5 Ecological Resources

This section presents the potential cumulative impacts on ecological resources at BNL.

5.7.4.5.1 Terrestrial Resources

As presented in Section 5.5.5.1, the proposed SNS site at BNL lies within the pine barrens area of Long Island. However, the 110 acres (45 ha) of land on the site represents less than 2 percent of the Pine Barrens protection area and lies entirely within the Compatible Growth Area rather than the more stringently protected Core

Table 5.7.4.3-1. Comparison of SNS boiler emission rates to county-wide emission totals.

	SNS Emissions (lb/hr)[a]	Suffolk County Total Average Emission Rate (lb/hr)	% Increase from SNS Emissions
SO_2	0.02	4,350.0	0.00046
NO_x	3.49	2,123.9	0.16
CO	0.73	481.5	0.15
Particulate Matter (PM_{10})	0.42	107.4	0.39

[a] Based on cumulative output of 10 boilers at the proposed SNS facility with total heat load of 34,870,000 Btu/hr. Boilers do not operate at total heat load continuously.

Preservation Area. Cumulative impacts to the Pine Barrens would be minimal. Construction associated with the Programmed Improvements of the AGS complex is limited to areas within existing facilities or existing utility rights-of-way. No land would be cleared.

The Pine Barrens Protection Act was enacted in 1993 after the environmental assessment for RHIC was completed. The land occupied by the RHIC facilities was included in the Compatible Growth Area. The construction of RHIC is utilizing facilities that already existed for the ISABELLE/CBA project at BNL, plus other facilities and components that already were built and operational at BNL. Thus, very little undisturbed land was cleared for RHIC.

5.7.4.5.2 Wetlands

Wetlands occur in the headwaters of the Peconic River. However, construction and operation of the proposed SNS facility would have minimal effect on these wetlands.

Construction-associated improvements to the AGS is limited to areas within existing facilities or existing utility rights-of-way. No land would be cleared.

No construction activities for the RHIC facility occurred in a wetland. However, there was a potential for indirect effects on wetlands. By implementing appropriate mitigation measures, such as immediate mulching and reseeding of disturbed areas and the use of standard erosion control practices adjacent to wetlands, these secondary effects were expected to be minimal. The NYSDEC issued a Notice of Determination of Non-Significance in response to the request for authorization to construct, submitted by DOE to the NYSDEC in accordance with Article 24 of the Environmental Conservation Law, Protection of Freshwater Wetlands. Thus, cumulative impacts on wetlands from the foregoing facilities would be minimal.

5.7.4.5.3 Aquatic Resources

Cumulative impacts on aquatic resources at BNL would be expected to be minimal. The proposed site for the SNS project and the existing RHIC facilities are located within an area designated as “scenic” under the New York State Wild, Scenic, and Recreational River Act. The ISABELLE/CBA facilities, to be used by RHIC, were constructed prior to the 1987 designation of the portion of the Peconic River flowing through BNA as “scenic.” The general public does not have open access for use and enjoyment of the river within the BNL boundary. At the RHIC location, the Peconic River is an intermittent stream. No impacts on the scenic nature of the river resulting from RHIC activities were identified in the environmental assessment.

The 300-ft (91-m) buffer zone of natural vegetation that would be established between the Peconic River and the proposed SNS would protect the scenic nature of the river.

The only potential effect on the Peconic River identified by the RHIC EA is increased sediment loading during construction. Construction activities at RHIC would be completed prior to the start of construction on the proposed SNS facility. The potential for increased sediment loading in the Peconic River during construction of the proposed SNS also exists. Effective erosion control measures are standard practice at DOE construction sites. This, coupled with the fact that construction activities for these projects would not be concurrent, would result in minimal cumulative impacts on the Peconic River.

5.7.4.5.4 Threatened and Endangered Species

No effects on threatened and endangered species were identified in the EA for the RHIC. Construction and operation of the proposed SNS facility would be expected to result in minimal effects on known threatened and endangered species. Thus, the cumulative effects on potential species would be uncertain but would be expected to be minimal.

5.7.4.6 Socioeconomic and Demographic Characteristics

Government operations (federal, state, and local), service sector businesses, and retail trade dominate the economics of the BNL ROI. Activities included in the operation of BNL account for much less than one percent (0.02) of the employment, wage and salary, and business activity in the two-county ROI. The proposed programmed improvements of the AGS would upgrade existing facilities, and the construction and operation would be performed by the current workforce. This proposed action would not create any jobs or cause population changes. Therefore, it would not affect ROI housing demand or community infrastructure. The construction of RHIC would also involve upgrades to existing facilities by the current workforce. However, RHIC would add 200 new jobs during operations. Some of these new workers would in-migrate with their families from outside the ROI, but the effects on housing and community infrastructure would be minimal.

The incremental effects from the proposed SNS facility on the economy and community infrastructure of the ROI would be minimal. There would be some positive economic benefits in the form of new jobs created by construction and operation of the proposed SNS. Construction of the proposed SNS facility would require 578 full-time employees during the peak year and from 250 to 375 (1 MW to 4 MW) during operations. Most of the construction workforce and about half of the operations workforce would come from the ROI, and as such, the effects on housing and community services would be minimal. The details of these effects are given in Section 5.5.6.

No effects on environmental justice were identified from the operation of BNL or the construction and operation of the AGS or RHIC. The proposed SNS facility would also have no effects on environmental justice at BNL. Therefore, there would be no cumulative effects on environmental justice.

5.7.4.7 Cultural Resources

This section assesses the cumulative impacts of the proposed action and other actions on the cultural resources at BNL.

5.7.4.7.1 Prehistoric Resources

No prehistoric sites listed on or considered to be eligible for listing on the NRHP have been identified on the proposed SNS site at BNL or in its vicinity. As a result, the proposed action would have no effect on prehistoric cultural resources. Therefore, the proposed action would not contribute to cumulative impacts on prehistoric cultural resources at BNL.

5.7.4.7.2 Historic Resources

The footprint for the ISABELLE/CBA facility was surveyed and archaeologically tested for cultural resources to support the NEPA process in 1977. These efforts resulted in the location of 14 Historic Period archaeological sites dating to World War I. Subsequently, the New York State Historic Preservation Officer (SHPO) indicated that construction of ISABELLE/CBA could proceed as a result of compliance with requirements under the National Historic Preservation Act (NHPA) and Executive Order 11593 (DOE-CH 1991: 14). After extensive construction had already occurred, the project was cancelled. The RHIC was later proposed for construction entirely within the footprint of the partially constructed ISABELLE/CBA facility. In an opinion issued on January 2, 1991, the SHPO indicated that RHIC would have no effect on cultural resources listed on or eligible for listing on the NRHP (Miltenberger et al. 1990; DOE-CH 1991: 14). This would include Historic Period cultural resources at BNL.

With respect to the other project included in this cumulative impacts analysis, the absence of Historic Period cultural resources in the AGS complex indicates that proposed improvements to the AGS would not affect Historic Period cultural resources at BNL (DOE-CH 1994: 14). Considering the absence of cultural resources impacts from RHIC and AGS, the destruction of potentially NRHP-eligible World War I features at Stations 2, 4, 8, and 10 on the proposed SNS site would not contribute to cumulative impacts on Historic Period cultural resources at BNL.

5.7.4.7.3 Traditional Cultural Properties

No TCPs are known to exist on the proposed SNS site at BNL or anywhere else on laboratory land. As a result, no TCPs would be affected by implementation of the proposed action. Therefore, the proposed action would not contribute to cumulative impacts on TCPs at BNL.

5.7.4.8 Land Use

This section assesses the cumulative impacts of the proposed action and other actions on land use at BNL.

5.7.4.8.1 Current Land Use

The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the basic characteristics of the land that influence land use in the vicinity of BNL and throughout most of the laboratory. This would also be true of the effects from RHIC and improvements to the AGS. Therefore, these actions would have no reasonably discernible cumulative impacts on land use outside BNL and throughout most of the laboratory.

The proposed action would introduce development to approximately 110 acres (45 ha) of land on the proposed SNS site. Because of its location on the site of a previous construction project, RHIC would involve very little disturbance of previously undeveloped land (DOE-CH 1991: 27). The AGS improvements would occur within a previously developed area of the laboratory. Therefore, the proposed action would not contribute to cumulative impacts on undeveloped land at BNL.

The proposed action would change the current use of 110 acres (45 ha) of land on the proposed SNS site from Open Space to Industrial/Commercial. The construction of RHIC would occur in the previously developed area associated with ISABELLE/CBA, and the AGS improvements would occur within another Industrial/Commercial land use area. As a result, no changes in current land use would be associated with RHIC and improvements to the AGS. Therefore, the proposed action would not contribute to cumulative impacts on current land use at BNL.

No NERP land is present at BNL. Consequently, the proposed action would not reduce the environmental research potential of NERP land.

The land on and in the vicinity of the proposed SNS site is not being used by environmental research projects. As a result, the proposed action would not contribute to cumulative impacts on the use of land by such projects.

5.7.4.8.2 Future Land Use

The RHIC and AGS improvements would be compatible with the Industrial/Commercial zoning of their sites. Therefore, the proposed action would not contribute to cumulative impacts involving the future use of land for purposes other than those for which it is zoned.

No future uses of proposed SNS site and vicinity land for environmental research are planned. As a result, the cumulative impacts of the proposed action on specific future research projects cannot be assessed.

5.7.4.8.3 Parks, Preserves, and Recreational Resources

The effects of the proposed action would not be of sufficient scope, magnitude, or duration to alter the key land characteristics that support park, nature preserve, and recreational land uses outside the ANL boundaries. Consequently, implementation of the proposed action would have minimal effects on the following land uses in the vicinity of BNL: Brookhaven State Park, Rocky Point State Park, Wildwood State Park, recreational use of the Peconic and Carmens Rivers, Calverton Naval Weapons Plant (recreational areas), Cathedral Pines County Park, South Haven County Park, Wertheim National Wildlife Refuge, and Randall Road Hunting Station. The NEPA documentation for RHIC and the AGS improvements does not identify potential effects on these land uses (DOE-CH 1991; 1994). Thus, the cumulative effect of these actions on parks, preserves, and recreational land use would be uncertain. However, it is expected that construction and operation of the SNS would not contribute to cumulative impacts on parks, preserves, and recreational land uses in the vicinity of BNL.

5.7.4.8.4 Visual Resources

Most of the visual panoramas in the area immediately surrounding BNL and within the laboratory contain features indicative of development. Cumulatively, the proposed action, RHIC, and AGS improvements would be compatible with the existing visual environment of the area. Therefore, the cumulative impact of these actions on visual resources at BNL would be minimal.

5.7.4.9 Human Health

During normal operations, all SNS effluents containing radioactive or toxic materials would be gaseous. Based on 1995 emissions for all existing BNL facilities, the hypothetical maximally exposed individual received a dose of 0.06 mrem via air pathways, while the offsite population received a dose of 3.2 person-rem. DOE includes the RHIC and the programmed improvements of the AGS in the analysis of cumulative impacts for a proposed SNS facility at BNL. Operation of the RHIC and other facilities supporting it would result in an additional dose from air pathways of 0.016 mrem/yr to the hypothetical maximally exposed individual and 6 mrem/yr to the offsite population. Operation of the improved AGS and other facilities in tandem with these improvements would add 0.29 mrem/yr to the maximally exposed individual. No estimate of the increment in dose to the offsite population is available.

For the proposed 1-MW SNS facility, the increment in air pathway dose to the maximally exposed individual would be 0.89 mrem/yr and 20 person-rem/yr to the offsite population. For the proposed 4-MW SNS facility, the corresponding doses are 3.4 mrem/yr for the maximally exposed individual and 76 person-rem/yr for the offsite population. The ingestion component of the air pathway dose for the proposed SNS has been conservatively estimated based on the inhalation component of the air pathways. In spite of this conservatism and the conservatism of assuming that the maximally exposed individual is at the same location in each case, the cumulative dose via air pathways of 3.8 mrem/yr based on the proposed 4-MW SNS facility is still below the applicable limit of 10 mrem/yr.

Based on a risk conversion factor of 0.0005 LCFs/person-rem, the cumulative impacts of BNL emissions with those from the proposed SNS facility could result in fatalities at both 1 MW (0.46 LCFs) and 4 MW (1.6 LCFs). LCFs of 1.0 or greater do not mean that any actual deaths would occur. Rather, LCFs provide a common and conservative basis for comparisons of alternatives.

Airborne concentrations of mercury would be approximately 10,000 times less than applicable standards for workers and the public and would not contribute to cumulative toxic health impacts.

5.7.4.10 Infrastructure

This section discusses the cumulative impacts on transportation and utility systems from the construction and operation of the proposed SNS, programmed improvements on the AGS, and RHIC.

5.7.4.10.1 Transportation

BNL is accessed by three major four-lane, divided highways. Currently, about 2,500 vehicles per day enter and exit BNL. In 1990, a transportation master plan was developed for BNL that evaluated traffic circulation impacts. The results of the study indicate that the transportation infrastructure in and around BNL could adequately service predicted traffic of 3,060 round-trips per day. The programmed improvements on the AGS would not increase traffic because the existing workforce would construct the upgrades and operate the facilities. The existing workforce would also construct the upgrades to existing facilities needed for RHIC. The operation of RHIC would increase traffic by about 160 round-trips per day. Locating the proposed SNS facility at BNL would increase traffic by 466 round-trips during the peak construction year and by 302 round-trips during operations. The addition of all these facilities would increase traffic, but the existing transportation infrastructure could accommodate this increase. The details of the effects from the proposed SNS are given in Section 5.5.10.1.

5.7.4.10.2 Utilities

BNL's current electrical demand is 52 MW. RHIC is projected to require 27.7 MW of electrical power with the injector system (AGS, Booster, LINAC, etc.) using another 16.8 MW strictly for accelerating ions that would be injected into RHIC. The proposed SNS facility would require 62 MW for the 1-MW beam and 90 MW for the 4-MW beam. Approximately 84 percent of BNL's energy demands are met by the New York Power Authority. They have 75,000 kW available for industrial use and would seriously consider requests for additional allocation from BNL for RHIC (DOE-CH 1991). The proposed SNS facility would require a new 69-kV transmission line to the LILCO's 138-kV grid located on the southeast corner of the BNL site. Required upgrades to the electrical systems for all of these facilities would occur within existing infrastructure corridors or alignments. Therefore, cumulative environmental impacts would be expected to be minimal.

The AGS used 1.37 mgpd (5.2 million lpd) of water for operations in 1992. However, the AGS is serviced with a closed-loop cooling system, and essentially all of the water pumped for AGS cooling purposes is returned to the aquifer through recharge basins. RHIC's requirements of 144,000 gpd (545,098 lpd) represent about 3 percent of the margin-of-safe-yield volume of 5.2 mgpd (19.7 million lpd) available to BNL. RHIC would require 450 gpm (1,703 lpm) for cooling purposes. This is a small increment of the 4,500 gpm (17,034 lpm) that BNL withdraws and the 2,250 gpm (8,517 lpm) it returns to recharge basins. The proposed SNS facility would require 800 gpm (3,028 lpm) for the 1-MW beam and 1,600 gpm (6,057 lpm) for the 4-MW beam. BNL has the capacity to pump 7,200 gpm (27,255 lpm) and would be able to accommodate all of these facilities. The details of the effects of the proposed SNS facility on utilities are given in Section 5.5.10.2.

5.7.4.11 Waste Management Facilities

All of the waste generated during construction and operation of the proposed SNS facility would be transferred to BNL for processing. The existing BNL waste management facilities for sanitary wastes and for treatment of liquid low-level radioactive wastes have sufficient capacity to accommodate the waste streams from the proposed SNS. However, current storage capacity for hazardous wastes, low-level radioactive wastes, and mixed wastes would not be able to accommodate the projected volumes of SNS wastes (refer to Section 5.5.11). These projections include wastes from future activities. The current storage facilities would have to be expanded to increase RCRA-permitted storage capacity to accommodate the storage of these future wastes. Considering that BNL recently finished construction of a new waste management facility, a requirement to expand this facility in the future would incur additional resources. Consequently, SNS operations would have an effect on waste management operations at BNL.

5.7.5 NO-ACTION ALTERNATIVE

The proposed SNS facility would not be constructed, operated, or closed at any location under the No-Action Alternative. Consequently, implementation of this alternative would not contribute to cumulative impacts.

5.8 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

The impact assessment conducted in this EIS has identified potential adverse impacts along with mitigation measures that could be implemented to either avoid or minimize these effects. The residual adverse impacts are unavoidable and are discussed below.

5.8.1 ORNL ALTERNATIVE (PREFERRED ALTERNATIVE)

The unavoidable adverse environmental impacts that would result from implementation of the proposed action at ORNL are as follows:

- Neutron activation of soils in the berm used to shield the linac tunnel.

- Site runoff and the SNS cooling water collected in the sediment retention basin would be discharged to WOC at a point south of Bethel Valley Road. The discharge rate would be 0.36 to 0.50 mgpd (1.36 to 1.9 million lpd), increasing stream velocity and channel erosion in WOC. Potential changes in water parameters, such as an increase in temperature, would occur. As a result of the increased water flow out of White Oak Lake, radionuclide releases at White Oak Dam would potentially increase by minimal amounts.

- Potential localized increase in groundwater radionuclide concentrations due to leaching of neutron-activated soil in the shielding berm for the linac tunnel. Exceedance of drinking water limits for a human receptor would be highly unlikely.

- Removal of vegetation, primarily of oak-hickory forest and planted pine stands, from 110 acres (45 ha) of land on the proposed SNS site. Vegetation would also be removed within new utility corridors and rights-of-way. Vegetation would be removed from approximately 20 percent of NERP Natural Area 52.

- Two small wetlands [total area of 0.12 acres (0.05 ha)] would be destroyed to allow for upgrading of Chestnut Ridge Road, the primary access road to the proposed SNS site. DOE, in consultation with USACOE and the State of Tennessee, would develop a plan to mitigate these effects either by constructing new wetland habitat or by enhancing existing wetland habitats.

- Introduce large-scale development to the undeveloped proposed SNS site, utility corridors, and new rights-of-way.

- Near-term and future adverse effects of emissions from the SNS boiler stacks on CO_2 monitoring under the TDFCMP in the Walker Branch Watershed. The CO_2 output from the proposed SNS would include exhaust emissions from construction equipment and from personal vehicles driven to the site by operations employees beginning in FY 2005. Two ORNL ecological research projects would be adversely affected by these CO_2 emissions. The CO_2 effects could be mitigated, which would result in minimal effects. The effects of NO_x on TDFCMP monitoring would be minimal. After SNS operations begin in late FY 2005, water vapor emitted by the SNS cooling towers may affect TDFCMP monitoring and eight ORNL ecological research projects, including a continuation of some current projects and several planned projects. If agreed to by NOAA/ATDD and DOE, Phase II air quality modeling could be useful in better defining these water vapor effects. In all cases, the effects from emissions would be loss of data quality, data comparability over time, and the ability to effectively meet research objectives.

- Approximately 26,516 acres (10,735 ha) of ORR land are open to the public for recreational deer hunting. Construction of the SNS would reduce the total open to the public for recreational deer hunting by 110 acres (45 ha). This restriction would continue during the operational life cycle of the SNS.

- The proposed SNS facilities would come into view along the upper reaches of Chestnut Ridge Road and the southwest access road to the proposed SNS site. During construction these roads would be traveled by DOE and ORNL personnel, construction workers, and service providers. During operations, they would be traveled by DOE personnel, SNS employees, service providers, and visitors to the SNS facilities, including visiting scientists.

- During normal operations, releases of small amounts of radiation from the proposed SNS facility in the form of direct radiation and airborne emissions would be unavoidable. The potential for adverse effects due to these releases is based on the very conservative assumptions used to estimate ingestion dose to the public based on inhalation dose. The highest doses to maximally exposed individuals and populations from airborne emissions would occur during operations at 4 MW. A member of the public could receive a dose of 1.5 mrem/yr, and an uninvolved worker could receive a dose of 0.37 mrem/yr. Based on the assumption that the proposed SNS operates at 1 MW for 10 years and at 4 MW for 30 years, a total of 0.84 LCFs could occur in the offsite population over the entire 40-year life of the facility.

- Construction and operation of the proposed SNS would increase traffic on the roads leading to the proposed SNS site. The resulting increases in traffic congestion and accidents would be unavoidable and could require upgrading the affected roads to accommodate increased traffic and minimize accidents.

5.8.2 LANL ALTERNATIVE

Implementation of the proposed action at LANL would result in the following unavoidable adverse environmental impacts:

- Neutron activation of soils in the berm used to shield the linac tunnel.

- Site runoff and the SNS cooling water collected in the retention basin would be discharged to intermittent drainages in

TA-70. The discharge rate would be 0.36 to 0.50 mgpd (1.36 to 1.9 million lpd), increasing stream velocity and channel erosion in these intermittent streams. Potential changes in water parameters, such as an increase in temperature, would occur when water is present in the streams.

- Potential localized increase in groundwater radionuclide concentrations due to leaching of neutron-activated soil in the shielding berm for the linac tunnel. Groundwater effects would be minimal because of the low soil infiltration rate and great depth [820 ft (250 m)] to the main aquifer.

- Sustained groundwater pumping over 40 years to serve the needs of the proposed SNS facility could lower water levels in area wells and reduce the long-term productivity of the main aquifer that serves the LANL area.

- Removal of vegetation, primarily piñon-juniper woodlands and scattered juniper savannas, from 110 acres (45 ha) of land on the proposed SNS site. Vegetation would also be removed within new utility corridors and rights-of-way.

- Five NRHP-eligible prehistoric archaeological sites within the 65 percent survey area on and adjacent to the SNS site would be destroyed by site preparation activities under the proposed action. In the unsurveyed 35 percent of the proposed SNS site, any prehistoric sites listed on or eligible for listing on the NRHP would also be destroyed during site preparation.

- Thirty-five percent of the proposed SNS site has not been surveyed for historic cultural resources. However, site preparation activities in this area would destroy any historic sites, structures, or features listed on or eligible for listing on the NRHP.

- Five TCPs (all prehistoric archaeological sites in the 65 percent survey area on and adjacent to the SNS site) would be destroyed by site preparation activities under the proposed action. If any prehistoric archaeological sites are located within the unsurveyed 35 percent of the proposed SNS site, these TCPs will also be destroyed by site preparation. The unavoidable adverse impacts on water resources listed in this section would also be unavoidable adverse impacts on TCPs.

- Introduction of large-scale development to the undeveloped proposed SNS site, utility corridors, and new rights-of-way.

- Potential restriction or ending of public hiking trail use near the proposed SNS site in TA-70.

- The proposed action would change views in its vicinity from undeveloped piñon-juniper woodlands to industrial development. During construction and operations, the SNS facilities would be visible to travelers along State Route 4 and the access road to the SNS. These facilities would also be visible from points on the proposed SNS site. During the night hours, facility lighting would be highly noticeable to viewers because no other large, lighted facilities are present in this remote area of LANL. However, the SNS facilities would not be visible from White Rock or popular public use areas in Bandelier National Monument.

- Potable water demand for the proposed SNS facility during operations would exceed the groundwater-based distribution system's capacity by 1.75 mgpd (6.62 million lpd).

- During normal operations, releases of small amounts of radiation from the proposed SNS facility in the form of direct radiation and airborne emissions would be unavoidable. The potential for adverse effects due to these releases is based on the very conservative assumptions used to estimate ingestion dose to the public based on inhalation dose. The highest doses to maximally exposed individuals and populations from airborne emissions would occur during operations at 4 MW. A member of the public could receive a dose of 1.2 mrem/yr, and an uninvolved worker could receive a dose of 0.23 mrem/yr. Based on the assumption that the proposed SNS operates at 1 MW for 10 years and at 4 MW for 30 years, a total of 0.15 LCFs could occur in the offsite population over the entire 40-year life of the facility.

- The proposed SNS site is isolated from the other facilities at LANL and would require a considerable investment in new infrastructure to provide the necessary utilities to the SNS. Moreover, the existing electrical power system at LANL does not have adequate electrical capacity to meet significant future demands such as those required by the proposed SNS. New ways of getting more power to the site would have to be pursued, and there are no pending strategies to do that at this time.

5.8.3 ANL ALTERNATIVE

The unavoidable adverse environmental impacts that would result from implementation of the proposed action at ANL are as follows:

- Neutron activation of soils in the berm used to shield the linac tunnel.

- Site runoff and the SNS cooling water collected in the sediment retention basin would be discharged to an unnamed tributary of Sawmill Creek. The discharge rate would be 0.36 to 0.50 mgpd (1.36 to 1.9 million lpd), increasing stream velocity and channel erosion in the tributary. Potential changes in water parameters, such as an increase in temperature, would occur.

- Potential localized increase in groundwater radionuclide concentrations due to leaching of neutron-activated soil in the shielding berm for the linac tunnel. A potable groundwater aquifer lies at a depth of 165 ft (50 m). The downward rate of water movement through the saturated zone of the Wadsworth Till is only 3.0 ft/yr (0.9 m/yr). High clay content of the till would retard radionuclide migration, but accurate prediction of migration rates and the potential for aquifer contamination would be difficult because of the complex deposits.

- A total of 3.5 acres (1.4 ha) of wetland habitat would be destroyed to allow construction of the proposed SNS facility. DOE, in consultation with the USACOE and the State of Illinois, would develop a plan to mitigate this effect, either by constructing new wetland habitat or by enhancing existing wetland habitats.

- Removal of vegetation from Ecology Plots 6, 7, and 8 and Open Space land on the proposed SNS site. Vegetation would also be removed within new utility corridors and rights-of-way.

- Introduction of large-scale development to Ecology Plots 6, 7, and 8, Open Space land on the proposed SNS site, utility corridors, and new rights-of-way.

- The proposed SNS site would be located in proximity to the west perimeter fence of ANL. This fence would be adjacent to the Waterfall Glen Nature Preserve. During construction and operations, the SNS facilities would be potentially visible from deep interior points within the preserve, especially on the west side during late autumn, winter, and early spring.

- During normal operations, releases of small amounts of radiation from the proposed SNS facility in the form of direct radiation and airborne emissions would be unavoidable. The potential for adverse effects due to these releases is based on the very conservative assumptions used to estimate ingestion dose to the public based on inhalation dose. The highest doses to maximally exposed individuals and populations from airborne emissions would occur during operations at 4 MW. A member of the public could receive a dose of 6.8 mrem/yr, and an uninvolved worker could receive a dose of 0.15 mrem/yr. Based on the assumption that the proposed SNS operates at 1 MW for 10 years and at 4 MW for 30 years, a total of 3.1 LCFs could occur in the offsite population over the entire 40-year life of the facility.

- The proposed SNS site is within the 800 Area at ANL, and the footprint for this site would overlay Westgate Road. Approximately 1 mi (1.6 km) of the existing Westgate Road would have to be relocated to replace the existing ANL site access.

5.8.4 BNL ALTERNATIVE

Implementation of the proposed action at BNL would result in the following unavoidable adverse environmental impacts:

- Neutron activation of soils in the berm used to shield the linac tunnel.

- Site runoff and the SNS cooling water collected in the sediment retention basin would be discharged to the headwaters of the Peconic River. The discharge rate would be 0.36 to 0.50 mgpd (1.36 to 1.9 million lpd), increasing stream velocity and channel erosion in the river. Potential changes in water parameters, such as an increase in temperature, would occur.

- Potential increase in groundwater radionuclide concentrations due to leaching of neutron-activated soil in the shielding berm for the linac tunnel. The sole source aquifer for Long Island would lie only 20 ft (6.1 m) below the proposed SNS site. High permeability of the soils [17 ft/yr (5.2 m/yr)] would allow unacceptably high levels of radionuclides in the aquifer in the immediate vicinity of the proposed SNS site. Exceedance of drinking water limits for a human receptor at an offsite location would be unlikely.

- Removal of vegetation from 110 acres (45 ha) of Open Space land on the proposed

SNS site. This vegetation would be primarily oak and pine forest in the Compatible Growth Area of the established Pine Barrens Protection Area. Vegetation would also be removed within new utility corridors and rights-of-way.

- A number of potentially NRHP-eligible earthen features at Stations 2, 4, 8, and 10 on the proposed SNS site may have been associated with World War I trench warfare training at Camp Upton. They would be destroyed by construction activities under the proposed action.

- Introduction of large-scale development to the undeveloped proposed SNS site, utility corridors, and new rights-of-way.

- The proposed action would add the SNS facilities to an existing visual environment indicative of development.

- During normal operations, releases of small amounts of radiation from the proposed SNS facility in the form of direct radiation and airborne emissions would be unavoidable. The potential for adverse effects due to these releases is based on the very conservative assumptions used to estimate ingestion dose to the public based on inhalation dose. The highest doses to maximally exposed individuals and populations from airborne emissions would occur during operations at 4 MW. A member of the public could receive a dose of 2.6 mrem/yr, and an uninvolved worker could receive a dose of 0.13 mrem/yr. Based on the assumption that the proposed SNS operates at 1 MW for 10 years and at 4 MW for 30 years, a total of 2.1 LCFs could occur in the offsite population over the entire 40-year life of the facility.

5.8.5 NO-ACTION ALTERNATIVE

The proposed SNS would not be constructed, operated, or retired at any location under the No-Action Alternative. Consequently, no unavoidable adverse environmental impacts would result from implementation of this alternative.

5.9 SHORT-TERM USE AND LONG-TERM PRODUCTIVITY

The proposed action is projected to last for a minimum period of 40 years on the alternative site selected for construction and operation of the SNS. The effects of this short-term use of the environment and the No-Action Alternative on the long-term productivity of the environment are assessed in this section.

5.9.1 ORNL ALTERNATIVE (PREFERRED ALTERNATIVE)

DOE has no current plans to return the proposed SNS site to environmental conditions approaching those of a greenfield at the end of its operational life cycle, although this option has not been totally eliminated from consideration. If such an option were implemented, the proposed SNS site environment would be available for productive uses commensurate with the cleanup levels achieved during site remediation.

Two possible options for decommissioning of the proposed SNS are being actively considered: in situ decommissioning and limited decontamination combined with in situ decommissioning. As a result, use of the 110-acre (45-ha) SNS site and adjacent land for other productive purposes could be limited for an indeterminate number of years beyond the operational life cycle of the SNS. The proposed SNS site represents less than one half percent of the total forested area on the ORR.

Impacts would occur on the development of groundwater in the immediate vicinity of the SNS site due to the release of radionuclides. The impact on groundwater productivity would be localized and insignificant in terms of unaffected groundwater resources within the surrounding watershed that would be available for development.

5.9.2 LANL ALTERNATIVE

The primary source of potable water for LANL and the Los Alamos area is a groundwater aquifer. This aquifer is not officially designated as a sole source aquifer, but it essentially functions as one. Operation of the proposed SNS would require 1.2 to 2.3 mgpd (4.5 million lpd) of groundwater from this aquifer. If the continuous daily demand for SNS operations were only half of what would actually be required to operate the proposed 4-MW SNS facility, pumping of water from the main aquifer would have to increase by 25 percent to meet this demand. Sustained pumping at this magnitude over much of the minimum 40-year operational life cycle of the proposed SNS facility could lower water levels in nearby wells and ultimately affect the long-term productivity of the main aquifer. Lower water levels would occur if water withdrawal rates from the main aquifer exceed natural recharge in the arid climate of the Los Alamos area. This possibility would place water demands for the proposed SNS facility in competition with future growth demands by commercial, industrial, and residential users. These potential limitations on aquifer productivity could persist for an indeterminate period beyond the operational life cycle of the proposed SNS.

Impacts would occur on the development of groundwater in the immediate vicinity of the SNS site due to the release of radionuclides. The impact on groundwater productivity would be localized and insignificant in terms of unaffected groundwater resources within the surrounding watershed that would be available for development.

DOE has no current plans to return the proposed SNS site to environmental conditions approaching those of a greenfield at the end of its operational life cycle, although this option has not been totally eliminated from consideration. If such an option were implemented, the proposed SNS site environment would be available for productive uses commensurate with the cleanup levels achieved during site remediation.

Two possible options for decommissioning of the proposed SNS are being actively considered: in situ decommissioning and limited decontamination combined with in situ decommissioning. As a result, use of the 110-acre (45-ha) SNS site and adjacent land for other productive purposes could be limited for an indeterminate number of years beyond the operational life cycle of the SNS. The proposed SNS site represents approximately 10 percent of the piñon-juniper habitat in TA-70.

5.9.3 ANL ALTERNATIVE

DOE has no current plans to return the proposed SNS site to environmental conditions approaching those of a greenfield at the end of its operational life cycle, although this option has not been totally eliminated from consideration. If such an option were implemented, the proposed SNS site environment would be available for productive uses commensurate with the cleanup levels achieved during site remediation.

Two possible options for decommissioning of the proposed SNS are being actively considered: in situ decommissioning and limited decontamination combined with in situ decommissioning. As a result, use of the 110-acre (45-ha) SNS site and adjacent land for other productive purposes could be limited for an indeterminate number of years beyond the operational life cycle of the SNS.

Impacts would occur on the development of groundwater in the immediate vicinity of the SNS site due to the release of radionuclides. The impact on groundwater productivity would be localized and insignificant in terms of unaffected groundwater resources within the surrounding watershed that would be available for development.

5.9.4 BNL ALTERNATIVE

Operation of the proposed SNS facility would result in some neutron activation of the soils in the linac berm, even with specially engineered, multilayer shielding. The minimal ability of proposed SNS site soils to retard the transport of contaminants in groundwater and their high permeability would allow for the leaching of contaminated soils and rapid migration of radionuclides to the sole source aquifer that lies only 20 ft (6.1 m) beneath the proposed SNS site. Radionuclide accumulations in this aquifer could reach unacceptable levels, although contaminant migration to offsite locations in concentrations of concern to local drinking water quality would be improbable.

Impacts would occur on the development of groundwater in the immediate vicinity of the SNS site due to the release of radionuclides. The impact on groundwater productivity would be localized and insignificant in terms of unaffected groundwater resources within the surrounding watershed that would be available for development.

DOE has no current plans to return the proposed SNS site to environmental conditions approaching those of a greenfield at the end of its operational life cycle, although this option has not been totally eliminated from consideration. If such an option were implemented, the proposed SNS site environment would be available for productive uses commensurate with the cleanup levels achieved during site remediation.

Two possible options for retirement of the proposed SNS facility are being actively considered: in situ decommissioning and limited decontamination combined with in situ decommissioning. As a result, use of the 110-acre (45-ha) SNS site and adjacent land for other productive purposes could be limited for an indeterminate number of years beyond the operational life cycle of the SNS. The proposed site lies within the Pine Barrens area of Long Island. The 110 acres (45-ha) represent less than two percent of the Pine Barrens Protection Area. The proposed SNS would be constructed entirely within the Compatible Growth Area of the Pine Barrens, not within the more stringently Protected Core Preservation Area (refer to Section 4.4.8.4).

5.9.5 NO-ACTION ALTERNATIVE

The proposed SNS facility would not be constructed, operated, or closed at any location under the No-Action Alternative. No short-term use of the environment would occur under this alternative. Consequently, such use would have no effect on the long-term productivity of the environment.

5.10 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The irreversible and irretrievable commitment of resources associated with the proposed action (SNS siting alternatives) and the No-Action Alternative are presented in Table 5.10-1.

5.11 MITIGATION MEASURES AND MONITORING PLAN

One of the major functions of an EIS is to specify measures that could be taken to mitigate adverse environmental impacts identified through the impact analysis. Mitigation measures may be classified according to three basic categories: (1) measures required by law or regulations; (2) measures that are built into a project from the start to avoid effects; and (3) measures that are developed in response to adverse impacts identified in the environmental impact analyses.

This section summarizes the mitigation measures that may be applied to potential effects associated with each of the alternatives analyzed in this EIS. Mitigation measures required by law or regulation are not discussed in this section. The applicable laws and regulations that embody such requirements are described in Chapter 6. Also, routine mitigation measures that would be implemented as part of standard practices for construction or operation are not included in the summary. These measures would include practices such as installing silt fences to minimize soil erosion and sediment transport during construction.

5.11.1 ORNL ALTERNATIVE (PREFERRED ALTERNATIVE)

Measure designed to avoid adverse environmental impacts that would result from implementing the proposed action on the SNS site at ORNL would be incorporated in SNS construction. DOE is committed to implementation of the following avoidance measures:

- A retention basin would be constructed to collect surface water runoff from the proposed SNS site. It would be used to settle sediment particles entrapped in the runoff and to control the rate of water discharge from the basin into WOC. As a result, effects on stream characteristics and flow, water quality, and aquatic resources downstream from the outfall into WOC would be minimized.

- Water from the cooling towers would be temporarily collected in the retention basin. The basin would be committed to lowering the temperature of the cooling water prior to its discharge into WOC. This reduction

Table 5.10-1. Irreversible and/or irretrievable commitment of resources (proposed SNS facility at 1 MW for 40 years).

Factor	No-Action	ORNL Alternative	LANL Alternative	ANL Alternative	BNL Alternative
Land use					
Land (ac)	0	110	110	110	110
Forested (ac)	0	75±	50±	50±	75±
Construction					
Concrete (yd^3)	0	50,000	50,000	50,000	50,000
Steel Shielding (tons)	0	4,000	4,000	4,000	4,000
Utilities					
Electricity[a] (gWh)	0	10,183	10,183	10,183	10,183
Water[b] (gals)	0	9.4E+09	9.4E+09	9.4E+09	9.4E+09
Steam[c] (lb)	0	0	4.8E+09	4.8E+09	0
Natural Gas (bcf)[d]	0	1.73	NA	NA	2.67
Workforce					
Direct (persons)	0	275	275	275	275
Indirect	0	1,314	1,314	1,314	1,314
Construction	0	2,349	2,349	2,349	2,349

[a] Assume full power for 240 days/yr for 40 yrs at 85%.
[b] Assume continuous 800 gpm (3,028 lpm) use for 240 days/yr for 40 yrs at 85%.
[c] Energy required to produce steam based on APS usage at ANL, adjusted for degree days.
[d] Billion cubic feet - based on 23.565 mcf/hr at ORNL in January, adjusted for degree days.
NA - Not available.

would minimize the potential effects of elevated water temperatures on the ambient temperature of the creek and temperature-sensitive aquatic resources.

- The cooling water effluent from the proposed SNS facility would be dechlorinated prior to discharge into the retention basin to minimize effects on aquatic resources downstream from the outfall to WOC.

- The discharge from the retention basin would be routed by pipeline to a WOC outfall point south of Bethel Valley Road. This pipeline would avoid effects on baseline NPDES monitoring activities, including the ORNL Biological Monitoring and Abatement Program (BMAP), and other ORNL research activities involving the headwaters of WOC.

- The shielding design of the proposed SNS facility would be modified to minimize neutron activation of the linac berm soils, leaching of radionuclides by groundwater, and subsurface migration of radionuclide contamination. This design would include a crushed limestone interval covered by a geomembrane liner to protect the groundwater and inhibit its flow.

- A continuously forested pathway would be retained along Chestnut Ridge during vegetation clearing to minimize effects on terrestrial wildlife movements.

- A 100- to 200-ft (34- to 68-m) buffer zone of uncleared vegetation would be retained along the headwaters of WOC near the proposed SNS site to minimize the effects of solar radiation on water temperature and cool water aquatic resources (for example, fish species such as the banded sculpin and blacknose dace).

A number of measures would be taken to mitigate adverse environmental impacts that would result from implementing the proposed action on the SNS site at ORNL. DOE is committed to implementation of the following mitigation measures:

- The effects of elevated continuous noise from the cooling towers and other sources on SNS site personnel and visitors would be minimized with landscape barriers to the extent possible. Such barriers would include the use of trees as sound baffles.

- Wetlands in the vicinity of the proposed SNS site would be potentially damaged or eliminated during construction and operation of the SNS. Effects of the proposed action on wetlands would be mitigated by implementing measures to prevent their damage, repair unpreventable damage, or replace eliminated wetlands with an equal or greater amount of man-made wetlands. These man-made wetlands would be as much like the original wetlands as possible. Such mitigative actions would meet the current federal policy calling for no net loss of wetlands as a result of U.S. government activities.

- Appropriate measures would be implemented to protect identified specimens of pink lady's slipper and American ginseng during implementation of the proposed action. On a case-by-case basis, appropriate measures would be taken to protect any other specimens of threatened and endangered species identified during a systematic biological survey of the proposed SNS site that would occur prior to implementation of the proposed action.

- Traffic impacts would be mitigated by improvements to eastbound segments of Bethel Valley Road and southbound segments of State Road 62.

- If radioactive mixed waste generated by the SNS were to exceed the capacity of current storage facilities at ORNL, mitigation measures would have to be taken. Increasing the RCRA-permitted storage capacity at the laboratory would mitigate this.

DOE is considering the following mitigation measures at ORNL but has not yet committed to their implementation:

- Emissions of CO_2 during construction and operation of the SNS would affect TDFCMP measurements by NOAA/ATDD and susceptible ORNL-ESD ecological research projects in the Walker Branch Watershed. These effects could be mitigated by relocating the NOAA/ATDD meteorological monitoring tower to a Walker Branch Watershed location less susceptible to the effects of the CO_2 emissions or by building a new tower at this different location.

- Emissions of CO_2 from natural gas boiler stacks during operation of the SNS would affect TDFCMP measurements and susceptible ORNL-ESD ecological research projects in the Walker Branch Watershed. These effects could be mitigated by installing electric heat pumps in the SNS heating system instead of natural gas boilers. This would eliminate CO_2 emissions from the heating system.

The prevention of future impacts after implementation of the proposed action on the SNS site at ORNL would be dependent upon plans for monitoring of the environment. DOE is committed to implementation of the following environmental monitoring measures:

- The groundwater at the proposed SNS site would be routinely monitored for radionuclide contamination.

- Emissions of airborne radioactivity and direct radiation would be routinely monitored throughout the life of the facility. Data gathered over approximately 10 years of operation at 1 MW would be used to evaluate and modify design and operating procedures, as necessary, prior to operation at 4 MW.

5.11.2 LANL Alternative

Measures designed to avoid adverse environmental impacts that would result from implementing the proposed action on the SNS site at LANL would be incorporated into SNS construction. DOE is committed to implementation of the following avoidance measures:

- The shielding design of the proposed SNS would be modified to minimize neutron activation of the linac berm soils, leaching of radionuclides by groundwater, and subsurface migration of the radionuclide contamination. This design would include a crushed limestone interval covered by a geomembrane liner to protect the groundwater and inhibit its flow.

A number of measures would be taken to mitigate adverse environmental impacts that would result from implementing the proposed action on the SNS site at LANL. DOE is committed to implementation of the following mitigation measures:

- The effects of elevated continuous noise from the cooling towers and other sources on SNS site personnel and visitors would be minimized with landscape barriers to the extent possible.

- Appropriate measures would be taken on a case-by-case basis to protect specimens of T&E species identified during a systematic biological survey of the proposed SNS site that would occur prior to implementation of the proposed action.

- Five prehistoric archaeological sites, all eligible for listing on the NRHP, are located on the proposed SNS site. In addition, these sites would be considered to be TCPs by local tribal groups. These sites are within the 65 percent of the proposed SNS site that has been surveyed for cultural resources. These sites would be destroyed during construction of the proposed SNS. This destruction would be mitigated through data recovery operations, consisting primarily of archaeological excavations and detailed architectural recording of the prehistoric structures at the five sites. The remaining 35 percent of the proposed SNS site and a

100-ft (30.5-m) buffer zone around it would be surveyed for cultural resources prior to implementation of the proposed action, if the site at LANL were selected for construction of the proposed SNS facility. Any NRHP-eligible prehistoric or historic cultural resources identified in this area would be subject to the same types of mitigation measures or other more appropriate measures determined on a case-by-case basis.

- DOE-AL has not consulted with Native American and Hispanic groups about the occurrence of other specific TCPs on the proposed SNS site or in its vicinity at LANL. If this site were chosen for construction of the proposed SNS facility, these consultations would be made prior to implementation of the proposed action. Appropriate measures to mitigate effects on any TCPs that may be identified through these consultations would be implemented on a case-by-case basis.

- The solid LLW generated by the SNS would cause a minimal effect on LANL's waste treatment facilities. Alternative treatment methods would have to be considered.

- The sanitary waste generated by the SNS would cause a minimal effect on LANL's waste treatment and disposal capabilities. Alternative treatment and disposal methods would have to be found.

DOE is considering the following mitigation measures at LANL but has not yet committed to their implementation:

- Construction of new utility infrastructure would be necessary to support the electrical power demands of the SNS. Additionally, it would be necessary to pursue several regional and multistate strategies to provide a 62-MW supply. These include a new regional (multistate) power grid configuration or possibly an SNS site-specific power generation station.

The prevention of future impacts after implementation of the proposed action on the SNS site at LANL would be dependent upon plans for monitoring of the environment. DOE is committed to implementation of the following environmental monitoring measures:

- Emissions of airborne radioactivity and direct radiation would be routinely monitored throughout the life of the facility. Data gathered over approximately 10 years of operation at 1 MW would be used to evaluate and modify design and operating procedures, as necessary, prior to operation at 4 MW.

5.11.3 ANL ALTERNATIVE

Measures designed to avoid adverse environmental impacts that would result from implementing the proposed action on the SNS site at ANL would be incorporated into SNS construction. DOE is committed to implementation of the following avoidance measures:

- The eastern edge of the proposed SNS site in ANL overlays a portion of the 100-year floodplain along an unnamed tributary of Sawmill Creek. In addition, the south tip of the linac tunnel would encroach the 100-year floodplain of Freund Brook. Potential effects from flooding would be mitigated in several ways, including filling and stabilization of these areas for buildings or structures, alteration of drainage patterns, and construction of drainage features (storm drains and canals) to direct storm water flow away from these areas.

- A retention basin would be constructed to collect surface water runoff from the proposed SNS site. It would be used to settle sediment particles entrapped in the runoff and to control the rate of water discharge from the basin into a small tributary of Sawmill Creek. As a result, effects on stream characteristics and flow, water quality, and aquatic resources downstream from the outfall would be minimized.

- Water from the cooling towers would be temporarily collected in the retention basin. The basin would be committed to lowering the temperature of the cooling water prior to its discharge into the tributary of Sawmill Creek. This reduction would minimize the potential effects of elevated water temperatures on the ambient temperature of the creek and aquatic resources.

- The shielding design of the proposed SNS facility would be modified to minimize neutron activation of the linac berm soils, leaching of radionuclides by groundwater, and subsurface migration of the radionuclide contamination. This design would include a crushed limestone interval covered by a geomembrane liner to protect the groundwater and inhibit its flow.

- A 100 to 200-ft (30 to 68-m) buffer zone of uncleared vegetation would be retained around Freund Brook to minimize surface water runoff and the effects of sediment loading on bottom-dwelling fauna.

A number of measures would be taken to mitigate adverse environmental impacts that would result from implementing the proposed action on the SNS site at ANL. DOE is committed to implementation of the following mitigation measures:

- The effects of elevated continuous noise from the cooling towers and other sources on SNS site personnel and visitors would be minimized with landscape barriers to the extent possible. Such barriers would include the use of trees as sound baffles.

- Approximately 3.5 acres (1.4 ha) of wetlands would be eliminated during construction of the proposed SNS. These wetlands are located on the proposed SNS site in ANL. Additional wetlands in the vicinity of the proposed SNS site would be temporarily affected during construction. These effects would be mitigated by implementing measures to prevent their damage, repair unpreventable damage, or replace eliminated wetlands with an equal or greater amount of man-made wetlands. These man-made wetlands would be as much like the original wetlands as possible. Such mitigative actions would meet the current federal policy calling for no net loss of wetlands as a result of U.S. government activities.

- Appropriate measures would be taken on a case-by-case basis to protect specimens of threatened and endangered species identified during a systematic biological survey of the proposed SNS site that would occur prior to implementation of the proposed action.

- The eligibility of 11DU207 for listing on the NRHP has not been assessed by ANL. If the proposed SNS site at ANL were chosen for construction of the SNS, this assessment would be made prior to the initiation of construction-related activities on the site. If the assessment indicates that 11DU207 is an NRHP-eligible cultural resource, appropriate measures would be implemented to mitigate effects from the proposed SNS facility. These measures would include avoidance, if possible, or archaeological excavation.

- The remaining support services operations in the 800 Area would be displaced by construction of the proposed SNS. This land use effect would be mitigated by transferring these operations to another area of ANL.

- The footprint for the SNS overlays Westgate Road. Approximately 1 mi (1.6 km) of this road would be relocated to the north to circumvent the proposed SNS site and replace the existing Westgate Road access.

The prevention of future impacts after implementation of the proposed action on the SNS site at ANL would be dependent upon plans for monitoring of the environment. DOE is committed to implementation of the following environmental monitoring measures:

- The groundwater at the proposed SNS site would be routinely monitored for radionuclide contamination.

- Emissions of airborne radioactivity and direct radiation would be routinely monitored throughout the life of the facility. Data gathered over approximately 10 years of operation at 1 MW would be used to evaluate and modify design and operating procedures, as necessary, prior to operation at 4 MW.

5.11.4 BNL ALTERNATIVE

Measures designed to avoid adverse environmental impacts that would result from implementing the proposed action on the SNS site at BNL would be incorporated into SNS construction. DOE is committed to implementation of the following avoidance measures:

- A retention basin would be constructed to collect surface water runoff from the proposed SNS site. It would be used to settle sediment particles entrapped in the runoff and to control the rate of water discharge from the basin into the Peconic River. As a result, effects on stream characteristics and flow, water quality, and aquatic resources downstream from the outfall into the river would be minimized.

- Water from the cooling towers would be temporarily collected in the retention basin. The basin would be committed to lowering the temperature of the cooling water prior to its discharge into the Peconic River. This reduction would minimize the potential effects of elevated water temperatures on the ambient temperature of the creek and temperature-sensitive aquatic resources.

- The cooling water effluent from the proposed SNS facility would be dechlorinated prior to discharge into the retention basin to minimize effects on aquatic resources downstream from the discharge outfall to the Peconic River.

- The discharge from the retention basin would be routed by pipeline to an outfall point on the Peconic River. This outfall would be located near the current outfall for the STP. Routing the discharge to this location would avoid effects on wetlands located upstream from the outfall.

- A minimum 300-ft (91-m) buffer zone of uncleared vegetation would be retained between the proposed SNS site and the Peconic River to minimize surface water runoff, sediment loading, and effects on aquatic resources.

A number of measures would be taken to mitigate adverse environmental impacts that would result from implementing the proposed action on the SNS site at BNL. DOE is committed to implementation of the following mitigation measures:

- The effects of elevated continuous noise from the cooling towers and other sources on SNS site personnel and visitors would be minimized with landscape barriers to the extent possible. Such barriers would include the use of trees as sound baffles.

- Appropriate measures would be implemented to protect identified specimens of spotted wintergreen, bayberry, and swamp azalea (state-protected species) during implementation of the proposed action. On a case-by-case basis, appropriate measures would be taken to protect any specimens of threatened and endangered species identified during a systematic biological survey of the proposed SNS site that would occur prior to implementation of the proposed action.

- A number of earthen features at Stations 2, 4, 8, and 10 on the proposed SNS site at BNL may have been used for World War I trench warfare training at Camp Upton. These features are potentially eligible for listing on the NRHP. They would be destroyed during construction of the proposed SNS facility. This effect would be mitigated through data recovery, which would consist of archaeological excavation.

- Hazardous waste generated by the proposed SNS facility would exceed the capacity of current RCRA storage facilities at BNL. This exceedance would be mitigated by increasing the permitted storage capacity for hazardous waste at the laboratory.

- Solid and liquid low-level radioactive waste generated by the proposed SNS facility would exceed the capacity of current storage facilities at BNL. This would be mitigated by increasing the permitted storage capacity for these wastes at the laboratory.

- Mixed waste generated by the proposed SNS facility would exceed the capacity of current RCRA storage facilities at BNL. This would be mitigated by increasing the permitted storage capacity for mixed waste at the laboratory.

- The liquid and solid hazardous wastes generated by the SNS would exceed BNL's current storage capacity. Storage facility capabilities must be expanded to increase RCRA-permitted storage capacity to accommodate the storage of these future wastes.

- The liquid and solid low-level radioactive wastes generated by the SNS would exceed BNL's current storage capacity. Storage facility capabilities must be expanded to increase RCRA-permitted storage capacity to accommodate the storage of these future wastes.

- The liquid and solid mixed wastes generated by the SNS would exceed BNL's current storage capacity. Storage facility capabilities must be expanded to increase RCRA-permitted storage capacity to accommodate the storage of these future wastes.

DOE is considering the following mitigation measures at BNL but has not yet committed to their implementations:

- The constructed proposed SNS facility at BNL would sit only 20 ft (6.1 m) above the sole source aquifer for Long Island. The sandy soils on the proposed SNS site are highly permeable, forming a rapid vertical migration route from a contaminated area of soil to the aquifer. Because of the potential for neutron activation of linac berm soil during SNS operations, a complex multilayer shielding design would be implemented on the proposed SNS site. This shielding would minimize neutron activation of the berm soils, leaching of radionuclides by groundwater, and subsurface migration of the radionuclide contamination.

The prevention of future impacts after implementation of the proposed action on the SNS site at BNL would be dependent upon plans for monitoring of the environment. DOE is committed to implementation of the following environmental monitoring measures:

- The groundwater at the proposed SNS site would be routinely monitored for radionuclide contamination.

- Emissions of airborne radioactivity and direct radiation would be routinely monitored throughout the life of the facility. Data gathered over approximately 10 years of operation at 1 MW would be used to evaluate and modify design and operating procedures, as necessary, prior to operation at 4 MW.

5.11.5 NO-ACTION ALTERNATIVE

The proposed SNS facility would not be constructed or operated at any location under the No-Action Alternative. Consequently, no environmental effects would occur as a result of this alternative, and no mitigation measures would be required.

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CHAPTER 6: PERMITS AND CONSULTATIONS

The major laws, regulations, executive orders, and Department of Energy (DOE) orders that would apply to the proposed action are discussed in this chapter. This discussion includes the federal and state environmental permits required to construct and operate the proposed Spallation Neutron Source (SNS). In addition, it describes the consultations and actions required to protect cultural resources, endangered species, and migratory birds located on and in the vicinity of the alternative proposed SNS sites.

6.1 FEDERAL AND STATE REQUIREMENTS

The federal laws, executive orders, and state environmental laws that would be applicable to construction and operation of the proposed SNS are described in this section, along with the regulations that are used to implement the laws. The laws are presented according to whether they were passed by the U.S. Congress (federal) or the state legislatures in Tennessee, New Mexico, Illinois, or New York. The executive orders are all federal requirements issued by the President of the U.S.

All of these requirements are presented in short tables under major subject headings, such as air quality, water quality, and waste management. The names of the laws and the formal numerical designations for the executive orders are presented in the second column. The third column contains the locations of the laws in the federal and state statutory codes. All of the indicated laws are considered to include subsequent amendments to them. The titles of the executive orders are also presented in this column. The fourth column contains the beginning citation numbers or a citation number range for the regulations that were developed to implement the laws.

The tables are followed by brief descriptions of the laws, executive orders, and regulations. Although some state environmental laws and regulations can be more stringent than their federal counterparts, their contents, especially at the regulatory level, must be at least as rigorous as the federal requirements. As a result, their content is mostly federal in origin. For this reason, the laws and regulations in this section are largely described at the federal level.

Many of the environmental laws and regulations require permits for performing certain activities that could be harmful to the environment. In addition, some require formal consultations with state and federal agencies about the potential effects of proposed actions on particular aspects of the environment. The permitting and consultation requirements applicable to the proposed action being assessed in this environmental impact statement (EIS) are included within the descriptions of the laws that mandate them. The required permits and consultations are summarized in Table 6.1-1.

The Environmental Protection Agency (EPA) has primary, umbrella responsibility for enforcement of the environmental laws and regulations that apply to the proposed action, but other federal agencies such as the U.S. Army Corps of Engineers (USACOE) and the U.S. Fish and Wildlife Service (USFWS) are charged with consultation, permitting, or

Table 6.1-1. Environmental permit and consultation requirements.

Activity/ Subject	Law	Requirements	Agency
Site Preparation	Clean Water Act (Section 404)	Section 404 Permit; State Aquatic Resource Alteration Permit (wetlands filling and stream alteration)	USACOE, TDEC, NMED, IEPA, NYSDEC
Stormwater Discharges	Clean Water Act	NPDES General Permit for Construction Activity; NPDES General Permit for Industrial Storm Water	EPA Region VI, TDEC, IEPA, NYSDEC
Wastewater Discharges	Clean Water Act	NPDES Permit for Industrial Activity (cooling water; groundwater interceptor system water)	EPA Region VI
Nonradioactive Air Emissions	Clean Air Act	Permits to construct new emissions sources; operating permits (natural gas boiler vents; laboratory hood vents; concrete batch plant)	TDEC, NMED, IEPA, NYSDEC
Radioactive Air Emissions	Clean Air Act	Permit to construct new emissions sources; NESHAP permit (Target Building and tunnel vent system stacks)	EPA Regions II, IV, and VI; IEPA
Structures over 200 ft (61 m) in height	Federal Aviation Act	Permit for structures over 200 ft (61 m) in height (construction cranes, water tower)	FAA
Cultural Resources	Archaeological Resource Protection Act	Excavation or removal permit data recovery at LANL or BNL	DOE
	National Historic Preservation Act	Section 106 consultation	SHPO
Endangered Species	Endangered Species Act	Consultation	USFWS
Migratory Birds	Migratory Bird Treaty Act	Consultation	USFWS

FAA - Federal Aviation Administration; TDEC – Tennessee Department of Environment and Conservation; NMED – New Mexico Environment Department; IEPA – Illinois Environmental Protection Agency; NYSDEC – New York State Department of Environmental Conservation; SHPO - State Historic Preservation Officer.

enforcement responsibilities that apply to specific aspects of the proposed action. The federal regulations relating to worker safety are enforced by the Occupational Safety and Health Administration (OSHA). Other requirements potentially applicable to the proposed action are administered by the Federal Aviation Administration (FAA).

The EPA has delegated most of its authority to enforce regulations to the states, although authority for some regulatory areas in some states is retained by the agency. Most of the state enforcement authority is lodged with the primary state environmental regulatory agencies. In Tennessee, New Mexico, Illinois, and New York, these agencies are, respectively, the Tennessee Department of Environment and Conservation (TDEC), New Mexico Environment Department (NMED), Illinois Environmental Protection Agency (IEPA), and New York State Department of Environmental Conservation (NYSDEC). Some enforcement authority, especially with regard to public water supplies and sanitary waste, is lodged with the state and local health departments.

6.1.1 AIR QUALITY

		Citation	
Jurisdiction	Statute	Statutes	Regulations
Federal	Clean Water Act	33 USC 1251 et seq.	40 CFR 110-136, 433-459
Tennessee	Tennessee Water Quality Control Act	TCA 69-3-101 et seq.	TCRR 1200-4-1 to 5, 7, 10-11
New Mexico	New Mexico Water Quality Control Act	NMSA 1978, Sections 74-6-4 et seq.	20 NMAC 6.1
Illinois	Environmental Protection Act	415 ILCS 5/11-13	35 Ill. Adm. Code 301
New York	New York State Environmental Conservation Law	Article 17	6 NYCRR 700-758

The Clean Air Act (CAA) is intended to protect and enhance the quality of the nation's air resources. Section 118 of the CAA places requirements on each federal agency that has jurisdiction over properties and facilities that might result in the discharge of air pollutants. Under this section, the agency must comply with all federal, state, interstate, and local requirements with regard to the control and abatement of air pollution.

This law requires the EPA to establish National Ambient Air Quality Standards (NAAQS), as necessary, to protect public health from any known or anticipated adverse effects of a regulated pollutant (42 USC 7409), while allowing an adequate margin of safety. It also requires the establishment of national standards of performance for new or modified stationary sources of atmospheric pollutants (42 USC 7411) and requires the evaluation of specific emission increases to prevent a significant deterioration in air quality (42 USC 7470). Hazardous air pollutants, including radionuclides, are regulated separately (42 USC 7412). Air emissions are regulated by the EPA in 40 CFR 50 through 99. In particular, radionuclide emissions are regulated under the National Emission Standards for Hazardous Air Pollutants (NESHAP) program (see 40 CFR 61).

The EPA has overall regulatory authority under the CAA, but this authority has been delegated to states that have established air pollution control programs approved by EPA. The state environmental regulatory agencies in Tennessee, New Mexico, Illinois, and New York have approved air programs. However, this approval does not extend to all the air regulations applicable to the national laboratories.

The EPA has retained regulatory authority over the new emission source performance standards (40 CFR 60, Subpart Db) in New York. In addition, the EPA has retained regulatory authority over the NESHAP for radionuclides in Tennessee, New Mexico, and New York. Furthermore, in Tennessee and New Mexico, EPA has retained regulatory authority relating to the stratospheric ozone protection provisions in Title VI of the CAA amendments of 1990.

Permits to construct and operate new air emissions sources would be required for new nonradiological sources used during construction and operation of the proposed SNS. These new sources would potentially include the vents for seven natural gas boilers in the building heating system, laboratory hood vents (nonradioactive use), and a concrete batch plant. These permits would contain operating conditions and emissions limitations for air pollutants.

Permits for construction of new radioactive emission sources and NESHAP permits for radionuclide emissions would be required for the target building and the linac tunnel ventilation stacks at the proposed SNS. In addition, such permits would be required for any laboratory hood vents that have the potential to emit radionuclides to the atmosphere during operation of the proposed SNS. As described in 40 CFR 61.96, if the effective dose equivalent caused by all emissions from facility operations is projected to be less than one percent of the 10 mrem per year NESHAP standard, an application for approval to construct under 40 CFR 61.07 would have to be filed. With prior EPA approval, 40 CFR 61.96 allows DOE to use methods other than the standard EPA methods for estimating the radionuclide source terms used in calculating the projected dose.

6.1.2 WATER QUALITY

		Citation	
Jurisdiction	Statute	Statutes	Regulations
Federal	Clean Air Act	42 USC 7401 et seq.	40 CFR 50-99
Tennessee	Tennessee Air Quality Act	TCA 53-3408 et seq.	TCRR 1200-3
New Mexico	New Mexico Air Quality Control Act	NMSA 1978, Sections 74-1-1 et seq.	20 NMAC 2.1
Illinois	Environmental Protection Act	415 ILCS 5/10, 27, 39, and 39.5	35 Ill. Adm. Code 201
New York	New York State Environmental Conservation Law	Article 19	6 NYCRR 200 and 380

The Clean Water Act (CWA) was enacted to restore and maintain the chemical, physical, and biological integrity of the nation’s water. It prohibits the discharge of toxic pollutants in toxic amounts to navigable waters of the U.S. (Section 101). Section 313 of the CWA requires all branches of the federal government engaged in any activity that might result in a discharge or runoff of pollutants to surface waters to comply with federal, state, interstate, and local requirements. In addition to setting water quality standards for the nation’s waterways, the CWA sets guidelines and limitations (Sections 301–303) for effluent discharges from point sources and provides authority (Sections 401–402) for the EPA to implement the National Pollutant Discharge Elimination System (NPDES) permitting program under 40 CFR 122.

The EPA has delegated primary enforcement authority for the CWA and the NPDES permitting program to the state environmental regulatory agencies in Tennessee, Illinois, and New York. In New Mexico, EPA has not delegated full CWA enforcement authority to the state environmental regulatory agency. The NPDES permits for the Los Alamos National Laboratory (LANL) are issued by EPA Region VI in Dallas, Texas. However, NMED does perform limited compliance auditing and monitoring at LANL through a Section 106 water quality agreement with EPA.

The foregoing state and federal agencies have issued NPDES permits covering current industrial wastewater discharges at Oak Ridge National Laboratory (ORNL), LANL, Argonne National Laboratory (ANL), and Brookhaven National Laboratory (BNL). These permits establish effluent limitations for specific chemical pollutants, limitations on physical parameters such as water temperature and flow, and monitoring requirements. The cooling water discharge from the proposed SNS would need to be included under the laboratory NPDES permit for discharges associated with industrial activities.

Process wastewater from the proposed SNS would be treated in onsite waste treatment facilities, and the effluent from the treatment process would be discharged to surface waters. The Atomic Energy Act of 1954 (AEA) regulates the discharge to surface waters of radionuclides from source, by-product, and special nuclear materials. However, the proposed SNS is an accelerator facility, and the discharge of accelerator-produced radionuclides to surface waters is not regulated under this statute. These discharges are regulated by EPA [CWA (40 CFR 122) and NPDES program] or authorized state programs under the CWA. The proposed SNS wastewater containing accelerator-produced radionuclides would be treated in facilities that also treat radionuclides from source, by-product, or special nuclear materials, such as reactor waste. At the outfalls for these treatment facilities, it would be impossible to determine whether a particular radionuclide in the discharge came from an accelerator or a reactor, which raises the issue of whether the discharge would be regulated under the AEA or the CWA. A possible approach would be to comply with the more restrictive discharge limits under the CWA, which are administered by EPA and the states.

There is no limit on the quantity or concentrations of radionuclides that can be discharged to surface waters under the current AEA requirements, as long as it can be shown that such discharges do not result in radiation doses in excess of established limits. The CWA and state rules establish limits on concentrations of radionuclides in effluents discharged to unrestricted areas and quantity limits on discharges to certain types of systems, such as sanitary sewer systems. However, DOE and ORNL have historically questioned the state of Tennessee's authority to regulate AEA-exempt radionuclide discharges to surface waters. This approach to compliance with respect to the proposed SNS waste treatment discharges would bring this controversy into sharper focus at ORNL and potentially at the other three national laboratories (DeVore 1997:1).

Another approach to this regulatory issue would be to proceed with compliance under a radionuclide-by-radionuclide scenario. Radionuclides from source, by-product, and special nuclear materials (for example, ^{137}Cs and ^{90}Sr) would be regulated under the AEA discharge rules. Accelerator-produced radionuclides, such as ^{7}Be, would be regulated under EPA or state rules. Radionuclides produced by both accelerator and nonaccelerator sources would be regulated under EPA or state rules. This regulation of common products in the treatment plant discharges would be the only departure from current practice (DeVore 1997:2).

Section 402(p) of the CWA authorizes the establishment of regulations to control the issuance of NPDES permits for stormwater discharges. These permits apply to discharges of stormwater from construction activities and point source discharges of stormwater associated with industrial activity. An NPDES general permit covering stormwater discharges from construction activity would be required for construction of the proposed SNS. In addition, an approved stormwater pollution prevention and erosion control plan specific to the construction activity would be required. An NPDES general permit for point-source stormwater discharges associated with industrial activity would be required for operation of the proposed SNS. The national laboratory selected for construction of the proposed SNS would be required to revise its site-wide Storm Water Pollution Prevention Plan to include the new stormwater point source on the sediment retention basin at the proposed SNS.

Section 316(a) of the CWA authorizes the Regional Administrator of EPA to set alternative effluent limitations on the thermal component of industrial discharges, if the owner/operator demonstrates that the proposed thermal effluent limitations are more stringent than necessary to ensure the protection and propagation of a balanced population of fish, shellfish, and wildlife in or on a body of water into which the discharge is to be made. In support of its request for a Section 316(a) exception, the owner/operator must submit with its NPDES permit application scientific documentation showing that the expected heated effluent will not result in appreciable harm to the indigenous aquatic community of the receiving water body. This scientific documentation is called a Section 316(a) Demonstration.

A Section 316(a) Demonstration may be required for the thermal component of the proposed SNS cooling water discharge. If required at ORNL, ANL, or BNL, this satisfactory demonstration would be made to the state environmental regulatory agencies. If required at LANL, the demonstration would be made to EPA Region VI. In all cases, demonstration oversight would be provided by EPA.

Section 404 of the CWA requires the issuance of a Section 404 permit for discharge of dredge or fill material into the waters of the U.S. This includes the filling of wetland areas by construction projects. The authority to implement these requirements and issue the permits has been given to the USACOE. In addition, a state environmental regulatory agency may require a state permit to physically alter waters of the state, which usually include streams and wetlands. For example, in Tennessee, TDEC requires an Aquatic Resource Alteration Permit (ARAP) to alter the waters of the state. Section 401 of the CWA requires certification that discharges from construction or operation of facilities, including discharges of dredge and fill material into navigable waters, will comply with applicable water quality standards. This certification is normally granted by the state regulatory agencies and is a prerequisite for receiving a Section 404 permit and state permits such as the Tennessee ARAP. When a federal construction project would result in the filling of a wetland area, the issuance of a Section 404 permit is usually contingent upon approval of a wetlands mitigation plan by the USACOE.

Construction activities would result in the partial filling of a wetland area overlapping the site of the sediment retention basin associated with the proposed SNS at ORNL. If the site in ANL were selected for construction of the proposed SNS, several wetland areas in ANL would be filled. These actions would require a Section 404 permit and a Tennessee ARAP or a similar state permit from IEPA. Furthermore, Section 404 and state permitting may be required for wastewater discharge conveyances, outfall structures, and the bridging of small streams, especially with regard to road improvements and the piping of retention basin discharge to White Oak Creek at ORNL and the Peconic River at BNL.

The primary objective of the Safe Drinking Water Act (SDWA) is to protect the quality of public water supplies and all sources of drinking water. The implementing regulations are administered by EPA or authorized state environmental regulatory agencies, and they establish standards applicable to public water systems. These standards include maximum contaminant levels (chemicals and radioactivity) in public water systems, which are defined as water systems that serve at least 15 service connections used by year-round residents or regularly serve at least 25 year-round residents. Other programs established by the SDWA include the Sole Source Aquifer Program, the Wellhead Protection Program, and the Underground Injection Control Program.

		Citation	
Jurisdiction	Statute	Statutes	Regulations
Federal	Safe Drinking Water Act	42 USC 300(F) et seq.	40 CFR 141-143
Tennessee	Tennessee Safe Drinking Water Act	TCA 68-221-701 et seq.	TCRR 1200-4-6, 1200-4-9, and 1200-5-1
New Mexico	Environmental Improvement Act	NMSA 1978, Section 74-1-8	20 NMAC 7.1
Illinois	Environmental Protection Act	Ill. Rev. Stat. 1981, ch 111 1/2, pars. 1001 et seq.	35 Ill. Adm. Code 601
New York	New York State Public Health Law	Sections 201, 206, and 225	10 NYCRR 5

EPA has delegated regulatory enforcement authority under the SDWA to state regulatory agencies in Tennessee, New Mexico, Illinois, and New York. In most cases, compliance with public water supply and contaminant monitoring requirements is overseen by state and local health departments. During operation of the proposed SNS, the levels of specific radioactive and chemical contaminants in the potable water system would have to be monitored on a regular basis to ensure cross-connection control and protection of human health.

Jurisdiction	Order No.	Title
Federal	Executive Order 12903	Energy Efficiency and Water Conservation at Federal Facilities

Executive Order 12903 requires federal agencies to develop and implement a program for the conservation of energy and water resources.

6.1.3 HAZARDOUS MATERIALS STORAGE AND HANDLING

Jurisdiction	Statute	Citation: Statutes	Citation: Regulations
Federal	See Section 6.2.2		
New York	New York State Environmental Conservation Law	Article 40	6 NYCRR 595-599

Improper storage and handling of hazardous materials poses serious risks to human health, public safety, and the environment. The federal and state requirements for hazardous materials storage and handling are aimed at minimizing these risks by identifying materials considered to be hazardous and establishing standards for hazardous materials storage facilities, storage and handling operations, response to releases, release reporting, and corrective action. The hazardous materials storage and handling activities conducted during construction and operation of the proposed SNS would be required to comply with the applicable portions of these requirements.

6.1.4 WASTE MANAGEMENT

The treatment, storage, or disposal (TSD) of hazardous and nonhazardous solid waste is governed by the Resource Conservation and Recovery Act (RCRA). Under Section 3006, a state that seeks to administer and enforce a hazardous waste program pursuant to RCRA may apply for EPA authorization of its program. The environmental regulatory agencies in the potential host states for the proposed SNS have received authorization from EPA to implement hazardous waste management programs.

Jurisdiction	Statute	Citation: Statutes	Citation: Regulations
Federal	Resource Conservation and Recovery Act	42 USC 6901 et seq.	40 CFR 240-282
Tennessee	Tennessee Hazardous Waste Management Act	TCA 68-212-101 et seq.	TCRR 1200-1-11
New Mexico	New Mexico Hazardous Waste Act	NMSA 1978, Section 74-1-6 et seq.	20 NMAC 4.1
Illinois	Environmental Protection Act	415 ILCS 5/13. 22.4, and 27	35 Ill. Adm. Code 700
New York	New York State Environmental Conservation Law	Article 27	6 NYCRR 370

RCRA and state hazardous waste regulations contain criteria for identifying hazardous wastes, requirements for hazardous waste transportation and handling, and requirements for the TSD of hazardous waste. The regulations imposed on a generator or TSD facility vary according to the types of hazardous waste generated, quantities of waste generated, characteristics of the TSD methods applied, and the attributes of the facilities used to manage the wastes. A RCRA permit is required for facilities that store hazardous waste onsite for more than 90 days, treat it, or dispose of it. Generators may be allowed to treat hazardous wastes onsite without a RCRA permit, provided that all applicable requirements are met.

The construction and operation of the SNS would generate hazardous waste and mixed waste. Mixed waste is a waste that is both hazardous and radioactive. Hazardous wastes would be accumulated at the SNS site for up to 90 days. The 90-day hazardous waste accumulation areas would be managed in compliance with applicable federal (RCRA) and state hazardous waste regulations. Hazardous waste would be transported to a permitted hazardous waste storage or treatment facility at the host site within the 90-day accumulation time limit.

Jurisdiction	Title	Statute Citation
Federal	The Federal Facility Compliance Act	42 USC 6921 et seq.

The Federal Facility Compliance Act (FFCA) was enacted on October 6, 1992. This legislation made federal facilities liable for federal/state fines and penalties for the illegal management of mixed waste, particularly its storage beyond established time limits. However, this law temporarily postpones the imposition of fines and penalties for mixed waste storage violations at DOE sites because sufficient treatment capacity for these wastes does not exist on a national scale. The postponement allows DOE to prepare plans for developing treatment capacity for the mixed waste generated or stored at each of its facilities. After consultation with other affected states, each plan must be approved by a facility's host state or the EPA, and the responsible regulatory agency must issue a consent order requiring compliance with the plan. Under the FFCA, DOE is not subject to fines and penalties for storage prohibition violations as long as it is in compliance with an approved plan and consent order and meets all other applicable regulations.

The FFCA would apply to any new mixed waste stream generated during construction or operation of the proposed SNS. DOE would be required to provide the state environmental regulatory agencies with information on the generation of these new mixed waste streams, and the mixed wastes in these streams would have to be managed in compliance with all applicable requirements.

Jurisdiction	Title	Statute Citation
Federal	Pollution Prevention Act	42 USC 13101 et seq.
Tennessee	Tennessee Hazardous Waste Reduction Act	TCA 68-212-301
New York	New York State Environmental Conservation Law	Article 27

The Pollution Prevention Act establishes a national policy for waste management and pollution control that focuses first on source reduction, followed sequentially by environmentally safe recycling, treatment, and disposal. Disposal or releases to the environment should occur only as a last resort. In response, DOE has committed to participation in the U.S. EPA 33/50 Pollution Prevention Program (Superfund Amendments and Reauthorization Act, Section 313). The goal for facilities already involved in Section 313 compliance was to achieve a 33 percent reduction in the release of 17 priority chemicals by 1997, using 1993 baseline quantities. On August 3, 1993, President Clinton issued Executive Order 12856 (see below), which resulted in expansion of the 33/50 Pollution Prevention Program. Under the expanded program, DOE must reduce its total releases of all toxic chemicals 50 percent by December 31, 1999. In addition, DOE is requiring each of its sites to establish site-specific goals to reduce the generation of all waste types.

Jurisdiction	Order Number	Title
Federal	Executive Order 12856	Right-to-Know Laws and Pollution Prevention Requirements

Executive Order 12856 requires all federal agencies to reduce the toxic chemicals entering any waste stream. This order also requires federal agencies to (1) report toxic chemicals entering waste streams; (2) improve emergency planning, response, and accident notification; and (3) encourage clean technologies and the testing of innovative pollution prevention technologies.

Jurisdiction	Order Number	Title
Federal	Executive Order 13101	Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition

Executive Order 13101 states a national policy preference for pollution prevention (reducing the generation of waste at its source) over waste recycling, treatment, and disposal. If pollution prevention is not feasible, wastes should be recycled or treated in an environmentally safe manner. Disposal should be used only as a last resort.

The Secretary of Energy is required to incorporate waste prevention and recycling into daily DOE operations. Markets for recovered materials must be expanded through greater DOE preference and demand for products made from such materials. In addition, DOE must implement cost-effective procurement programs that favor the purchase of environmentally preferable products and services. These are products and services with a lesser or reduced effect on human health and the environment compared to competing products and services used for the same purposes.

This executive order would require the incorporation of waste prevention and recycling into construction and operation of the proposed SNS, consistent with the demands of efficiency and cost-effectiveness. Procurement programs would be implemented to favor the purchase of environmentally preferable products and services, which would include products made from recovered materials.

6.1.5 FLOODPLAINS AND WETLANDS

Jurisdiction	Order Number	Title
Federal	Executive Order 11988	Floodplain Management

Executive Order 11988 requires federal agencies to establish procedures to ensure that the potential effects of flood hazards and floodplain management are considered for any action undertaken in a floodplain and that floodplain impacts be avoided to the extent practicable.

Jurisdiction	Order Number	Title
Federal	Executive Order 11990	Protection of Wetlands

Executive Order 11990 requires government agencies to avoid any short- and long-term adverse impacts on wetlands wherever there is a practicable alternative. It requires federal agencies to identify potential impacts to wetlands resulting from proposed activities and to minimize these impacts. Where impacts cannot be avoided, action must be taken to mitigate the damage by repairing or replacing the wetlands with an equal or greater amount of a man-made wetland as much like the original wetland as possible. The current federal policy is for no net loss of wetlands as a result of federal activities.

Jurisdiction	
Federal	See Sections 6.1.2 and 6.2.1

The discharge of dredge or fill material into wetlands is regulated at the federal level under Section 404 of the CWA and at the state level.

The relevant requirements and permits are discussed in Section 6.1.2. In addition, DOE has promulgated its own regulations pertinent to floodplains and wetlands management. These regulations are cited in Section 6.2.1.

6.1.6 WILDLIFE AND ECOSYSTEMS

		Citation	
Jurisdiction	Statute	Statute	Regulation
Federal	Endangered Species Act	16 USC 1531 et seq.	50 CFR 17, 23–24, 81, 217, 220–222, 225–227, 402, 424, 450–453

The Endangered Species Act is intended to prevent the further decline of endangered and threatened species and to restore these species and their habitats. The Act is jointly administered by the U. S. Department of Commerce (National Marine Fisheries Service) and the U.S. Department of the Interior (DOI) (USFWS). Section 7 requires consultation with the USFWS and the National Marine Fisheries Service to determine if endangered and threatened species or their critical habitats are in the vicinity of a proposed federal action.

The states also have various laws and regulations aimed at protecting endangered species, threatened species, other species of concern, and their habitats. Under these requirements, the states have issued lists of protected species that are state-level counterparts of the federal lists, but often with additional protection and concern categories that reflect state priorities.

The alternative proposed SNS sites and adjacent lands have been surveyed at the reconnaissance level for endangered, threatened, and special-concern floral and faunal species. These surveys encompassed species listed by the federal government, Tennessee, New Mexico, Illinois, and New York. In addition, the survey areas were evaluated for the presence or absence of potential habitats for these species. DOE has initiated informal consultations with the USFWS.

		Citation	
Jurisdiction	Statute	Statute	Regulation
Federal	Migratory Bird Treaty Act	16 USC 703 et seq.	50 CFR 20

The Migratory Bird Treaty Act is intended to protect birds that have common migration patterns between the U.S. and Canada, Mexico, Japan, and Russia. It regulates the harvest of migratory birds by specifying the mode of harvest, hunting seasons, bag limits, and other requirements. The Act stipulates that it is unlawful at any time, by any means, or in any manner to “kill . . . any migratory bird.”

DOE would be required to consult with the USFWS about potential impacts of the proposed SNS on migratory birds. In accordance with the USFWS Mitigation Policy, DOE would be required to evaluate ways to avoid or minimize any such impacts during construction and operation of the proposed SNS.

		Citation	
Jurisdiction	Statute	Statute	Regulation
Federal	Bald and Golden Eagle Protection Act	16 USC 668-668d	50 CFR 21-22

The Bald and Golden Eagle Protection Act makes it unlawful to take, pursue, molest, or disturb bald and golden eagles, their nests, or their eggs anywhere in the U.S. (Sections 668, 668c). A permit must be obtained from the DOI to relocate a nest that interferes with resource development or recovery operations.

No evidence of bald or golden eagle activity has been encountered on the four alternative proposed SNS sites. If bald or golden eagles, their nests, or their eggs appear on the chosen proposed SNS site prior to the initiation of construction-related activities, DOE would be required to obtain a permit for their disturbance or relocation.

6.1.7 CULTURAL AND HISTORIC RESOURCES

Jurisdiction	Statute	Citation	
		Statute	Regulation
Federal	National Historic Preservation Act	16 USC 470 et seq.	36 CFR 60-61, 63, and 800-812

The National Historic Preservation Act (NHPA) authorizes the Secretary of the Interior to maintain the National Register of Historic Places (NRHP). Under this statute, federal agencies must consider the potential effects of proposed projects on properties listed on or eligible for listing on the NRHP. Section 106 of the NHPA requires the formal review of a proposed action to determine its effects on historic properties. Under this review process, the federal agency must consult with the State Historic Preservation Officer (SHPO) in the state where the action would be implemented as part of an effort to locate possible historic properties and evaluate their NRHP eligibility. If an eligible or listed historic property is identified, the federal agency continues consultation with the SHPO to assess the effect of the proposed action on the property. If the action is determined to have an adverse effect on the property, consultation with the SHPO and Advisory Council on Historic Preservation will usually generate a Memorandum of Agreement containing stipulations that must be followed to mitigate the adverse effects.

The Section 106 review process has been initiated for each of the four alternative proposed SNS sites. It began with reconnaissance-level surveys for cultural resources on and in the vicinity of three alternative sites. Sufficient survey data on the proposed SNS site at ANL already existed prior to the beginning of the EIS process. The surveys at ORNL and BNL have been completed. Only 65 percent of the proposed SNS site and an associated buffer zone at LANL have been surveyed. DOE has initiated required consultations with the SHPOs in Tennessee, New Mexico, Illinois, and New York.

Jurisdiction	Statute	Citation	
		Statute	Regulation
Federal	Archaeo-logical Resource Protection Act	16 USC 470 et seq.	18 CFR 1812, 32 CFR 299, 36 CFR 296, and 43 CFR 7

The Archaeological Resource Protection Act requires a permit for any excavation or removal of archaeological resources from public or Native American lands. Excavations must be undertaken for the purpose of furthering archaeological knowledge in the public interest. Any resources that are removed must remain the property of the U.S. If a resource is on land owned by a Native American tribe, then consent must be obtained from the tribe before a permit is issued, and the permit must contain terms or conditions requested by the tribe.

Potential cultural resources dating to the Historic Period (World War I) have been identified on the proposed SNS site at BNL. Prehistoric archaeological resources eligible for listing on the NRHP have been identified on the proposed SNS site at LANL. If the proposed SNS site at BNL is chosen for construction, Phase II archaeological test excavations may be necessary to definitively assess the presence of Historic Period resources eligible for listing on the NRHP. Any necessary mitigation of potentially adverse impacts on NRHP-eligible resources at a proposed SNS site would likely be done through archaeological data recovery operations. These operations would involve the excavation and removal of artifacts. The archaeological testing, excavation, and removal operations would require a permit under the Act. This permit would be issued by DOE.

6.1.8 NATIVE AMERICANS

		Citation	
Jurisdiction	Statute	Statute	Regulation
Federal	Native American Graves Protection and Repatriation Act	25 USC 3001	43 CFR 10

This law directs the Secretary of the Interior to assume responsibilities for repatriation of federal archaeological collections and collections held by museums that are culturally affiliated with Native American tribes and are receiving federal funding. Major actions to be taken under this law include (1) establishing a review committee with monitoring and policy-making responsibilities, (2) developing regulations for repatriation, including procedures for identifying the lineal descent or cultural affiliation needed for claims, (3) overseeing museum programs designed to meet the inventory requirements and deadlines of this law, and (4) developing procedures to handle unexpected discoveries of graves or grave goods during activities on federal or tribal lands.

The provisions of this law would apply to the disposition of artifacts and human remains recovered during data recovery mitigation on the proposed SNS site at LANL, if this site is chosen for construction of the SNS. Remains from the Classic Period sites would be ancestral to the Native Americans at the Pueblo of San Ildefonso. Furthermore, if any inadvertent discoveries of Native American archaeological materials or human remains were to occur during construction or operation of the proposed SNS, their disposition would also be subject to the provisions of this law.

Jurisdiction	Statute	Citation
Federal	American Indian Religious Freedom Act	42 USC 1996

The provisions of the American Indian Religious Freedom Act reaffirm the religious freedom of American Indians under the first amendment to the constitution. The Act establishes a national policy to protect and preserve the inherent and constitutional right of American Indians to believe, express, and exercise their traditional religions. The Act requires that federal actions avoid interfering with access to sacred locations and traditional resources that are integral to the practice of religion.

Prehistoric cultural resources eligible for listing on the NRHP have been identified on the proposed SNS site at LANL. In addition, traditional cultural properties (TCPs) may occur on and adjacent to the site. If this site is chosen for construction of the proposed SNS, DOE would consult with the four accord tribes in the area (Pueblos of Cochiti, Jemez, Santa Clara, and San Ildefonso) concerning the occurrence of TCPs and cultural resources, mitigation of potential impacts on these resources, and other issues relating to the American Indian Religious Freedom Act.

Jurisdiction	Statute	Citation
Federal	Indian Sacred Sites	Executive Order 13007

Executive Order 13007 applies to agencies within the executive branch of the federal government that have statutory or administrative responsibility for managing federal lands that may contain American Indian sacred sites. A sacred site is defined as "…any specific, discrete, narrowly delineated location on Federal land that is identified by an Indian tribe, or Indian individual determined to be an appropriately authoritative representative of an Indian religion, as sacred by virtue of its established religious significance to, or ceremonial use by, an Indian religion; provided that the tribe or appropriately authoritative representative of an Indian religion has informed the agency of the existence of such a site."

To the extent practicable, permitted by law, and not clearly inconsistent with essential agency functions, DOE must accommodate access to and ceremonial use of Indian sacred sites on DOE lands by Indian religious practitioners. In addition, DOE must avoid adversely affecting the physical integrity of sacred sites and, where appropriate, maintain the confidentiality of such sites. Section 2 of this executive order requires the implementation of procedures to meet these requirements. Where practicable and appropriate, these procedures must ensure reasonable notice of proposed actions or land management policies that may restrict future access to or ceremonial use of sacred sites or adversely affect the physical integrity of such sites.

This executive order would be applicable to any sacred sites that might be identified on the proposed SNS site at LANL through consultations with American Indian tribal groups. No such sites are known to be present on the proposed SNS sites at ORNL, ANL, and BNL.

6.1.9 NOISE

Jurisdiction	Statute	Citation
Federal	Noise Control Act	42 USC 4901 et seq.

Section 4 of the Noise Control Act directs all federal agencies to carry out their programs in ways that promote an environment free of noise that jeopardizes human health and welfare.

6.1.10 HEALTH AND SAFETY

		Citation	
Jurisdiction	Statute	Statute	Regulation
Federal	Occupational Safety and Health Act	29 USC 651 et seq.	29 CFR 1910

The Occupational Safety and Health Act establishes standards to enhance safe and healthful working conditions in places of employment throughout the U.S. The Act is administered and enforced by the OSHA, an agency under the U.S. Department of Labor. While both OSHA and EPA have a mandate to reduce exposures to toxic substances, the OSHA jurisdiction is limited to safety and health conditions that exist in the workplace. The Act requires each employer to furnish its employees with a workplace free from recognized hazards likely to cause death or serious physical harm. Employees have a duty to comply with the OSHA standards and all rules, regulations, and orders issued under the Act.

The OSHA regulations establish specific standards that inform employers what must be done to achieve a safe and healthful working environment. This set of regulations establishes OSHA requirements for employee safety in a variety of working environments. It addresses employee emergency and fire prevention plans (29 CFR 1910.38), hazardous waste operations and emergency response (29 CFR 1910.120), and hazard communications (29 CFR 1910.1200). These rules enable employees to be aware of the dangers they face from hazardous materials in their workplace.

DOE emphasizes compliance with these regulations at facilities such as the proposed SNS. The contractor and subcontractor employees who work at such facilities must comply with the regulations applicable to their work, as prescribed through DOE orders. DOE keeps and makes available the various records of minor illnesses, injuries, and work-related deaths required by the OSHA regulations.

		Citation	
Jurisdiction	Statute	Statute	Regulation
Federal	Federal Aviation Act of 1958	49 USC 1504	14 CFR 77

The FAA requires a permit for any structure greater than 200 ft (61 m) in height that would affect navigable airspace. A permit would be required for structures at the proposed SNS site greater than 200 ft (61 m) in height. Construction cranes used at the proposed SNS site could require a permit.

Jurisdiction	Order Number	Order Title
Federal	Executive Order 12898	Environmental Justice

Executive Order 12898 requires federal agencies to identify and address disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations.

6.1.11 ENVIRONMENTAL PROTECTION

		Citation	
Jurisdiction	Statute	Statute	Regulation
Federal	National Environmental Policy Act	42 USC 4321 et seq.	40 CFR 1500–1508

The National Environmental Policy Act (NEPA) establishes a national policy promoting awareness of the consequences of human activity on the environment and consideration of environmental impacts during the early planning and decision-making stages of federal projects. Under the provisions of NEPA, federal agencies are required to assess the potential effects of their major proposed actions on the environment.

This EIS has been prepared in response to NEPA policies, regulatory requirements established by the Council on Environmental Quality (CEQ), and the DOE regulations for implementing the procedural provisions of NEPA. It discusses reasonable alternatives and their potential environmental consequences.

		Citation	
Jurisdiction	Statute	Statute	Regulation
Federal	Toxic Substances Control Act	USC 2601 et seq.	40 CFR 761-763

The Toxic Substances Control Act (TSCA) regulates the manufacture, use, treatment, storage, and disposal of certain toxic substances not regulated by RCRA or other statutes. These substances include polychlorinated biphenyls (PCBs) (40 CFR 761) and asbestos (40 CFR 763).

It is expected that the use of these materials in the proposed SNS would be limited or not occur at all. However, if they should be used, compliant programs and procedures would need to be implemented to address appropriate management and disposal of waste generated as a result of their use.

Jurisdiction	Order Number	Order Title
Federal	Executive Order 11514	Protection and Enhancement of Environmental Quality

Executive Order 11514 requires federal agencies to monitor and control their activities continually to protect and enhance the quality of the environment. In addition, it requires the development of procedures to ensure the fullest practicable provision of timely public information and understanding of federal plans and programs with environmental impacts.

6.1.12 EMERGENCY PLANNING AND RESPONSE

		Citation	
Jurisdiction	Statute	Statute	Regulation
Federal	Emergency Planning and Community Right-To-Know Act	42 USC 11001 et seq.	40 CFR 350-372

The Emergency Planning and Community Right-To-Know Act is also referred to as Title III of the Superfund Amendments and Reauthorization Act. This statute requires the owners and operators of facilities with hazardous substances to engage in emergency planning. In addition, they must notify their communities and government agencies about the storage, use, and release of hazardous substances at their facilities. Under Subtitle A of this statute, owners and operators must develop and maintain inventories of hazardous substances stored and used at their facilities. These inventories and information on releases of the substances must be reported to state emergency response authorities and the Local Emergency Planning Committee. This reporting is designed to ensure that emergency plans are sufficient to respond to unplanned releases of hazardous substances.

Hazardous substances may be used and stored at the proposed SNS. The host national laboratory for the proposed SNS would be required to fold the inventory and release information on these substances into its Emergency Planning and Community Right-to-Know Act reporting processes.

		Citation	
Jurisdiction	Statute	Statute	Regulation
Federal	Comprehensive Environmental Response, Compensation, and Liability Act	42 USC 9601 et seq.	40 CFR 300-302

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and its implementing regulations provide the needed general authority for federal and state governments to respond directly to hazardous substance incidents. The regulations require reporting of spills, including releases of radioactive materials, to the National Response Center.

DOE would be required to comply with these regulations if hazardous materials spills occur during construction and operation of the proposed SNS. Programs for the development of internal procedures to implement the CERCLA regulations are generally set forth in DOE orders.

		Citation	
Jurisdiction	Statute	Statute	Regulation
Federal	Hazardous Materials Transportation Act	49 USC 5101 et seq.	49 CFR 172

The requirements for marking, labeling, placarding, and documenting shipments of hazardous materials are presented in these regulations under the Hazardous Materials Transportation Act. In addition, they specify the requirements for providing hazardous materials information and training. Any hazardous materials shipped from the proposed SNS would be required to comply with these regulations.

		Citation	
Jurisdiction	Statute	Statute	Regulation
Federal	Atomic Energy Act of 1954	42 USC 2011 et seq.	10 CFR 30.72, Schedule C

This regulation is used by the public and private sector to determine if an emergency response plan must exist for unscheduled releases of radiological materials. It is one of the threshold criteria documents for DOE Emergency Preparedness Hazards Assessments required by DOE Order 151.1, *Comprehensive Emergency Management System*. An emergency response plan addressing the proposed SNS operations would need to be prepared in accordance with this regulation.

		Citation	
Jurisdiction	Statute	Statute	Regulation
Federal	Reorganization Plan No. 3 of 1978, Public Health and Welfare	42 USC 5121 et seq.	44 CFR 1-399

These regulations set forth the policies, procedures, and responsibilities of DOE, the Federal Emergency Management Agency, and the Nuclear Regulatory Commission (NRC) for implementing a Federal Emergency Preparedness Program, including radiological planning and preparedness. An emergency response plan, including radiological planning and preparedness for proposed SNS operations, would need to be prepared and implemented at the SNS in accordance with these requirements.

6.2 DOE REQUIREMENTS

DOE controls its operations through various sets of federal regulations and DOE orders covering a wide range of subjects. The regulations and DOE orders applicable to construction and operation of the proposed SNS are described in this section.

6.2.1 REGULATIONS

DOE regulations address wide-ranging areas such as environmental management, administrative requirements and procedures, energy conservation, nuclear safety, and classified information. For the purposes of this EIS, regulations relevant to the proposed action include 10 CFR 20, *Dose Limits for Individual Member of the Public*; 10 CFR 820, *Procedural Rules for DOE Nuclear Facilities*; 10 CFR 830, *Nuclear Safety Management—Contractor and Subcontractor Activities*; 10 CFR 835, *Occupational Radiation Protection*; 10 CFR 1021, *Compliance with NEPA*; and 10 CFR 1022, *Compliance with Floodplains/Wetlands Environmental Review Requirements*.

DOE has established occupational radiation protection standards to protect DOE personnel and contractor employees. These standards are set forth in the regulations under 10 CFR 835. These regulations establish standards, limits, and program requirements to protect individual workers from ionizing radiation that may be generated by DOE activities. These activities include, but are not limited to, the construction and operation of DOE facilities. The requirements under 10 CFR 835 would apply to construction and operation of the proposed SNS. The radioactive material storage and handling operations at the proposed SNS would be required to comply with these regulations.

6.2.2 DOE ORDERS

DOE orders contain statements of departmental policies, as well as the procedures and requirements necessary for implementing them.

A large number of DOE orders apply to implementation of the proposed action described in this EIS.

Hazardous materials storage and handling operations conducted under the proposed action would be required to comply with DOE Order 5480.4, *Environmental Protection, Safety, and Health Protection Standards*, and DOE Order 5480.7A, *Fire Protection*. These two orders require DOE and its contractors to comply with the National Fire Protection Association codes and standards, the OSHA regulations in 29 CFR 1910, and the DOE Explosives Safety Manual.

Additional DOE orders applicable to construction and operation of the proposed SNS are listed in Table 6.2.2-1.

Table 6.2.2-1. DOE orders applicable to the proposed action.

DOE Order	Title
151.1	Comprehensive Emergency Management System
225.1	Accident Investigations
231.1	Environment, Safety, and Health Reporting
232.1	Occurrence Reporting and Processing of Operations Information
420.1	Facility Safety
430.1	Life-Cycle Asset Management
440.1	Worker Protection Management for DOE Federal and Contractor Employees
441.1	DOE Radiological Health and Safety Policy
441.2	Extension of DOE Order 441.1
451.1A	National Environmental Policy Act Compliance Program
460.1A	Packaging and Transportation Safety
460.2	Departmental Materials and Packaging Management
470.1	Safeguards and Security Program
471.1	Identification and Protection of Unclassified Controlled Nuclear Information
471.2A	Information Security Program
472.1B	Personnel Security Activities
1300.2A	Department of Energy Technical Standards Program
1360.2B	Unclassified Computer Security Program
3790.1B	Federal Employee Occupational Safety and Health Program
4330.4B	Maintenance Management Program
4700.1	Project Management System
5400.1	General Environmental Protection Program
5400.3	Hazardous and Radioactive Mixed Waste Program
5400.5	Radiation Protection of the Public and the Environment
5480.17	Site Safety Representatives
5480.19	Conduct of Operations Requirements for DOE Facilities
5480.21	Unreviewed Safety Requirements
5480.22	Technical Safety Requirements
5480.23	Nuclear Safety Analysis Reports
5480.25	Safety of Accelerator Facilities
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements
5630.12A	Safeguards and Security Inspection and Evaluation Program
5632.1C	Protection and Control of Safeguards and Security Interests
5700.6C	Quality Assurance
5820.2A	Radioactive Waste Management
6430.1A	General Design Criteria

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GLOSSARY

Absorbed dose: The energy imparted by ionizing radiation per unit mass of irradiated material at the place of interest in that material. Expressed in units of radiation absorbed dose or grays, where 1 radiation absorbed dose equals 0.01 gray.

Accelerator: An apparatus for imparting high velocities to charged particles.

Accident: An unexpected or undesirable event that leads to the release of hazardous material within a facility or into the environment exposing workers or the public to hazardous materials or radiation.

Accumulator ring: A circular band that, when injected with particles, strips the electrons from the H^- ions leaving protons. When a sufficient amount of proton bunches are accumulated in the ring they are then released from the ring as a pulse.

Air pollutant: Any substance in the air that could, if in high enough concentration, harm humans, other animals, or vegetation.

Air quality standards: The level of pollutants in the air prescribed by regulations that may not be exceeded during a specified time in a defined area.

Alloy: A substance made from a mixture of a metal and one or more other metals or nonmetallic elements.

Alluvium: Clay, silt, sand, and/or gravel deposits found in a stream channel or in low parts of a stream valley that is subject to flooding.

Alpha particle: A positively charged particle, consisting of two protons and two neutrons, given off by the radioactive decay of many elements, including uranium, plutonium, and radon.

Ambient air: That portion of the atmosphere, external to buildings, to which the general public is exposed.

Ambient water quality standards: The level of pollutants in water, prescribed by regulations, that may not be exceeded during a specified time in a defined area.

Antiscaling agent: A chemical added to cooling water to prevent buildup on interior surfaces of cooling water systems.

Aqueous: Containing or dissolved in water.

Aquifer: Rock or sediment in a formation, group of formations, or part of a formation that is saturated and sufficiently permeable to conduct groundwater.

Aquitard: A less-permeable geologic unit in a stratigraphic sequence. The unit is not permeable enough to transmit significant quantities of water. Aquitards separate aquifers.

Archaeological site: Any location where humans have altered the terrain or discarded artifacts during either prehistoric or historic times.

Area of concern: Any site that has been identified as needing corrective action but for which there are no Resource and Conservation and Recovery Act or Comprehensive Environmental Response, Compensation, and Liability Act remediation requirements.

Arroyos: A watercourse (as a creek) in an arid region.

Artifact: An object produced or shaped by human workmanship of archaeological or historical interest.

As low as reasonably achievable (ALARA): The approach to manage and control exposures (both individual and collective) to the workforce and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. ALARA is not a dose limit but a process that has the objective of attaining doses as far below the applicable limits as is reasonably achievable (10 CFR 835.2).

Beam scattering: Beams of molecules are directed toward a surface and various properties are studied as a result of the beam/surface interaction. The scattered beam, desorbed reaction products, or adsorbed species can be detected.

Benthic: Occurring at the bottom of a body of water.

Beryllium: An extremely lightweight, strong metal used in weapons systems.

Beta particle: A negatively charged particle emitted during the radioactive decay of many radionuclides. A beta particle is identical to an electron. It has a short range in air and a small ability to penetrate other materials.

Biocides: A substance that is destructive to many different organisms.

Biodiversity: Biological diversity in an environment as indicated by numbers of different species of plants and animals.

Biodiveristy significance ranking (BSR): A system that ranks the importance of biological variety within an environment; ranks are from a high of 1 for outstanding significance to a low of 5 for general biodiversity interest.

Biota: Living organisms including plants and animals.

Brownfield: Previously developed land or contaminated land that has been remediated to accommodate certain uses.

Caldera: A volcanic crater that has a diameter many times that of the vent and is formed by collapse of the central part of a volcano or by explosions of extraordinary violence.

Cesium: A silver-white alkali metal. A radioisotope of cesium, cesium-137, is a common fission product.

Chert: A rock resembling flint and consisting essentially of a large amount of fibrous chalcedony with smaller amounts of cryptocrystalline quartz and amorphous silica.

Climatology: The science that deals with climates and investigates their phenomena and causes.

Code of Federal Regulations (CFR): A U.S. government publication containing the full range of federal regulations in codified form.

Cold neutrons: Neutrons with wavelengths >0.4 nanometers.

Cold War period: The historic period from 1949 to 1989, characterized by international tensions and nuclear armament buildup, especially between the U.S. and the U.S.S.R. The era began approximately at the end of World War II when the Atomic Energy Act was passed, establishing the Atomic Energy Commission, and ended with the dissolution of the U.S.S.R. into separate republics and the ending of large-scale nuclear weapons production in the U.S.

Committed effective dose equivalent: The sum of the products of the committed dose equivalent to an organ or tissue and the weighting factor applicable to each organ or tissue irradiated. The committed dose equivalent is the dose equivalent that will be received from an intake of radioactive material during the 50-year period following the intake.

Common Ground Process: This process is the response of the Oak Ridge Reservation to the 1993 mandate by the Assistant Secretary of Environmental Restoration and Waste Management and the Acting Associate Deputy Secretary for Facilities and Management (both within the Department of Energy) to identify stakeholder preferred alternatives for the future use of land and buildings at Department of Energy sites.

Community (biotic): All plants and animals occupying a specific area under relatively similar conditions.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): Provides a federal “Superfund” to clean up uncontrolled or abandoned hazardous waste sites, as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment. Through the Act, the Environmental Protection Agency was given power to seek out those parties responsible for any release and assure their cooperation in the cleanup.

Contamination: The deposition or discharge of chemicals, radionuclides, or particulate matter above a given threshold, usually associated with an effects level onto or into environmental media, structures, areas, objects, personnel, or nonhuman organisms.

Cretaceous Age: Geologic time making up the end of the Mesozoic Era, dating from approximately 144 million to 66 million years ago.

Criteria pollutant: Six air pollutants [sulfur dioxide, nitric oxides, carbon monoxide, ozone, particulate matter-10 (smaller than 10 microns in diameter), and lead] for which National Ambient Air Quality Standards are established by the U.S. Environmental Protection Agency.

Cultural resource: Any prehistoric or historic site, building, structure, district, or other place or object (including biota of importance) considered to be important to a culture, subculture, or community for scientific, traditional, or religious purposes or for any other reason.

Cumulative impacts: In an Environmental Impact Statement, the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or nonfederal), private industry, or individual undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR 1508.7).

Curie: The conventional unit of activity in a sample of radioactive material. The curie is equal to 37 billion disintegrations per second; which is approximately the rate of decay of 1 gram of radium; also a quantity of any nuclide or mixture of nuclides having 1 curie of radioactivity.

Decay (radioactive): The decrease in the amount of radioactive material with the passage of time due to the spontaneous transformation of an unstable nuclide into a different nuclide or into a different energy state of the same nuclide; the emission of nuclear radiation (alpha, beta, or gamma radiation) is part of the process.

Decontamination: The actions taken to reduce or remove substances that pose a substantial present or potential hazard to human health or the environment, such as radioactive or chemical contamination from facilities, equipment, or soils by washing, heating, chemical or electrochemical action, mechanical cleaning, or other techniques.

Deoxyribonucleic acid (DNA): Any of various nucleic acids that are usually the molecular basis of heredity, are localized especially in cell nuclei, and are constructed of a double helix held together by hydrogen bonds between purine and pyrimidine bases, that project inward from two chains containing alternate links of deoxyribose and phosphate.

Deposition: In geology, the laying down of potential rock-forming materials; sedimentation. In atmospheric transport, the settling out on ground and building surfaces of atmospheric aerosols and particles (“dry deposition”) or their removal from the air to the ground by precipitation (“wet deposition”).

Derived air concentrations: Airborne concentration of a radionuclide that, if inhaled for a work year, would result in a dose to an individual worker corresponding to the applicable dose limit.

Derived concentration guide (DCG): The concentration of a radionuclide in air or water that under conditions of continuous exposure for 1 year by one exposure mode (e.g., ingestion of water, submersion in air, or inhalation of air) would result in an effective dose equivalent equal to the annual dose limit for the group exposed. For the public, this would be a dose of 100 millirem to a reference human who inhales 8,400 cubic meters of air and ingests 730 liters (771 quarts) of water in a year.

Dispersion: The downwind spreading of a plume by turbulence and meander in wind direction, resulting in a plume of lower concentration over a larger area.

Disposal: The process of placing waste in a final repository.

Dose: A generic term that expresses the energy absorbed by a unit mass of material exposed to ionizing radiation (absorbed dose in units of rad or gray) or the product of a quality factor and the energy absorbed by human tissue exposed to ionizing radiation (dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent). In this Environmental Impact Statement, dose means effective dose equivalent, committed effective dose equivalent, or total effective dose equivalent as defined in this glossary.

Dose conversion factor: For internal exposures, the dose received per unit activity inhaled or ingested. For external exposures, the dose received per unit time exposed to a unit activity concentration.

Dose equivalent: The dose equivalent is the product of the absorbed dose and a quality factor that depends on the type of ionizing radiation.

Dose rate: The radiation dose delivered per unit time (e.g., rad/h).

Drainage basin: An aboveground area that supplies the water to a particular stream.

Drawdown: The subsurface difference in elevation between the natural water level in a formation and the reduced water level in the formation caused by the withdrawal of groundwater.

Drinking water standard: The prescribed level of constituents or characteristics in a drinking water supply that cannot be legally exceeded.

Ecology: The science dealing with the relationship of all living things with each other and with the environment.

Ecosystem: Living organisms and their nonliving (abiotic) environment functioning together as a community.

Effective dose equivalent (EDE): The sum of the products of the dose equivalent to an organ or tissue and the weighting factor applicable to each organ or tissue irradiated.

Effluent: Liquid or gaseous waste streams discharged into the environment.

Endangered species: Plants and animals that are threatened with extinction, serious depletion, or destruction of critical habitat. Requirements for declaring a species endangered are contained in the Endangered Species Act.

Environment: The sum of all external conditions and influences affecting the life, development, and ultimately the survival of an organism.

Environmental justice: The fair treatment of people of all races, cultures, incomes, and educational levels with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment implies that no population of people should be forced to shoulder a disproportionate share of the negative environmental impacts of pollution or environmental hazards due to a lack of political or economic strength.

Environmental Impact Statement (EIS): A document required of federal agencies by the National Environmental Policy Act for proposals for legislation or major federal actions significantly affecting the quality of the human environment. A tool for decision-making, it describes the positive and negative environmental impacts of the proposed action and alternative actions.

Environmental Restoration Integrated Water Quality Program: A program established in 1996 in an attempt to integrate the various biological, physical, and chemical monitoring activities that were being conducted across the Oak Ridge Reservation. The program uses data collected by other programs and additionally supplements these data with its own sampling. Monitoring data deemed most important to evaluating long-term trends and assessing offsite export are included in the program's scope.

Epicenter: The point on Earth's surface directly above the focus of an earthquake.

Erosion: A general term for the natural processes by which earth materials are loosened, dissolved, or worn away and moved from one place to another. Typical processes are wind and water as they carry away soil.

Fallout: Radioactive material that has been produced and distributed through the atmosphere as a result of above-ground testing of nuclear devices.

Fault: A fracture or a zone of fractures within a rock formation along which vertical, horizontal, or transverse slippage has occurred.

Floodplain: The lowlands adjoining inland and coastal waters and relatively flat areas including at a minimum that area inundated by a 1 percent or greater chance of flood in any given year.

Formation: In geology, the primary unit of formal stratigraphic mapping or description. Most formations possess certain distinctive features.

Fusion: Nuclear reaction in which light nuclei are fused together to form a heavier nucleus, accompanied by the release of immense amounts of energy and fast neutrons.

Gamma rays: High-energy, short-wavelength, electromagnetic radiation accompanying fission and emitted from the nucleus of an atom during radioactive decay. Gamma rays are very penetrating and can be effectively stopped only by dense materials (such as lead) or a thick layer of shielding materials.

Geology: The science that deals with Earth: the materials, processes, environments, and history of the planet, including the rocks and their formation and structure.

Geotechnical systems: The utilization of rocks or geological formations as a group of objects forming a network that serves a common purpose.

Greenfield: A site not previously developed or contaminated.

Groundwater: Water found beneath the Earth's surface.

Group: The geological term for the rock layer next in rank above formation.

Habitat: The part of the physical environment in which a plant or animal lives.

Half-life: The time in which half the atoms of a radioactive substance disintegrate to another nuclear form. Half-lives vary from millionths of a second to billions of years.

Hazardous material: A material, including a hazardous substance defined by 49 CFR 171.8, that poses a risk to health, safety, and property when transported or handled.

Hazardous waste: A solid waste that, because of its quantity, concentration, physical, chemical, or infectious characteristics, may significantly contribute to an increase in mortality: or may pose a potential hazard to human health or the environment when improperly treated, stored, or disposed. The Resource Conservation and Recovery Act defines a "solid waste" as including solid, liquid, semisolid, or contained gaseous material. By definition, hazardous waste has no radioactive components.

Heavy metals: Metallic or semimetallic elements of high molecular weight, such as mercury, chromium, cadmium, lead, and arsenic, that are toxic to plants and animals at known concentrations.

High efficiency particulate air (HEPA) filter: A disposable, extended media, dry-type filter with a rigid casing enclosing the full depth of the pleats. The filter exhibits a minimum efficiency of 99.97 percent when tested with an aerosol of essentially monodispersed 0.3-mm diameter test aerosol particles.

Historic resources: The sites, districts, structures, and objects considered limited and nonrenewable because of their association with historic events, persons, social, or historic movements.

Holocene: The current epoch of geologic time, which began approximately 10,000 years ago.

Human Genome Sequencing Project: The ultimate goal of the Human Genome (genetic material of an organism) Project is to determine the deoxyribonucleic acid (DNA) sequence of the entire human genome and to elucidate the genetic information by analyzing the structure and function of all the genes of humans and other organisms.

Hydric: Requiring an abundance of moisture.

Hydrology: The science dealing with the properties, distribution, and circulation of natural water systems.

In-situ decommissioning: To remove (as a ship or nuclear power plant) from service without completely dismantling.

Ion: An atom or molecule that has gained or lost one or more electrons to become electrically charged.

Ionizing radiation: Radiation with sufficient energy to displace electrons from atoms or molecules, thereby producing ions.

Isotope: An alternate form of an element that has the usual number of protons but a nonstandard number of neutrons; the fewer or additional neutrons give the isotope a different atomic weight than the regular element and may make the isotope radioactive.

Karst: An irregular limestone region with sinkholes, underground streams, and caverns.

Klystron: An electron tube used for the generation of ultra-high-frequency current.

Linac: Linear accelerator.

Linear accelerator (linac): A device in which charged particles are accelerated in a straight line by successive impulses from a series of electric fields.

Lithic: The description of rocks on the basis of such characteristics as color, mineralogic composition, and grain size.

Lithology: A rock formation having a particular set of characteristics.

Loam: A soil composed of a mixture of clay, silt, sand, and organic matter.

Low-income population: Community in which 25 percent or more of the population is characterized as living in poverty.

Low-level radioactive waste: All radioactive waste that is not classified as high-level waste, transuranic waste, spent nuclear fuel, or "11e(2) by-product material," as defined by DOE Order 5820.2A, *Radioactive Waste Management*. By-product material includes the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. Test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as low-level waste, provided the concentration of transuranic waste is less than 100 nanocuries per gram.

Maximum contaminant level : The maximum permissible level of a contaminant in water that is delivered to any user of a public water system, as measured within the system or at entry points, depending upon the contaminant (40 CFR 141).

Migration: The movement of a material through the soil or groundwater.

Mitigation: The alleviation of adverse impacts on resources; by avoidance, by limiting the degree or magnitude of an action, by repair or restoration, by preservation and maintenance that reduces or eliminates the impact, or by replacing or providing substitute resources or environments.

Mixed waste: Mixed waste contains both hazardous waste [as defined by the Resource Conservation and Recovery Act (RCRA) and its amendments] and radioactive waste (as defined by the Atomic Energy Act and its amendments). It is jointly regulated by the Nuclear Regulatory Commission (NRC) or NRC's Agreement States and the Environmental Protection Agency (EPA) or EPA's RCRA-Authorized States.

Moderator: A substance (as water) used for slowing down neutrons in a nuclear reactor.

Modified Mercalli intensity: A level on the modified Mercalli scale. A measure of the perceived intensity of earthquake ground shaking with 12 divisions, from I (not felt by people) to XII (damage nearly total).

Moraine: An accumulation of earth and stones carried and finally deposited by a glacier.

National Ambient Air Quality Standards (NAAQS): Air quality standards established by the *Clean Air Act*, as amended. The primary NAAQS are intended to protect the public health with an adequate margin of safety, and the secondary NAAQS are intended to protect the public welfare from any known or anticipated adverse effects of a pollutant.

National Emission Standards for Hazardous Air Pollutants (NESHAP): A set of national emission standards for listed hazardous pollutants emitted from specific classes or categories of new and existing sources. These standards were implemented in the Clean Air Act Amendments of 1977.

National Environmental Research Park (NERP): An outdoor laboratory set-aside for ecological research to study the environmental impacts of energy developments. NERPs were established by the Department of Energy to provide protected land areas for research and education in the environmental sciences and to demonstrate the environmental compatibility of energy technology development and use.

National Historic Preservation Act (NHPA): Congress passed the NHPA in 1966. The law established a national policy for the protection of historic and archaeological sites and outlined the responsibilities of federal and state governments in preserving our nation's history.

National Oceanic and Atmospheric Administration (NOAA): The organization within the Department of Commerce responsible for describing and predicting changes in Earth's environment and for conserving and managing the nation's coastal and marine resources.

National Pollutant Discharge Elimination System (NPDES) permit: The NPDES is a regulatory program (regulated through the Clean Water Act, as amended) of either the Environmental Protection Agency or state EPA-authorized agency that is designed to control all discharges of pollutants from point sources to U.S. waterways. NPDES permits regulate discharges into navigable waters from all point sources of pollution, including industries, municipal treatment plants, large agricultural feed lots, and return irrigation flows. Federal and State regulations (40 CFR Parts 122 and 125) require one of these permits for the discharge of pollutants from any point source into the waters of the U.S. regulated through the Clean Water Act, as amended.

National Register of Historic Places (NRHP): A list of districts, sites, buildings, structures, and objects of prehistoric or historic local, state, or national significance maintained by the Secretary of the Interior. The list is expanded as authorized by Section 2(b) of the Historic Sites Act of 1935 (16 U.S.C. 462) and Section 101(a)(1)(A) of the National Historic Preservation Act of 1966, as amended.

Native American: For purposes of this document, a Native American is defined as a tribe, people, or culture that is indigenous to the U.S. Also referred to as American Indians.

Net primary productivity: The net creation of organic matter by green plants.

Neutron: An elementary atomic particle that has no charge and a mass that is approximately the same as that of a proton. Neutrons are found in all atoms except the lightest isotopes of hydrogen.

Neutron activation analysis: Use of neutrons for the detection and quantification of trace amounts of substances within a larger sample.

Neutron flux: The number of neutrons passing through a unit area per second.

Neutron sources: The facilities and equipment used to produce neutrons.

Nuclear criticality: A state in which a self-sustaining nuclear chain reaction is achieved.

Nuclide: A species of atom characterized by its nuclear constitution (number of protons and number of neutrons).

Offsite: As used in this draft Environmental Impact Statement, the term denotes a location, facility, or activity occurring outside the boundary of the Oak Ridge Reservation, Los Alamos National Laboratory, Argonne National Laboratory, and Brookhaven National Laboratory sites.

Onsite: As used in this draft Environmental Impact Statement, the term denotes a location or activity occurring somewhere within the boundary of the Oak Ridge Reservation, Los Alamos National Laboratory, Argonne National Laboratory, and Brookhaven National Laboratory sites.

Oral reference dose: The daily oral intake per unit body weight that would be likely to be without appreciable risk of adverse health effects during a lifetime.

Organic compounds: Carbon compounds, which are, or are similar to, compounds produced by living organisms.

Outfall: Place where liquid effluents enter the environment and are monitored.

Oxide: A compound in which an element chemically combines with oxygen.

Ozone: A molecule of oxygen in which three oxygen atoms are chemically attached to each other.

Paleozoic Era: Geologic time dating from 570 million to 245 million years ago when seed-bearing plants, amphibians, and reptiles first appeared.

Particulates: Solid particles and liquid droplets small enough to become airborne.

Perched groundwater: A body of groundwater of small lateral dimensions lying above a more extensive aquifer.

Perched aquifer: A body of groundwater separated from an underlying body of groundwater by an unsaturated zone.

Perennial: Acting or lasting throughout the year or through many years (perpetual).

Perennial stream: A stream that contains water at all times except during extreme drought.

Permeability: Ability of liquid to flow through rock, groundwater, soil, or other substances.

Person-rem: Unit of radiation dose to a given population; the sum of the individual doses received by a collection of individuals.

pH: A measure of the hydrogen ion concentration in aqueous solution. Pure water has a pH of 7, acidic solutions have a pH less then 7, and basic solutions have a pH greater than 7.

Physiographic: Pertaining to the physical features of Earth's surface, such as land forms or bodies of water.

Pleistocene Epoch: Geologic time that occurred approximately 11,000 to 2 million years ago.

Plutonium: A heavy, radioactive, metallic element with the atomic number 94. It is produced artificially in a reactor by bombardment of uranium with neutrons and is used in the production of nuclear weapons.

Polychlorinated biphenyl (PCB): Any of several compounds that are produced by replacing hydrogen atoms in biphenyl with chlorine, have various industrial applications, and are poisonous environmental pollutants that tend to accumulate in animal tissues.

Potable: Suitable for drinking.

Potentiometric water level: Surface of the groundwater table or height to which the water level would rise in a confined aquifer.

Prehistoric: Of, relating to, or existing in times antedating written history.

Proton: An elementary atomic particle with a positive charge and a mass of approximately 1 amu (atomic mass unit).

Pueblo: The communal dwelling of an American Indian village of Arizona, New Mexico, or adjacent areas consisting of contiguous, flat-roofed stone or adobe houses in groups, sometimes several stories high; an American Indian village of the southwestern U.S., a member of a group of American Indian peoples of the southwestern U.S.

Radiation: The particles or electromagnetic energy emitted from the nuclei of radioactive atoms. Some elements are naturally radioactive; others are induced to become radioactive by bombardment in a reactor.

Radioactive waste: Materials from nuclear operations that are radioactive or are contaminated with radioactive materials and for which there is no practical use or for which recovery is impractical.

Radioactivity: The spontaneous decay or disintegration of unstable atomic nuclei, accompanied by the emission of radiation.

Radioisotope: An isotope of an element that undergoes spontaneous decay with the release of radioactive particles.

Radionuclide: Any radioactive element.

Reactor: An apparatus in which a chain reaction in fissionable material is initiated and controlled.

Record of Decision (ROD): A document prepared in accordance with the requirements of 40 CFR 1505.2. It provides a concise public record of DOE's decision on a proposed action for which an EIS was prepared. A ROD identifies the alternatives considered in reaching the decision, the environmentally preferable alternative(s), factors balanced by DOE in making the decision, whether all practicable means to avoid or minimize environmental harm have been adopted, and if not, why they were not.

Reference concentration (RfC): The concentration of a toxic material in air that, if inhaled daily, would be likely to be without appreciable risk of adverse health effects during a lifetime.

Reference dose: The dose associated with a reference concentration.

Region of Influence (ROI): For the purpose of this document, a site-specific geographic area that includes the counties that would be potentially affected by the proposed action.

Rem (Roentgen equivalent man): The conventional unit or radiation dose equivalent. A unit of individual dose of absorbed ionizing radiation used to measure the effect on human tissue. The dosage of an ionizing radiation that will cause the same biological effect as one roentgen of X-ray or gamma ray exposure.

Remediation: The process, or a phase in the process, of rendering radioactive, hazardous, or mixed waste environmentally safe, whether through processing, entombment, or other methods.

Rift: An elongated valley formed by the depression of a block of Earth's crust between two faults or groups of faults of approximately parallel strike.

Riparian: On or around rivers and streams.

Rip-rap: A foundation or sustaining wall of stones or chunks of concrete thrown together without order usually on an embankment slope to prevent erosion.

Roentgen: A unit of exposure to ionizing X-ray or gamma radiation equal to 2.58 x 10^{-4} coulomb per kilogram. (A coulomb is a unit of electrical charge.) A roentgen is approximately equal to 1 rad.

Runoff: The portion of rainfall, melted snow, or irrigation water that flows across the ground surface and may eventually enter streams.

Sanitary waste: Liquid or solid (includes sludge) wastes that are not hazardous or radioactive and that are generated by industrial, commercial, mining, or agricultural operations or from community activities.

Saprolite: Disintegrated rock that lies in its original place.

Seismic: Pertaining to any earth vibration, especially an earthquake.

Seismicity: Occurrence of earthquakes in space and time.

Shield: Material used to reduce the intensity of radiation that would irradiate personnel or equipment.

Short-lived: A designation for radionuclides with relatively short half-lives.

Silt: A sedimentary material consisting of fine mineral particles intermediate in size between sand and clay.

Slope factor: External exposure slope factors are central to the estimate of lifetime attributable radiation cancer incidence risk for each year of exposure to external radiation from photon-emitting radionuclides distributed uniformly in a thick layer of soil and are expressed as risk/yr per pCi/gram of soil.

Socioeconomic: The social and economic conditions in a study area.

Solid waste: As defined under the Resource Conservation and Recovery Act, any solid, semisolid, liquid, or contained gaseous materials discarded from industrial, commercial, mining, or agricultural operations and from community activities. Solid waste includes garbage; construction debris; commercial refuse; sludge from water supply facilities, or waste treatment plants, or air pollution control facilities; and other discarded materials. Solid waste does not include solid or dissolved materials in irrigation return flows or industrial discharges that are point sources subject to permits under section 402 of the Clean Water Act or source, special nuclear, or by-product material as defined by the Atomic Energy Act.

Solid waste management unit (SWMU): Any unit from which hazardous constituents may migrate, as defined by the Resource Conservation and Recovery Act. A designated area that is or is suspected to be the source of a release of hazardous material into the environment that will require investigation and/or corrective action.

Source term: The quantity of material released and parameters such as exhaust temperature that determine the downwind concentration, given a specific meteorological dispersion condition.

Stabilization: The action of making a nuclear material more stable by converting its physical or chemical form or placing it in a more stable environment.

Strata: Layers of rock, usually in a sequence.

Stratum: A single layer of rock, usually one of a sequence.

Stratigraphy: The science of rock strata or the characteristics of a particular set of rock strata.

Strontium: A soft, malleable, ductile metallic element of the alkaline-earth group.

Superconductor: A substance in which electrical resistance completely disappears, especially at very low temperatures.

Surface water: Water on Earth's surface, as distinguished from water in the ground (groundwater).

Thermal neutrons: Neutrons with a wavelength distribution peaked around 1.6 angstroms (one ten-billionth of a meter).

Threatened and endangered species: Animals, birds, fish, plants, or other living organisms in jeopardy of extinction by human-produced or natural changes in their environment. Requirements for declaring species threatened or endangered are contained in the Endangered Species Act of 1973.

Till: Unstratified glacial drift consisting of clay, sand, gravel, and boulders intermingled.

Total effective dose equivalent (TEDE): The sum of the committed effective dose equivalent for internal exposures (committed EDE) and the effective dose equivalent (EDE) for external exposures.

Traditional cultural property (TCP): A significant place or object associated with historical and cultural practices or beliefs of a living community that is rooted in that community's history and is important in maintaining the continuing cultural identity of the community.

Treatment: Any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize it, render it nonhazardous or less hazardous, or recover it, make it safer to transport, store or dispose of, or amenable for recovery, storage, or volume reduction.

Treatment, storage, or disposal (TSD) facility: A site, regulated by the Environmental Protection Agency and the state under the Resource Conservation and Recovery Act, where a hazardous substance is treated, stored, or disposed.

Tritium: A radioisotope of the element hydrogen with two neutrons and one proton. Common symbols for the isotope are H-3 and T.

Tuff: A rock composed of the finer kinds of volcanic detritus usually fused together by heat.

Uranium: A heavy, silvery-white metallic element (atomic number 92) with many radioisotopes. ^{235}Uranium is most commonly used as a fuel for nuclear fission. Another isotope, ^{238}uranium, can be transformed into fissionable ^{239}plutonium by its capture of a neutron in a nuclear reactor.

Vadose zone: A region in a porous medium in which the pore space is not filled with water.

Volatile organic compounds (VOCs): A broad range of organic compounds, often halogenated, that vaporize at ambient or relatively low temperatures. They include compounds such as benzene, chloroform, and methyl alcohol.

Waste acceptance criteria (WAC): Requirements established by treatment, storage, and disposal facilities for the acceptance of waste into a facility.

Water table: Water under the surface of the ground occurs in two zones, an upper unsaturated zone and the deeper saturated zone. The boundary between the two zones is the water table.

Wave guides: A quadrangular tube designed for the transfer of microwaves.

Weir: A dam in a stream or river to raise the water level or divert its flow.

Wetland: Land or areas exhibiting hydric (requiring considerable moisture) soil concentrations, saturated or inundated soil during some portion of the year, and plant species tolerant of such conditions.

Wind rose: A depiction of wind speed and direction frequency for a given period of time.

X-ray: A penetrating electromagnetic radiation, which may be generated by accelerating electrons to high velocity and suddenly stopping them by collision with a target material.

LIST OF PREPARERS

Name	Degree	Expertise	Experience
Enterprise Advisory Services, Inc.			
Donald W. Barksdale	M.A., English, 1971 B.A., English, 1968	Graphics and informational summaries	25 years preparing technical and nontechnical documents to ensure readability for general public dissemination.
David J. Bean	M.S., Zoology, 1980 B.A., Biology, 1973	EIS Task Manager, Biotic resources	24 years preparing environmental documents; NEPA, CERCLA, and environmental investigations.
Tracy C. Brown	M.A., Anthropology/ Archaeology, 1982 B.A., Anthropology, 1976	Cultural resources and land use	18 years preparing environmental documents; American archaeology, NEPA, waste management, regulatory compliance, and environmental investigations.
Douglas W. Combs	MBA, 1984 M.S., Geology, 1975 B.S., Geology, 1973	Geology, soils, and hydrology	11 years preparing environmental documents; NEPA, CERCLA, and environmental investigations.
Mark A. Mitckes	M.S., Chemical Engineering, 1975 B.S., Chemical Engineering, 1970	Air quality	28 years preparing environmental documents; NEPA, air quality, permitting, and modeling.
Lenell Woods	B.S., Environmental Engineering, 1998	Waste management	3 years providing waste management technical support on environmental assessments; waste certifications; and hazardous waste, pollution prevention, and land application programs.

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William R. Fleming	Ph.D., Public Policy, 1987 M.P.A., Urban & Environmental Problems, 1979 B.A., Political Science, 1976	Deputy Program Manager	17 years conducting and managing socioeconomic related studies; 8 years preparing and reviewing NEPA documents.
Barbara Lewis	M.S., Water Resources Management, 1984 B.A., Economics, 1978	Lead preparer, Socioeconomics	20 years experience performing socioeconomic analyses for a variety of projects related to infrastructure planning, water and energy resources, and hazardous and solid wastes.
Daniel J. Lowery	B.A., Geography 1988	Support facilities and infrastructure	10 years experience in land-use planning, transportation planning, and environmental compliance, including NEPA.
Michael McGarry	B.S., Natural Resources, 1989	Support facilities and infrastructure	9 years experience developing and reviewing DOE NEPA documents.
Kharol Stefanec Means	M.A., Public Administration, 1976 B.A., Political Economy, 1973	Support facilities and infrastructure	20 years experience performing environmental evaluations; permitting processes for energy, solid waste; mass transportation projects; NEPA; and the CEQ regulations.
Steve Miller	M.S., Economics, 1976 B.A., Economics, 1974	Economic modeling and impact assessment	23 years experience preparing socioeconomic studies for electric utility and natural resource development projects.
Lisa Padget	B.A., Chemistry, 1988	Human health calculations	6 years in quality assurance and human health effects (accident and normal conditions).

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APPENDIX A

SNS ACCIDENT SOURCE TERMS FOR EIS INPUT

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A. SNS ACCIDENT SOURCE TERMS FOR EIS INPUT

This appendix presents a description of postulated accidents at the proposed Spallation Neutron Source (SNS) facility. Specifically, it describes accidents with the potential to release radioactive materials into the environment surrounding the SNS.

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SPALLATION NEUTRON SOURCE ACCIDENT SOURCE TERMS FOR ENVIRONMENTAL IMPACT STATEMENT INPUT

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ACRONYMS

ac	alternating current
A/C	air conditioning
BDB	beyond-design Basis
BP	beam pulse/beam permit
CDR	Conceptual Design Report
DAC	derived air concentrations
DOE	U.S. Department of Energy
EIS	environmental impact statement
EU	extremely unlikely
FP	fast protect
HEPA	high-efficiency particulate air
HOG	hot off-gas
HT	tritiated hydrogen
HTO	tritiated water
HVAC	heating, ventilation, and air-conditioning
LLLW	liquid low-level waste
MCNP	monte carlo neutron photon
NIOSH	National Institute for Occupational Safety and Health
NRC	Nuclear Regulatory Commission
PPS	personnel protection system
R&D	research and development
SNS	Spallation Neutron Source
TBD	to be determined
TPS	target protection system
U	unlikely

SPALLATION NEUTRON SOURCE ACCIDENT SOURCE TERMS FOR ENVIRONMENTAL IMPACT STATEMENT INPUT

1. INTRODUCTION

This report is about accidents with the potential to release radioactive materials into the environment surrounding the Spallation Neutron Source (SNS). As shown in Chap. 2, the inventories of radioactivity at the SNS are dominated by the target facility. Source terms for a wide range of target facility accidents, from anticipated events to worst-case beyond-design-basis events, are provided in Chaps. 3 and 4. The most important criterion applied to these accident source terms is that they should not underestimate potential releases. Therefore, conservative methodology was employed for the release estimates. Although the source terms are very conservative, excessive conservatism has been avoided by basing the releases on physical principles.

Since it is envisioned that the SNS facility may eventually (after about 10 years) be expanded and modified to support a 4-MW proton beam operational capability, the source terms estimated in this report are applicable to a 4-MW operating proton beam power unless otherwise specified. This is bounding with regard to the 1-MW facility that will be built and operated initially. See further discussion below in Sect. 1.2.

1.1 OTHER TYPES OF ACCIDENTS

The accidents addressed in this report do not consider two types of accidents that could occur at the SNS: accidents involving nonradiological hazards and accidents involving external exposure to penetrating radiation. The nonradiological hazards are not included because, as explained in Sect. 9 of the *SNS Conceptual Design Report*[1] (CDR), the nonradiological hazards present at an accelerator site during construction or operation can be characterized as standard industrial hazards. None of the SNS nonradiological accident hazards have any potential for harming people away from the immediate vicinity of the SNS buildings.

1.1.1 Toxic Materials

The presence of a nominal 1-m^3 volume of mercury could be considered to be a nonroutine industrial hazard, but two factors mitigate against such a conclusion: (1) the SNS mercury target is kept inside a closed system maintained at temperatures well below the boiling point of mercury, which is located inside a nonoccupied, ventilated hot cell and (2) the degree of containment and surveillance dictated by its radioactivity is more than sufficient to prevent excessive human contact. As shown in Exhibit A, the air concentration limit necessary to prevent occupational mercury poisoning exceeds by a factor of ~10 (i.e., is 10 times more permissive than) the limit that would be necessary to prevent excessive exposure to radiation after only one year of operation of the accelerator at the initially planned 1 MW of proton beam power. As the facility undergoes the planned upgrading to 2 MW, followed by the eventual upgrade to 4 MW, the specific radioactivity content of the mercury increases in direct proportion. Therefore, controlling the airborne radioactivity of mercury will be more limiting than controlling airborne mercury toxicity throughout the planed life of the facility.

1.1.2 Flammable Gases

The SNS target facility cryogenic neutron moderator employs a small quantity of hydrogen gas (about 1.5 kg), normally in the liquid form. Accidents of this system are considered in Sect. 3.10 of this report and are shown not to form a significant source term for release of radioactive material. The conceptual design, as discussed in Sect. 5.3.2 of the SNS CDR, provides a double-barrier (triple-boundary) hydrogen containment concept (hydrogen surrounded by vacuum surrounded by helium), monitoring instrumentation with alarm annunciation and controls to minimize the risk presented to workers involved in the operation and/or maintenance of this system. The installed hardware, safety and warning devices, automatic alarms and controls, and administrative procedures are expected and intended to make serious work injury by hydrogen combustion an extremely unlikely event.

1.1.3 External Exposure

Accidents involving external exposure to penetrating radiation are not specifically addressed in this report because beam control accidents or other accidents involving external irradiation have no potential for injuring members of the public at the well shielded SNS. The SNS proton beam is at every point, and for every possible beam misdirection, separated from the outside of the facility by many feet of concrete, steel, and/or dirt. The SNS shielding is designed in accordance with a shielding design policy (J. A. Alonso et al, "NSNS Shielding Policy," NSNS/97-9, May 1997) that requires shielding sufficient to render radiation levels very low on the exterior of the shield. For example, the external radiation exposure rate must not exceed 10 mrem/year at the site boundary.

There is a nonnegligible possibility for radiation injury to workers, but the SNS design and operational teams plan to make full use of the successful approaches to personnel protection that have been worked out during the past 50 years of accelerator development in the United States. The SNS is proposed to be built for scientific investigations, but the accelerator design involves concepts that have been proven at other facilities. Each of the candidate laboratories for SNS siting currently has active radiological control programs for accelerators. As explained in Sect. 9 of the SNS CDR, the SNS worker radiological protection program will use shielding, automatic beam cut-off devices, entry control devices, warning devices, and operator radiological training to ensure minimal risk to workers during operation of the SNS.

The Department of Energy (DOE) Regulation 10 CFR 835, "Occupational Radiation Protection," provides standards that must be followed in order to minimize the risk of excessive radiation exposure at DOE facilities. This includes requirements that must be followed for controlling access to and posting of radiation areas, high radiation areas, and very high radiation areas. The 10 CFR 835 definition of very high radiation areas is >500 rads in 1 h at 1 m, which is clearly in the potentially lethal range. During beam operation at high beam power, the SNS high energy tunnels meet the definition of a very high radiation area. In addition to training, use of procedures, posting, and other administrative safety features and programs, the SNS will have a high integrity automatic safety system, the personnel protection system, that will discontinue the proton beam whenever anyone tries to gain access to the interior of the proton beam tunnel.

Considering both administrative and automatic control functions, the risk of fatality or radiation injury because of external radiation (e.g., attempting tunnel access during beam operation) is judged to be in the extremely unlikely category. Moreover, this risk is well understood and accepted by those who operate accelerators in the DOE complex. The risk of tunnel access during beam operation is addressed above because it involves the highest radiation levels and is the most "dramatic" throughout the SNS facility.

There are other lesser risks involving direct radiation, such as the possibility for excess exposure during movement of highly activated components inside the target hot cell, for example, or when loading highly activated components into shipping casks. These risks are controlled within 10 CFR 835 by administrative programs, automatic protective or warning devices, and/or facility design measures, as appropriate to each particular application. Movement of activated components in shipping casks on public roads is subject to the regulation of the U.S. Department of Transportation.

1.2 ACCIDENTS WITH POTENTIAL TO RELEASE RADIOACTIVE MATERIAL

The potential radiological consequence of an accident involving release of radioactive material is determined by the inventory of radioactivity present in the process, the available transport mechanisms, and the installed mitigative features. Section 2 discusses the inventories and dispersabilities of radioactive nuclides to be found in the SNS components and structures. Section 3 presents the spectrum of accidents for the target and target components and provides estimates of the source terms for reasonably foreseeable accidents involving the potential for release of radioactive material. Chapter 4 derives source terms for accidents involving the target facility hot off-gas system and other waste-related systems.

The initial design for the SNS is for a 1-MW accelerator with a 1-MW target facility, upgradable to a 2-MW operation with modest refitting (the goal is that the needed modifications should be able to be completed during a 6-month shutdown of the facility). It is expected that the 2-MW operation will be achieved within approximately 5 years. After that, it is planned that a second ring will be built and a target plug/cooling system will be installed in the target facility that will be capable of 4-MW operation. It will probably take more than 10 years for 4-MW operation to be realized, and additional approvals from DOE will be required before its realization. An objective of this report is to specify bounding source terms that are applicable to the 4-MW operation that may eventually be achieved, provided that the extensive target modifications are made and that the additional ring is constructed. Unless indicated otherwise, the source terms were calculated for the 4-MW operation and, thus, bounding for the 1-MW operation. In some cases, source terms are given for both the 1-MW and the 4-MW configuration for comparison purposes. (Note: the target facility radionuclide inventory is directly proportional to the proton beam power, so the initial radioactivity for 4-MW target operation is four times higher than that for 1-MW operation.)

The evaluation of risk must consider the probability that a given hypothetical accident will occur during a given period of time. Quantitative probabilities have not been developed for the SNS accident sequences, but the various potential events have been placed in the frequency categories introduced in DOE-STD-3009-94: Anticipated, Unlikely, Extremely Unlikely, and Beyond Extremely Unlikely (beyond design basis). Probability per unit time (frequency) ranges are indicated in Chap. 3 based upon whether an accident is likely to occur at least once in the life of the facility (anticipated event—frequency >0.025/year for a 40-year lifetime), not likely to occur even once in the facility lifetime (unlikely event—frequency range 0.025/year to 10^{-4}/year), or very unlikely to occur even during many facility lifetime or longer (extremely unlikely event). All of these three categories are considered to be design-basis events. A fourth category is postulated for risk assessment purposes—the beyond-design-basis (BDB) category. Events in this category are physically plausible but are not considered credible events. The frequency range could, in a very approximate sense, be stated as being from 10^{-8}/year to 10^{-6}/year. The BDB category events are postulated in order to obtain full understanding of potential consequences without being constrained as to whether the event(s) are actually credible.

Events are assigned to a frequency category based on experience and on engineering judgement considerations such as whether the failure in question is something relatively likely, such as a pump stopping or a valve being inadvertently closed by an operator; something somewhat unlikely (e.g., a sudden major pipe break or other boundary failure); or something very unlikely (e.g., the total failure of a redundant, multichannel beam cutoff system.

A bounding approach has been used for accident analysis in this report. The objective of the methods used to estimate source terms is to provide accident release estimates that have enough conservatism to allow for design evolution that will occur as the design proceeds from conceptual to detail design and then to construction.

In one spirit of ensuring bounding source terms, the accident durations are typically much longer than would be the case if any of the hypothetical events actually occurred. This is true because very little or no credit has been taken for accident mitigation procedures that would be available to the facility operators. Therefore, some accident durations longer than 8-hours, for example, are listed. This is done only to maximize the calculated bounding source terms and does not imply that the facility operators would not be able to take action to curtail an actual release much sooner.

This report should be read in conjunction with the SNS CDR and the SNS Design Manual (to be published later this year). The extensive descriptions of facilities and drawings contained in these design documents are not repeated here. In addition, reference can be made to recent papers[2,3] addressing the use of mercury in spallation neutron source systems.

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2. RADIONUCLIDE INVENTORIES

The purpose of this section is to acquaint the reader with the inventories of radioactive material that will accumulate in the SNS systems, structures, and components, and to point out which inventories of radionuclides could realistically be released in quantities sufficient to cause significant radiation exposure at a distance from the SNS facilities.

For the SNS, the greatest inventory of radioactive material is found in the target facility, more specifically in the mercury that is bombarded by the beam of 1000-MeV protons to produce neutrons by the spallation reaction. Activated mercury and radioactive spallation products (of atomic weight all the way down to tritium) are the byproducts of the intense neutron flux and the spallation reactions. Components other than the target become radioactive by virtue of spallation and/or activation, but at a much lower level and with a much more restricted list of radionuclides.

The methodology described in Sect. 5.4 of the SNS CDR was employed to calculate the inventories of radionuclides. This involved use of the HETC96 particle generation and hadronic transport code, the Monte Carlo neutron photon (MCNP) code for low energy (<20 MeV) neutron transport, and the ORIHET95 code to track isotope production and decay.[1] Only the radionuclides that are potentially significant are presented in Table 2.1.

The reported inventories are calculated under the assumption that the accelerator operates continuously at 4 MW for 30 years. This is a reasonable or conservative assumption for three reasons. First, the accelerator operation is not continuous. The total yearly operating time will actually be about 70% of the time (~6000 h per year). Typically, the proton beam will be on target for 3 or 4 weeks and then will be down for adjustment or experiment change-out. Once a year, there will be an approximately 6-week to 2-month outage for more time consuming maintenance and refurbishment. Thus, the nominal 40-year facility life will accumulate no more MW × years of proton beam time on-target than would 30 years of continuous service, if that were possible. Second, upgrading the SNS to a 4-MW power level will be a deliberate process, with the final upgrade from 2 MW to 4 MW requiring construction of a second accumulator ring (each ring will be capable of handling 2 MW of proton beam power). Thus, it may be 10 years before the power is upgraded to 4 MW. The reader is referred to the discussion in Sect. 1.3.5 of the CDR. Third, it is expected that a second target facility will be added early in facility life. This second target facility (a separate building) will operate at a lower pulsing rate (about 10/s instead of about 50 to 60/s) and also a lower beam power. This will take MW × years away from the higher-power main target building to which this report is addressed. These factors add a degree of conservatism to the Table 2.1 target system inventories.

DOE Standard 1027-1992 (Change Notice No. 1, September 1997) provides radioactivity thresholds for evaluating, on a quick, screening basis, whether the quantity of radioactivity in a facility is capable of causing only localized consequences (i.e., consistent with low hazard or Category 3 facilities), as opposed to being able to cause consequences that could cover a wider area on site (moderate hazard or Category 2 facilities). The Category 2 thresholds were used as a basis for comparison of inventories of radionuclides in different locations. For instance, where threshold values were not provided by STD-1027-92, the methodology defined in STD-1027-92 was used to calculate the appropriate thresholds.

Specifically, the Category 2 thresholds define how much radioactivity would have to be involved in a generic accident in order to cause a radiation dose of 1 rem at 300 m assuming a ground level release and specified meteorological conditions. The source terms (release fractions) assumed by STD-1027-92 for the generic accident are based on the physical form of the radioactive material involved: 100% is assumed for gaseous and highly volatile materials; 50% is assumed for halogens (e.g., iodine); 1% is assumed for semivolatiles such as mercury; and 0.1% is assumed for all others. For nuclides not specifically addressed in STD-1027-92 or other DOE publications, one user must input dose conversion factor values. For example, updated dose conversion values,[2,3] were used for mercury and mercury daughter radionuclides.[2,3]

In this chapter, radioactivity inventory thresholds based on STD-1027-92 methodology are used to obtain a relative understanding of the potential radiological health impacts of amounts of radioactivity found throughout the SNS facilities.

The results of the radionuclide inventory hazard screening (Table 2.1) show very clearly that the radionuclides in the target mercury dominate the potential release hazards. For example, if all the radionuclides in the SNS target mercury are considered, the SNS target mercury's spallation/activation products are estimated after 30 years of continuous operation at the maximum 4-MW beam power to have an aggregate radioactivity inventory of about 9.5 times the DOE Category 2 threshold, whereas the corresponding aggregate for any accelerator component (e.g., the neutral beam stop) would be more than two orders of magnitude lower. This identifies the mercury target and its hot cell as a preliminary candidate Hazard Category 2 facility. Whether the preliminary Category 2 designation remains, or is changed to Category 3, will depend upon analyses to be done in the next phase of design. As explained in DOE-STD-1027-92, ". . . for facilities initially classified as Hazard Category 2, if credible release fractions can be shown to be significantly different than these values based only on physical and chemical form and available dispersive energy sources . . .," the facility may be placed in Category 3 instead. This designation must be approved by DOE, and the burden of proof is upon the contractor to demonstrate that the ground rule conditions exist. Chapters 3 and 4 of this report provide conservative, event-sequence-specific source terms for more detailed study of the consequences of radioactivity release accidents of the SNS target mercury and related off-gas system.

A conclusion that can be drawn from Table 2.1 is that radioactive material release accidents of the accelerator, including its beam stops, would not be capable of causing significant radiation exposures beyond the confines of the accelerator. Considering the most highly activated part of the accelerator, the ring injection beam stop, we see that the total inventory is about 10% of the Category 2 limit. The corresponding radiation exposure that could, per the DOE-STD-1027-92 methodology, be expected at 300 m as a result of a beam stop accident, with ground level release of the prescribed fractions of the radionuclide inventory, would therefore be about 10% of 1 rem, or about 100 millirem, which is comparable to the annual natural background. For this reason, the source terms reported for further analysis in Chap. 3 concentrate on the much more radioactive target and related systems.

Exhibit B presents the inventory of radionuclides in the target mercury after 30 years of continuous irradiation by a 1-MW proton beam, which is equivalent to about 40 years of actual operation (~6000 h/year of high power beam operation). The inventory corresponding to operation for the same period at a 2-MW or a 4-MW proton beam power can be accurately determined by multiplying by 2 or 4, respectively, since the buildup and decay of radioactive nuclides is linear with respect to the proton beam power level.

Table 2.1. SNS radioactivity inventories survey for operation with 4-MW proton beam

Area or component (Ref. Table 5.4-5, Fig. 5.4-6 in SNS CDR, NSNS/CDR-2/V1)	**Radioactivity (Ci)** Decay energy (W)	Nuclides present in quantity >0.1% of DOE Cat. 2 hazard threshold[a]: Nuclide inventories[b] (Ci)	Fraction of DOE Cat. 2 threshold	**Dispersability assessment**
Per 10 m of linac or ring high energy beam tube and surroundings[c]	1.4 W in 680 Ci	None in quantity >0.1% of Cat 2 threshold	None	N/A
Accelerator neutral (i.e., ring injection) beam stop Cu + H_2O. Irradiated by 200 kW proton beam continuously for 30 years; equivalent to nominal 40-year life. This is bounding with respect to the other beam stops, which are operated intermittently	300 W in 2.8E6 Ci	***Volatile/gaseous*** H-3: 4.6E3 N-13: 166 N-16: 120 O-15: 654	 1.6E-2 2.6E-3 1.0E-2 1.1E-2	Most of the indicated H-3 inventory is bound in the copper metal of the beam stop and thus not readily releasable. The amount in beam stop coolant H_2O is estimated at well below 1000 Ci (this H_2O is periodically replenished). The gaseous isotopes of N and O are associated with the cooling water, and therefore subject to release
		Nonvolatile Cu-64: 2.8E6 P-32: 1.6E2 Co-60: 1.8E3 Na-22: 2.2E1 Co-56: 2.4E3	3.0E-2 1.6E-2 9.6E-3 3.0E-3 2.4E-3	Release of these nuclides would require vaporization of the metallic beam stop (highly unlikely) combined with failure of the beam stop ventilation system HEPA[d] filters to eliminate any resulting aerosol from the exhaust air
Accelerator neutral beam stop, stainless steel + H_2O (i.e., inner shielding)	114 W in 2.8E5 Ci	***Nonvolatile*** Fe-55: 1.2E5	 4.8E-3	Significant release would require vaporization of the stainless steel shielding structure combined with failure of the beam stop ventilation system HEPA filters
Target SS-316 after 1 year (expected replacement before 0.5-year)	3.3E2 W in 3.6E5 Ci	***Nonvolatile*** P-32: 2.0E2 Cr-51: 2.8E5 Fe-59: 5.7E3 Fe-55: 5.0E4 Na-22: 1.1E1 K-42: 7.4E1 Mn-54: 4.6E3	 1.9E-2 2.7E-3 2.1E-3 2.1E-3 1.7E-3 1.6E-3 1.1E-3	Nonvolatile elements held inside stainless steel. Not subject to release unless stainless steel is vaporized and HEPA filters fail
Target, H_2O (shroud cooling water)	46 W in 4.7E3 Ci	N-13: 6.2E2 N-16: 3.9E2 O-14: 2.1E2 O-15: 2.9E3	1.0E-2 3.4E-2 1.8E-2 4.6E-2	Volatile/gaseous nuclides subject to release if water spill occurs

Table 2.1 (continued)

Area or component (Ref. Table 5.4-5, Fig. 5.4-6 in SNS CDR, NSNS/CDR-2/V1)	**Radioactivity (Ci)** Decay energy (W)	Nuclides present in quantity >0.1% of DOE Cat. 2 hazard threshold[a] Nuclide inventories[b] (Ci)	Fraction of DOE Cat. 2 threshold	**Dispersability assessment**
Target, moderator Al	540 W in 3.0E4 Ci	Na-22: 42 Na-24: 330 Al-28: 2.9E4	6.6E-3 9.8E-2 1.E-3	Structure made of nonvolatile aluminum that is not released unless vaporized
Target, cryogenic H_2 moderator	~0	None	None	N/A
Target, moderator H_2O	7 W in 488 Ci	***Volatile/gaseous*** N-13: 75 N-16: 110 O-15: 270	 1.2E-3 9.6E-3 4.4E-3	Gaseous nuclides could be released if target moderator water spilled
Target, Reg. IV & V, reflector Be/D_2O (As noted in the SNS CDR, lead is under consideration for use in reflector rods; due to the relatively low activation characteristics of lead, this does not increase the hazard profile of the reflector activation products substantially above what is shown here for Be)	4.3 kW in 2.7E6 Ci	***Volatile/gaseous*** H-3: 3200 N-13: 420 N-16: 520 O-15: 1700	 1.1E-2 6.8E-3 4.6E-2 2.7E-2	Gaseous nuclides could be released if reflector cooling water spilled
		Nonvolatile P-32: 2.0E1 Cr-51: 1.4E6 Mn-54: 1.E4 Fe-55: 1.1E6 Fe-59: 3.3E4 Co-60: 2.8E2 Ni-63: 1.3E5	 1.9E-3 1.4E-2 2.4E-3 4.5E-2 1.2E-2 1.5E-3 8.6E-3	Nonvolatile elements in the reflector metal structure. Release would require mass vaporization combined with failure of HEPA filtration
Target, Reg. VI & VII Ni reflector + D_2O coolant	0.64 kW in 2.5E5 Ci	***Volatile/gaseous*** N-16: 23 O-15: 74	 2.0E-3 1.2E-3	Gaseous nuclides could be released if reflector cooling water spilled.
		Nonvolatile Co-56: 1.1E4 Co-57: 2.7E4 Co-58: 1.4E4 Co-60: 1.2E3 Ni-63: 1.2E5	 1.0E-2 7.2E-3 3.6E-3 6.1E-3 8.1E-3	Nonvolatile elements in the reflector metal structure. Release would require mass vaporization combined with failure of HEPA filtration

Table 2.1 (continued)

Area or component (Ref. Table 5.4-5, Fig. 5.4-6 in SNS CDR, NSNS/CDR-2/V1)	Radioactivity (Ci): Decay energy (W)	Nuclides present in quantity >0.1% of DOE Cat. 2 hazard threshold[a]: Nuclide inventories[b] (Ci)	Fraction of DOE Cat. 2 threshold	**Dispersability assessment**
Target, Reg. VIII & IX Ni reflector + H_2O coolant	3.1 kW in 6.0E5 Ci	***Volatile/gaseous***		Gaseous nuclides could be released if reflector cooling water spilled
		N-13: 122	2.E-3	
		N-16: 87	7.6E-3	
		O-15: 860	1.4E-2	
		Nonvolatile		Nonvolatile elements in the reflector metal structure. Release would require mass vaporization combined with failure of HEPA filtration
		Na-22: 2.7E1	4.2E-3	
		Mn-52: 1.2E4	2.9E-3	
		Mn-54: 8.5E3	2.0E-3	
		Co-55: 1.4E3	1.3E-3	
		Co-56: 7.4E4	7.1E-2	
		Co-57: 1.5E5	4.1E-2	
		Co-58: 4.2E4	1.1E-2	
		Co-60: 6.3E3	3.3E-2	
		Ni-56: 3.6E3	1.3E-3	
		Ni-57: 4.1E4	3.7E-3	
		Ni-63: 1.4E4	9.1E-3	
Target, Reg. X Ni reflector + H_2O coolant	2.1 kW in 7.0E5 Ci	***Volatile/gaseous***		Gaseous nuclides could be released if reflector cooling water spilled.
		N-13: 68	1.1E-3	
		N-16: 82	7.1E-3	
		O-15: 260	4.1E-3	
		Nonvolatile		Nonvolatile elements in the reflector metal structure. Release would require mass vaporization combined with failure of HEPA filtration
		Co-56: 3.13E4	3.0E-2	
		Co-57: 8.3E4	2.2E-2	
		Co-58: 5.3E4	1.4E-2	
		Co-60: 3.9E3	2.0E-2	
		Ni-57: 1.9E4	1.7E-3	
		Ni-63: 4.1E5	2.7E-2	
		Ni-65: 6.7E4	1.0E-3	
Target, Reg. XI and XII, Fe shielding + H_2O coolant	200 W in 2.0E5 Ci	***Volatile/gaseous***		Gaseous nuclides could be released if shield cooling water spilled
		N-16: 14 Ci	1.3E-3	
		Nonvolatile		Nonvolatile elements in the reflector metal structure. Release would require mass vaporization (not credible) and failure of HEPA filtration (unlikely)
		Na-22: 1.4E1	2.2E-3	
		P-32: 4.0E1	3.9E-3	
		Mn-54: 6.7E3	1.8E-3	
		Fe-55: 1.8E5	7.5E-3	

Table 2.1 (continued)

Area or component (Ref. Table 5.4-5, Fig. 5.4-6 in SNS CDR, NSNS/CDR-2/V1)	Decay energy (W)	**Radioactivity (Ci)** Nuclides present in quantity >1.0% of DOE Cat. 2 hazard threshold[a]: Nuclide inventories[b] (Ci)	Fraction of DOE Cat. 2 threshold	**Dispersability assessment**
Target, Hg, after 30-year continuous irradiation by 4 MW proton beam (The mercury H_2O coolant does not become activated because it is outside the target plug. Double-walled heat exchanger tubes are used to prevent Hg from entering the cooling H_2O) The target mercury is not changed during the facility life. The buildup of radioactivity is not dependent upon the total Hg volume (~1 m^3), or upon the rate of circulation of the mercury.	9.6 kW in 3.6E6 Ci	**Volatile/gaseous** H-3: 2.4E5	 (0.78)	The parentheses indicate that this inventory will not actually be present—a helium purge flow purges gaseous H-3 from the target Hg and transports it to a hydride bed in the hot off-gas system, where it is unlikely to be released (see Sect. 4). Some tritium will form stable, nonvolatile hydrides with spallation products in the Hg, but tritium in this state will not be readily releasable
		Semivolatile I-124: 6.8E1 I-125: 3.0E2 I-126: 1.4E1 Hg-189: 6.8E3 Hg-193:4.1E4 Hg-194: 4.5E3 Hg-195: 6.9E4 Hg-197: 4.7E5 Hg-203: 3.3E5	 0.052 0.27 0.023 0.16 0.067 0.24 0.13 2.6 3.0	Iodine combines chemically with Hg to form Hg2I2, but the accident source terms assume 100% release to ensure conservatism (see Chap. 3) Hg is subject to evaporation in Hg spill accidents, which is considered in formulation of the source terms (see Chap. 3).

Table 2.1 (continued)

Area or component (Ref. Table 5.4-5, Fig. 5.4-6 in SNS CDR, NSNS/CDR-2/V1)	Decay energy (W)	**Radioactivity (Ci)** **Nuclides present in quantity** >1.0% of DOE Cat. 2 hazard threshold[a] Nuclide inventories[b] (Ci)	Fraction of DOE Cat. 2 threshold	**Dispersability assessment**
		Nonvolatile		Not subject to release: these elements have essentially zero vapor pressure at normal and accident temperatures. They are either dissolved in the Hg or have plated out on an interior Hg system surface or been filtered out of the Hg
		Gd-148: 7.6E2	2.2	
		Hf-172: 1.6E4	0.14	
		Au-195: 9.0E4	3.8E-2	
		Au-188: 1.3E4	3.1E-2	
		W-175: 1.3E4	3.0E-2	
		W-174: 1.2E4	2.8E-2	
		Hf-171: 9.4E3	2.2E-2	
		Os-183M: 8.76E3	2.0E-2	
		Lu-168: 7.2E3	1.7E-2	
		Ta-171: 7.2E3	1.7E-2	
		Lu-167: 7.0E3	1.6E-2	
		Os-179: 7.0E3	1.6E-2	
		Tb-152: 6.4E3	1.5E-2	
		Hf-168: 6.1E3	1.4E-2	
		Ho-158: 5.8E3	1.4E-2	
		Ta-170: 5.6E3	1.3E-2	
		Dy-153: 5.0E3	1.2E-2	
		Er-158: 5.0E3	1.2E-2	
		Tm-164: 4.9E3	1.1E-2	
		Dy-152: 4.8E3	1.1E-2	
		Yb-164: 4.8E3	1.1E-2	
		W-172: 4.8E3	1.1E-2	
		Ho-160: 4.5E3	1.1E-2	
		Tm-165: 4.4E3	1.0E-2	
		Er-160: 4.4E3	1.0E-2	

Table notes:

[a]DOE Standard 1027-1992 defines facility hazard categories and inventory thresholds for screening purposes. The Category 2 threshold for a nuclide is the quantity of that nuclide that, if involved in an accident, could impart a radiation dose of 1 rem at a distance of 300 m under average meteorological conditions. Published threshold values were available from STD-1027 or from DOE-STD-6003-96 for most of the nuclides in this table. Where neither published threshold values nor dose conversion factors were available, the thresholds were typically taken as the 4.3E5 generic threshold value suggested by STD-1027-1992 for beta-gamma emitters. (See also Exhibit B)

[b]Note "E" nomenclature used to indicate 10 raised to a power (e.g., E-3 means 10^{-3}). Reported inventories are for 4-MW operation for 40 years (40 years of on and off operational cycles is simulated as 30 years of continuous operation in the calculations). The beam stops are assumed to operate continuously at 0.2 MW for 30 years. Beam stops may be operated for short periods at higher beam power, but the 0.2 MW for 30 years is conservative with respect to inventory buildup over the life of the facility. Only the neutral beam stop (ring injection stop) operates continuously during normal operation.

[c]The high energy end of the linac and the ring operate with particle energy of ~1000 MeV. The activation levels become progressively lower from the high energy end to the low energy end. The activity calculations represented the beam tube and its immediate surroundings (e.g., magnets) as one lump of copper. The activation levels present in the linac and ring beam tube and surrounding structures depends on beam losses that are not a direct function of proton beam power. When the SNS is upgraded from 1 to 2 and/or to 4 MW, every attempt will be made to maintain the same beam losses in order to avoid increased structural activation that would complicate radiation protection for maintenance activities. No activation occurs in the ion-source facility because particle energies are below the coulomb barrier there.

[d]High-efficiency particulate air.

2.1 REFERENCES

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3. SOURCE TERM DEVELOPMENT: TARGET AND TARGET COMPONENTS

3.1 INTRODUCTION

This chapter provides detailed consideration of target and target component accidents that could release significant amounts of radioactive material to the environment (see Chap. 4 for target facility hot off-gas system accidents and liquid waste system–related accidents). Recommended source terms for target facility accidents are summarized in Table 3.1, and the major facts of the accident sequences are presented in Table 3.2. Individual sequences and source term development are discussed in Sects. 3.1 through 3.17. In some cases, the same source term applies—in a bounding sense—to several accidents. Table 3.1 indicates which events are bounded by each of the given recommended source terms.

The initial design for the SNS is a 1-MW target facility upgradable to a 2-MW operation with minimal refitting (e.g., up to a 6-month shutdown for any needed modifications). It is expected that the 2-MW operation will be achieved within approximately 5 years. After that, it is planned that a second ring will be built, and a target plug/cooling system will be installed in the target facility that will be capable of 4-MW operation. It will probably take more than 10 years for 4-MW operation to be realized. An objective of this chapter has been to specify source terms that are applicable to 4-MW operation. Unless indicated otherwise, the stated source terms are for 4-MW operation, and, therefore, bounding with respect to 1-MW operation.

3.1.1 Selection of Target Accident Sequences

As shown in Chap. 2, the target mercury has the most significant inventory of radioactive materials of all the SNS components and systems. Preventing release of those radioactive materials depends primarily upon three things: (1) maintaining control of the energy input to the mercury (i.e., the proton beam), (2) maintaining continuous cooling of the mercury during proton beam operation, and (3) maintaining the integrity of the mercury system itself. The first four accident sequences in this chapter evaluate potential source terms associated with these three important parameters. Section 3.2 examines beam control faults; Sect. 3.3, system integrity faults; Sect. 3.4, loss of mercury forced flow; and Sect. 3.5, loss of mercury cooling water. Depending on sequence-specific details and additional failures that are assumed, any of the first four sequences could involve release of mercury and/or its contained spallation and activation products. Section 3.14, loss of off-site power; Sect. 3.15, fire; and Sect. 3.16, natural phenomena, evaluate external events or common mode internal events that could affect mercury system integrity and/or cooling. The decay heat generation in the mercury after cutoff of the proton beam is sufficiently low that events such as loss of off-site power (Sect. 3.14) do not have the potential for compromise of mercury confinement integrity.

When the proton beam is operating, about 66% of the beam's energy ends up as thermal energy dissipation in the mercury held in the mercury vessel. The balance of the proton beam's energy supplies binding energy for the spallation process, escapes into the surrounding components, or is subtracted from the beam as it passes through the barriers between the accelerator-produced beam and actual target mercury: these barriers are the proton beam window, the water-cooled shroud, and the front face ("window") of the mercury vessel (see Fig. 5.3-6 in Chap. 5 of the CDR). Clearly, the beam has the potential to cause failure of mercury

Table 3.1. Source term summary—mercury target systems
(frequency ranges: $2.5(10)^{-2}$/year<**A**<10^0/year; 10^{-4}/year<**U**<$2.5(10)^{-2}$/year;
10^{-6}/year<**EU**<10^{-4}/year)

Frequency category	**Event(s)** (sequence number(s) as used throughout Chap. 3, Table 3.2)	**Recommended source term**		
		Material released	Time span[a]	Nuclides released to environment
A	1, 3, 4, 5, 6, 7, 13	None	NA	None
A	2.SL—Loss of Hg vessel or pipe integrity: slow leak to air inside target cell	Hg vapor	Indeterminant	Radiation exposure calculation not required since operation would be curtailed before exceeding EPA off-site airborne exposure limit
A	8.SL—Loss of H_2O or D_2O component cooling system integrity, slow leak	Tritiated H_2O or D_2O vapor, as applicable	Indeterminant	Radiation exposure calculation not required since operation would be curtailed before exceeding EPA off-site airborne exposure limit
A	8.SL—Slow leak into core vessel (this is an example of the sort of event that 8.SL can represent)	Tritiated H_2O or D_2O vapor, as applicable	30 d	18 L of H_2O or D_2O released over 30-d period. Source term is 90 Ci of tritium for D_2O cooling system and 9 Ci of tritium for H_2O cooling system
A	8.MF—Loss of H_2O component cooling system integrity, major failure	Tritiated H_2O plus N and O gaseous nuclides	First 5 min: mist release and N, O release. First 1/2 h: H_2O vapor release	150 L of H_2O evaporated over a ≥1/2-h period releasing 75 Ci of tritium. See Table 3.6 for N and I isotopes release. Mist entrainment release: 7.5 Ci tritium plus List 8 (Exhibit E) * [beam power/ (1 MW)] * 0.005
A	8.MF, 7/ABC/—Loss of D_2O component cooling system integrity, major failure	Tritiated D_2O plus N and O gaseous nuclides	First 5 min: mist release and N, O release. First 1/2 h: D_2O vapor release	150 L of D_2O evaporated over a ≥1/2-h period releasing 750 Ci of tritium. The N and O isotopes (see Table 3.4) released over a ≥5-min period. Mist entrainment releases: 75 Ci tritium plus List 8 (Exhibit E) * (beam power/ 1 MW) * 0.005
U	10—Loss of integrity of target core vessel (~3.5-m diam target containment vessel)	Gaseous products from spallation, activation of air	NA	Radiation exposure calculation not required since operation would be curtailed before exceeding EPA off-site airborne exposure limit
U	12—HEPA filter failure	Unfiltered target cell exhaust released	NA	Radiation exposure calculation not required since operation would be curtailed before exceeding EPA off-site airborne exposure limit
U	2.MF—Loss of Hg vessel or pipe integrity: major fault	Hg vapor, radio-iodine	Initial release specified for first 10 min; additional release over 8 d	1 L of nondrained Hg assumed to evaporate over 8-d (0.14% of total inventory). See Table 3.4. Iodine contained in 1 L of Hg assumed to be released

Table 3.1 (continued)

Frequency category	**Event(s)** (sequence number(s) as used throughout Chap. 3, Table 3.2)	Recommended source term		
		Material released	Time span[a]	Nuclides released to environment
U	Design basis natural phenomena—tornado, earthquake	Either no release or minor releases since natural phenomena in the unlikely range are within the target facility design basis		
EU	2.MF/mercury enclosure/—Major loss of Hg vessel or pipe integrity with assumed failure of mercury enclosure and/or its drainage system. Also bounds other EU events (e.g., EU filter fire, EU natural phenomena)	Hg vapor, radio-iodine	Initial release specified for first 10 min; additional release over 30 d	See Table 3.4. Total of 0.24% of Hg and 100% of iodine released
BDB	2/ABC/, 3/ABC/—Loss of Hg forced circulation with failure of the BP and TPS automatic beam cutoffs, plus Hg drainage path blocked, water-cooled shroud failure	Hg vapor, radio-iodine	Releases broken down for first 10 min, days 1–7, and days 8–30	Total of 1.1% (1-MW case) or 1.3% of Hg released (4-MW case). 100% of radioiodines released in either case. See Table 3.8

[a]The time spans listed are bounding and do not credit the full range of recovery actions that operations personnel would take to curtail or stop releases much sooner.

containment barriers and/or to cause elevated mercury temperatures in a short period of time. After cut off of the proton beam, the rate of decay heat dissipation within the mercury (~2.5 kW at 1 MW or 10 kW at 4 MW) does not require active cooling.

Other target systems (e.g., moderators and reflectors) have radioactive material inventories, and this chapter also considers accident sequences that could threaten release of radioactive material from those systems. Chapter 4 considers potential target facility off-gas and waste system accident sequences and source terms.

3.1.2 Proton Beam Cutoff

The single most important parameter in any target facility accident sequence is timely cut off of the proton beam when unusual conditions occur. In order to prevent damage, the cutoff must occur on a time scale consistent with the abnormal condition that is occurring. For example, following a loss of forced mercury flow, the beam must be cut off while the flow is coasting down if damage is to be avoided (i.e., within a few seconds). At the slower end of the spectrum, following a loss of cooling to the mercury heat exchanger, the beam must be cut off within a few minutes. Failure to cut the beam off can result in inadequate cooling of the mercury vessel walls with uncontrolled heat-up and over-temperature failure. Furthermore, continued proton beam operation following barrier failure would provide a driving energy for escape of radioactive material from the target system.

Table 3.2. Target accidents
(frequency ranges: $2.5*10^{-2}$/year<**A**<10^{0}/year; 10^{-4}/year<**U**<$2.5*10^{-2}$/year;
10^{-6}/year<**EU**<10^{-4}/year)

Sequence (frequency range)	**How detected**	**Automatic protective actions**	**System response or damage**	**Mitigating actions or features**	**End state**
Events that initially (by definition) or potentially involve mercury system integrity					
1.A—Loss of control of proton beam: too narrow beam focus (A)	•Focusing magnet diagnostic signals •Beam current density detector upstream of target	•Automatic beam cutoff (ABC) via beam permit (BP) system	No damage. High proton flux density for one or two pulses not sufficient to cause damage	NA	Proton beam cutoff, target facility in standby
1.A/ABC/—Too narrow beam focus, with failure of focusing magnet and beam focus alarms (EU)	•Same as above, plus possibility of Hg spill-related alarms •Change in neutron production	•Failure of BP beam trip(s) on focus fault •BP or TPS cutoff on Hg spill-related signals	Proton beam might overheat the Hg vessel and/or water-cooled shroud leading to H_2O and/or Hg spill(s)	•Mercury spill confinement and drainage system •Hot cell ventilation and air treatment systems •If water-cooled shroud fails, neutron beam windows prevent radioactive material from entering the neutron beam tubes/guides	Proton beam cutoff, and: •Passive dissipation of Hg decay heat (no pumping required) •Spilled mercury in collection tank or other closed location within hot cell or core vessel
1.B—Loss of control of proton beam: diffuse focus (A)	•Change in neutron production	NA—none needed	No damage expected—diffuse focus distributes proton beam over wider area, reducing heat flux	NA—none needed	May continue operating at near normal, or proton beam may be cut off
1.C—Misdirected proton beam (A)	•Magnet status alarm •Tunnel radiation level	•ABC—via BP	None. Beam cutoff occurs before any damage can occur	•The collimator prevents impingement of proton beam upon nontarget components (e.g., moderators or reflectors)	Beam off for troubleshooting
1.C/ABC/—Misdirected proton beam with failure of magnet status and tunnel radiation alarms (EU)	Same as above plus alarms on: •Loss of beam tube vacuum, and •Isolation valve closure	•ABC on magnet status, tunnel radiation fail •ABC on isolation valve closure after loss of vacuum	Proton beam may burn through the beam tube: •Resulting loss of beam tube vacuum initiates signal for auto closure of "upstream" isolation valve	•The collimator prevents impingement of proton beam upon nontarget components	Beam tube burned through and isolated from ring beam tube by closed isolation valve; some ablation of scraper

Table 3.2 (continued)

Sequence (frequency range)	**How detected**	**Automatic protective actions**	**System response or damage**	**Mitigating actions or features**	**End state**
2.MF—Loss of Hg vessel or pipe integrity: major fault (U) (MF = major failure)	•Hg presence (e.g., conductivity alarm) •Low level in reservoir tank	•ABC by BP and/or TPS	Hg pump maintains Hg circulation until level too low. ABC occurs before circulation ceases or additional damage	•Mercury spill confinement and drainage system •Hot cell ventilation and air treatment systems	Spilled mercury drains to collection tank. Passive dissipation of decay heat
2.MF/ABC/—Loss of Hg vessel or pipe integrity with failure of mercury level and leakage alarms (EU)	Same as above, plus •Target cell radiation levels	•ABC by BP and TPS fail •ABC by the personnel protection system (PPS) based on high radiation levels in target hot cell	The initiating boundary failure plus possibly some additional ablation of otherwise uninvolved target structures	Same as above	Same as above
2.SL—Loss of Hg vessel or pipe integrity: slow leak to air (A) (SL = slow leak)	Radiation levels in cell exhaust, stack emission monitors	NA	No damage except spread of contamination	Operators take the target out of service to avoid exceeding annual emission limits	Proton beam is cut off with active or passive cooling to remove residual heat from the Hg
2.HXL—leak in Hg*H2O heat exchanger (A)	Interspace between double-walled heat exchanger tubes is monitored	NA	NA	Operators shut down the operation when/if tube leakage excessive	•Shutdown in preparation for heat exchanger repair and cell cleanup
3—Loss of mercury pumping (A)	•Hg Pump status •Hg flow, or pump ΔP •Hg temperature	•ABC by BP and/or TPS	No damage. Proton beam cut off before Hg temperature becomes excessive	NA	•Proton beam is cut off •Passive removal of nuclide decay heat from target Hg
3/ABC/—Loss of mercury pumping with failures of pump status/flow alarms (EU to BDB)	Same as above, plus spill-related signals: •Hg level inside Hg system •Hg presence outside Hg system	•ABC failure but back-up ABC on spill-related signal(s) occurs if Hg vessel fails	•Hg temp increases •Hg vessel may fail if Hg boiling occurs •Sequence after Hg vessel failure (if any) similar to other Hg spill events	If severe enough to cause Hg boundary failure, then Hg drainage and confinement features provide mitigation	•Proton beam is cutoff •Passive removal of nuclide decay heat from target Hg
4—Loss of H_2O cooling of Hg*H_2O heat exchanger (A)	•H_2O cooling flow •H_2O pump status, or •Hg temperature	•ABC by BP and/or TPS	No damage. Hg temp begins increasing, but proton beam is quickly cut off	None needed	•Proton beam is cut off •Passive removal of nuclide decay heat from target Hg

Table 3.2 (continued)

Sequence (frequency range)	**How detected**	**Automatic protective actions**	**System response or damage**	**Mitigating actions or features**	**End state**
4/ABC/—Loss of cooling H_2O flow in Hg*H_2O heat exchanger with failure of cooling water pumping status alarm(s) (EU)	Same as above, plus spill-related signals: •Hg level inside Hg system •Hg presence outside Hg system	•ABC failure •Back-up ABC on spill-related signals	•Hg temp increases •Burn through or rupture of Hg vessel could occur if localized Hg boiling occurs •Sequence after Hg vessel failure (if any) similar to other Hg spill events	•Heat-up rate (25°C/min for 1-MW operation) allows adequate time for operator cut off of proton beam before damage (e.g., failure of Hg boundary)	•Proton beam is cut off before significant damage •Hg circulation continues with passive dissipation of decay heat-to-heat sinks surrounding the Hg system
Events involving target component cooling					
5—Loss of H_2O flow: water-cooled shroud (A)	Pump status and/or low flow alarm(s)	•ABC by BP and/or TPS	No damage due to prompt beam cut off	NA	Proton beam cut off, target facility in standby
5/ABC/—Same as above, with failure of pump status and/or low flow alarm(s) (EU)	•Increase in neutron production •Increase in core vessel pressure	•ABC failure	•Shroud may fail if H_2O boils	Spilled H_2O, if any, drains to the collection tank or remains inside core vessel. Aluminum windows prevent radioactivity from entering the neutron beam tubes/guides	Proton beam cut off, target facility shut down for recovery and repair
6—Loss of H_2O flow to proton beam window (A)	•Cooling system status alarms •Cooling H_2O low flow alarm	•ABC	No damage due to prompt beam cut off	NA	Proton beam cut off, target facility in standby
6/ABC/—Loss of H_2O flow to proton beam window with failure of proton beam cut off (EU or BDB)	The above, plus alarms related to loss of proton beam tube vacuum and isolation valve closure	•ABC by TPS and BP fail •ABC on isolation valve closure signal or inherent beam loss due to loss of vacuum	•Proton beam window may fail if H_2O boils, causing loss of vacuum inside the proton beam tube, resulting in automatic closure of "upstream" isolation valve (to preserve vacuum in ring tube, etc.) •H_2O spill if proton beam window fails	•Neutron beam windows prevent transport of radioactive material released inside core vessel (e.g., due to spilled H_2O, if any) from entering the neutron beam tubes/guides	•Proton beam cut off, target facility shut down for damage assessment. Cooling water may be spilled inside core vessel. •He from core vessel has filled the failed proton beam tube up to the upstream isolation valve

Table 3.2 (continued)

Sequence (frequency range)	**How detected**	**Automatic protective actions**	**System response or damage**	**Mitigating actions or features**	**End state**
7—Loss of H_2O or D_2O flow to target component (reflector, moderator, etc.) (A)	•Cooling system status alarms •Cooling H_2O and/or D_2O flow alarms	•ABC by TPS and/or BP	•Proton beam cut off occurs before significant heat-up can occur •Active cooling not required for removal of radionuclide decay heat after proton beam cut off	NA	Proton beam cut off; target facility in standby
7/ABC/—Same, with failure of proton beam cut off (EU)	Same as above, plus: •Core vessel pressure alarm	•ABC failure	•If boiling occurs, component cooling pipe or vessel may burst, spilling H_2O or D_2O inside core vessel •Component may overheat, but heat losses to surrounding structures will prevent extensive melting	•If no automatic beam cut off occurs, the operators would initiate manual beam cut off in response to various alarms. There would be adequate time (>1 min for most components) for operator action •H_2O spillage drains to drain tanks or remains inside core vessel	Target facility shut down for damage assessment
8.MF—Loss of H_2O or D_2O system integrity [U for any given system, A for multiple systems]	•Cooling system status alarms •Cooling H_2O and/or D_2O flow alarms •Core vessel pressure alarm (possible)	•ABC	•Proton beam cut off before significant component heat-up. •Cooling H_2O or D_2O, as applicable released inside core vessel, target cell, or pump vault (depends on location of failure)	•Spillage drains to core vessel or to drain tank, depending on location of failure	Target facility shut down for damage assessment

Table 3.2 (continued)

Sequence (frequency range)	**How detected**	**Automatic protective actions**	**System response or damage**	**Mitigating actions or features**	**End state**
8.MF/ABC/—Same with failure of proton beam cut off (EU)	Same as above	•ABC failure	•Cooling H_2O or D_2O, as applicable, released inside core vessel, target cell or pump vault •Component may overheat. Extensive melting unlikely	•If no automatic beam cut off occurs, the operators would initiate manual beam cutoff in response to various alarms •H_2O spillage, if any, drains to drain tanks	Target facility shut down for damage assessment
8.SL—Loss of H_2O or D_2O system integrity (A)	Depending on location, one or more of following: •Core vessel pressure alarm •Exhaust radiation alarm(s) •Affected cooling system low-water-inventory-related signal(s)/alarm(s)	Probably none, until or unless coolant system flow affected	Slow leak does not affect coolant flow initially (or until significant inventory loss has occurred)	•Drainage paths and drain tanks or sumps are provided for coolant leaking from any system •Based on stack monitoring, operation of the target facility would be curtailed before annual release limits exceeded	Target facility shut down for repair
9.A—Loss of cryogenic moderator integrity: both the helium and the vacuum barriers fail inside core vessel (EU—multiple failures required for any release)	•Cryogenic moderator pressure and temperature indications, alarms. Vacuum indications and alarms; helium barrier space indications and alarms	TBD	•No damage expected: release of H_2 to core vessel does not result in a flammable mixture because the core vessel is He purged •Total release of the H_2 inventory to the core vessel actuates the core vessel pressure relief path to safe venting of the He/H_2 gas mixture	•Core vessel He atmosphere prevents flammable mixtures inside •If only the primary hydrogen (H_2) barrier fails, the vacuum system is designed to vent the H leakage safely. Sub-sequent failure of outer vacuum boundary contained by helium barrier	Target facility shut down for assessment of damage to cryogenic system, and reestablishment of the core vessel helium atmosphere prior to further operation

Table 3.2 (continued)

Sequence (frequency range)	**How detected**	**Automatic protective actions**	**System response or damage**	**Mitigating actions or features**	**End state**
9.B—Same but between core vessel and safe room (EU)	Same as above	TBD	Leak	The cryogenic lines are enclosed in a protected trench that communicates with the safe room. An H_2 leak in the line would flow to the safe room	Same as above
Other miscellaneous target facility events					
9.C—Same but inside safe room (U to EU—maintenance activities occur in safe room, so this may increase frequency of a hydrogen leak to the U range)	Same as above, plus •Safe room atmosphere H_2 alarm (if all boundaries fail)	Initiation of enhanced ventilation mode	•Ventilation flow rate increases before H_2 increases to the flammable point •Operators take action to transfer the H_2 inventory to the storage tank before it is all lost out the leak	•The H_2 storage tank (located outdoors) can hold the entire H_2 inventory •The safe room has blow-out panel(s) to minimize the formation of projectiles should deflagration or detonation occur inside	Same as above
10—Loss of core vessel integrity (U)	Core vessel pressure alarm; atmosphere gas analyzer alarm	NA	He or air drawn into core vessel •Spallation; activation of air	Operators would shut down the target operation due to inability to maintain desired pressure and/or indication of air in the core vessel helium purge exhaust	Proton beam cut off and target shut down for repair
11—Loss of core vessel He atmosphere control (A)	•Core vessel pressure; helium purge flow indication and alarm		Little or no immediate effect. Long-term loss of He purge would eventually allow air ingress, which would be undesirable	It would take an extended loss of He purge flow to permit inleakage of air into core vessel	Proton beam cut off and target shut down for needed repair of He purge system; reestablish core vessel atmosphere control

Table 3.2 (continued)

Sequence (frequency range)	**How detected**	**Automatic protective actions**	**System response or damage**	**Mitigating actions or features**	**End state**
12.A—Target cell ventilation system failures: loss of blower power or ventilation flow (A)	Control room instruments and alarms—cell negative pressure, ventilation system flow	None	Cell exhaust flow stops, hot cell air pressure increases toward atmospheric pressure	Operators would work to reestablish the flow by starting standby blower(s), utilizing standby power, etc. Airborne contamination from inside the target cell could eventually diffuse into adjacent operating spaces	Facility restored to normal operation with the ventilation system returned to service
12.B—Target cell ventilation system failures: HEPA filter failure (U)	Exhaust duct radiation level or concentration	None	Decrease in removal of particulate matter. Gross filter failure could result in some increase in air flow	Operators would take the failed HEPA filter out of service after diagnosis of the condition	Facility restored to normal operation with the faulty filter out of service
Facility-wide, external events, natural phenomena					
13—Loss of off-site power (A)	Loss of normal (A/C) lighting, other services	None	Loss of off-site power cuts off the proton beam. No damage	The proton beam cannot be maintained without magnet and other power. Forced circulation not required for mercury or other decay heat removal. Diesel generators started to maintain hot cell negative pressure until off-site power regained	Facility restored to normal operation after recovery of off-site power
14—Fire (U)	Visual/auditory alarms on fire detector panel	Automatic fire sprinklers provided where needed	Fire could possibly initiate one of the failures that initiate events 1 through 12	See CDR Sect. 9.2.1	Facility shut down for damage assessment

Table 3.2 (continued)

Sequence (frequency range)	**How detected**	**Automatic protective actions**	**System response or damage**	**Mitigating actions or features**	**End state**
15—Natural phenomena-tornado and seismic (U)	Primary senses. Information updates from laboratory shift supervisor	None	No “significant” damage since safety significant component required to function after design basis earthquake or high wind event	Target facility is classed PC-2 for natural phenomena resistance (CDR Table 8.4-2, Sect. 9.2.1)	Facility shut down for damage assessment
Events involving target hot off-gas system and waste systems—see Chap. 4.					
Beyond-design-basis accidents—see Sect. 3.17.					

In recognition of the economic and safety significance of proton beam cutoff to the target, a highly reliable system has been provided: the target protection system (TPS). This system was discussed in the SNS CDR as part of the personnel protection system (PPS). The new name was chosen to designate formally that the target protection function should be separated from the PPS function in order to ensure the appropriate design and operation of each. The TPS will be documented in the SNS Design Manual (to be published later in FY 1998).

The TPS consists of the instrumentation necessary to measure target cooling and integrity parameters, and the wiring and logic necessary to prevent the initiation of proton beam pulses when parameters are not within specified ranges. The basic design objective is to cut off the beam for any event that could result in loss of mercury system integrity or upon any indication that loss of mercury system integrity has occurred. The actual mechanism for beam cut off is to prevent formation of pulses at the ion source in the very low energy end of the accelerator instead of trying to interrupt the high-energy proton beam itself. The parameters being considered for inclusion in the TPS include target mercury temperature, flow, pump outlet pressure, pump power status, and mercury presence outside the mercury system. In general, a design objective is that more than one operational parameter should be available to trigger the TPS beam cutoff for any given event. For example, mercury flow as well as pump status could signal a loss-of-flow event.

The TPS is envisioned to be a two-channel system, with 1-out-of-2 logic and fail-safe design. Separation and independence between the two channels is provided in the design as needed to ensure very high reliability for the beam cut-off function.

The primary purpose of the PPS is to protect personnel, by cutting off the proton beam in the event of unusual radiation levels or if accelerator tunnel access is attempted during beam operation, but the PPS also provides a beam cutoff of last resort for accident sequences involving the total failure of both the TPS and the run permit/beam pulse (BP) enable systems. The PPS is able to do this because any accident sequence that leads to voiding in the target plug or loss of mercury from the target plug will, in effect, put the beam about 3 m closer to the outside of the shielding, resulting in higher than normal radiation levels in and near the target hot cell wall. With respect to the target integrity, the PPS is a considered to be a cutoff of “last resort” because it is not predictive—it does not occur until some leakage of mercury has occurred (or boiling causes voiding in the mercury). Under full beam power, the voiding in the target vessel is consistent with loss or impairment of mercury vessel integrity. By contrast, the TPS and BP systems are predictive because they sense conditions that could cause loss of integrity and could actuate beam cutoff before the barrier damage happens.

The BP automatic beam cut-off function is credited in the analysis of some target accidents because it is implemented in a manner that is separate and independent from the TPS and PPS. If BP and TPS do share instrument outputs, it is through circuits that provide electrical/electronic isolation. The fast protect (FP) system is provided for equipment protection and to provide a means of very rapid detection of abnormal beam conditions in the accelerator, storage ring, or transfer tunnels. The purpose of the FP system is to prevent the initiation of more than 1 pulse under conditions of poor beam focus or directional control. Besides providing rapid equipment protection, the FP system minimizes activation of components surrounding the proton beam tube by very rapid cutoff when beam losses exceed a preset value. The FP system is directed at the proton beam upstream from the target facility. The FP system is not credited in the analysis of target facility accidents.

One additional proton beam cut-off mechanism is available and is credited or considered in some accident sequences. This is a manual beam cutoff by the control room operator. For the purposes of these analyses, it is assumed that after a period of 1 min with multiple alarms in the control room, the operator would initiate a manual beam cutoff using the switch provided in the control room for that purpose. This is a realistic, and conservative, assumption because it will be required that the SNS control room be occupied by a qualified operator during beam operation at power and because the operators will be trained to initiate the manual cutoff immediately upon the occurrence of multiple target system alarm annunciations.

3.1.3 Radionuclide Transport for Source Term Determinations

The unique nature of using a low-temperature liquid metal as a target and the physical properties of the spallation products have been recognized in the derivation of source terms. The target mercury is expected to last the entire life of the facility (40 year) because, even considering the eventual upgrade to a 4-MW proton beam power, only about 0.2% of the mercury is transformed by spallation into nonmercury spallation and/or activation products over the facility’s life. Most of the spallation products are well below their solubility limits in mercury at the end of the 40-year facility design life. The need or desirability for cleanup of the mercury during facility life has not been determined, although allowance has been made in the conceptual design for cleanup. As a minimum, it is expected that filtration will be provided for the removal of insoluble spallation products.

The SNS accidents are relatively low temperature and are low-pressure events for several reasons. The boiling point of mercury is 357°C at 1 atm of pressure. The SNS mercury system operates at low pressure (a maximum of about 3 atm in the mercury vessel, for example) because the target vessel is not designed to withstand a high internal pressure. The normal hot leg temperature of the circulating mercury is only 110°C, and automatic, highly reliable systems interrupt the proton beam when conditions deviate significantly from normal. If the automatic beam trips fail and boiling of the mercury occurs, failure of the vessel could result, allowing the mercury to leak from the mercury vessel, and bringing other automatic beam trips into play.

In contrast to the low temperatures achievable in accidents of the SNS, the boiling points of all of the spallation products, excepting I and Xe, are well above the boiling point of mercury. At the boiling point of mercury, all but Xe and I have very low to negligible vapor pressures. Therefore, in an accident in which mercury is heated above the normal range, or in which mercury is spilled and can evaporate, the mercury vaporizes selectively, separating from and leaving the spallation products behind. Distillation is a recognized method of purifying mercury. The five most risk-significant nongaseous spallation or activation products that are generated in the target mercury are shown in Table 3.3 (see Table 2.1 for radioactivity quantities involved).

As can be seen from Table 3.3, the dissolved solids have negligible vapor pressure in the temperature range for mercury accidents. Exhibit C discusses the vapor pressures of spallation products and their potential for release.

Table 3.3. The five most risk significant nongaseous radioactive elements found in target mercury

Element[a]	Melting point (°C)	Boiling point (°C)	Fraction released in SNS accidents
Hg	–39	357	<1%, as limited by evaporation or Hg carrying capacity of air
I	114	184	Assumed release of 100% of I in Hg heated to boiling point or exposed to air for >24 h[b]
Gd	1314	3264	Negligible
Hf	2233	4603	Negligible
Au	1064	2856	Negligible

[a]Essentially all of the gaseous spallation products (e.g., H and Xe) are removed from the target Hg by the normal He purge flow, and are, therefore, not present in significant quantities for release in an accident of the target mercury. Their possible release in off-gas system accidents is covered in Chap. 4 of this report.

[b]The elemental melting and boiling points are given above for discussion purposes. In the target Hg, the I is held in the form Hg2I2, which decomposes upon heating or oxidation, releasing HgI2 that can be released and transported in vapor form.

Although it is evident that the solid spallation products are not susceptible to vaporization-based transport at the relatively low temperature range for SNS accidents, other methods of transport need to be examined. This would include the postulated entrainment of small mercury droplets in the air from the interior of the hot cell during the leakage phase of a loss-of-integrity accident. By this essentially mechanical transport method, each droplet carried along with the flowing air would take all of its spallation products with it. There are several reasons why such transport is not a practical reality in accidents examined for the SNS:

- Mercury has a high surface tension, which makes it difficult for small droplets to form; and, if droplets of mercury are formed, mercury’s high density requires relatively high air velocity to remain suspended.
- For accidents involving boiling of mercury, the possible two-phase mixture (i.e., liquid plus gaseous mercury) is first discharged to an interior space where velocity is very low, allowing droplets to settle out.
- The ventilation flow in the interior of the hot cell has a residence time on the order of 10 min and, therefore, cannot stir up any kind of a breeze of air that could sweep up particulate or help mist particles remain aloft.
- Mist eliminator stages are provided as necessary to prevent the downstream HEPA filters from becoming clogged or wetted by any feasible mist component.

- The HEPA filters would be effective in stopping airborne particulate matter of any kind. Small mercury droplets stopped on a HEPA filter would continue to evaporate, eventually leaving behind a concentrated mercury–spallation product amalgam mixture.

These factors combine to justify the conclusion that the release fractions of mercury solid/ nonvolatile fission products are negligibly small.

3.1.4 Core Vessel Atmosphere Control and Venting

The core vessel is the ~3.5-m diam. vessel (continuing design work has resulted in an increase in diameter from ~2 m to ~3.5 m) in the target station that holds the target's moderators, reflectors, and the shielding that requires active water cooling. The normal atmosphere inside the core vessel is helium gas. The helium purge flow is supplied at such a rate that the vessel's atmosphere is exchanged about once per 100 h (see CDR Table 5.3-6). The purge exhaust is routed to the contaminated off-gas system.

The normal pressure inside the core vessel is slightly less than 1 atm, but should the pressure inside the vessel exceed 2 atm, a relief line opens to prevent overpressurization. The vessel could withstand more than 2 atm, but the neutron beam windows are made thin to minimize neutron losses, so they can be expected to fail first. The reason that this venting capability is provided is that a 2-atm internal pressure could be exceeded (without venting) if a worst-case, multiple-barrier failure of the cryogenic moderator system released the cryogenic hydrogen into the core vessel. Special design requirements on the venting path design will be required in order to control flammability of the helium/hydrogen effluent should venting occur after a cryogenic moderator failure. The design of the venting path is ongoing, but, because of the possible flammability of its effluent, it is expected that the vent line will not vent into the normal ventilation system, or through a blower (unless it is hydrogen-qualified), and that parts or all of the vent path may be normally inerted. Potential hydrogen flammability accidents are examined in Sect. 3.10.

Since significant amounts of contamination may exist inside the core vessel during normal operation and more could be released in the event of an accident, it is required that the normal and relief venting paths discharge to the environment through HEPA filters. The relief venting path will have the appropriate features to protect the HEPA filters and ensure their operation including, for example, a diffuser section to allow velocity to decrease and a demister stage to remove any entrained mist.

3.1.5 Target Building and Beam Stop Ventilation

Target building ventilation is discussed in Sect. 8.6.3.7 of the CDR, and illustrated schematically on CDR drawing NSNS-18-012. Target building areas with potential for airborne radioactive material are included in the target confinement systems (primary and/or secondary confinement systems). The conceptual design follows accepted practices, such as ensuring that air flows from areas with lower potential for airborne contamination to areas of higher potential for contamination. Exhaust air is routed through HEPA filter banks. Each HEPA filter bank is designed to include prefilters and/or mist eliminators, as appropriate, and the exhaust point is the target building stack. The HEPA filters are credited with being able to remove non-volatile particulate matter, but not with being able to remove iodine or mercury (i.e., since these two elements can become airborne in vapor form). Filtration units specifically for mercury vapor removal from air inside the target hot cell are under consideration, but any such additional mercury vapor removal capability is not credited in any of the accident source terms.

Ventilation for beam stop buildings is exhausted to the environment through HEPA filters (as discussed in CDR Sect. 8.6.3.10). Each beam stop is designed for 200-kW continuous duty, although it is expected that only the ring injection beam stop will be operated continuously during normal operation. Activation levels of the coolant in the ring injection beam stops are expected to be significantly greater than in the other beam stops. Therefore, it has been decided that the HEPA exhaust for the ring injection beam stop should be routed such that it joins the target confinement exhaust and is discharged to the environment through the target building exhaust stack (see CDR Sect. 8.6.3.7).

3.2 LOSS OF CONTROL OF PROTON BEAM FOCUS OR DIRECTIONAL CONTROL (ACCIDENT SEQUENCE 1)

3.2.1 Sequence of Events

The proton beam could, hypothetically, be misdirected in such a manner as to cause overheating and release of radioactive material. To prevent such a possibility, the accelerator is equipped with the highly reliable, automatic systems discussed above that cut off the beam when abnormal conditions apply. In addition, the close-fitting collimator in the transfer tunnel immediately upstream from the proton beam window (in the ~3.5-m diam core vessel) is a passive device that prevents the beam from being misdirected onto target components other than the mercury vessel (i.e., the mercury-filled vessel that is the actual target of the proton beam). For any anticipated failures of beam control, inherent design features and automatic cut-off circuits preclude system damage.

The only beam control event that has any potential for causing release of mercury would be a focusing fault in which the beam is concentrated into a smaller than normal area as it impinges upon the mercury vessel. Preliminary conceptual design information shows that it may be possible for the beam under these abnormal circumstances to be focused onto a smaller, but not yet quantified, fraction of its normal area. Analysis has not been done to determine how much beam concentration the mercury vessel can withstand. Therefore, in addition to focusing magnet status signals, the conceptual design includes a provision for a beam focus sensor (comb-like device that detects the spatial energy distribution of the beam) that will be keyed in to one of the automatic beam cut-off systems. Thus, the excess beam focus base case anticipated event has no damage or release of radioactive material because the beam is cut off before damage can occur.

3.2.2 Estimated Frequency Range

It is anticipated that beam control faults will occur during the 40-year nominal life of the facility (i.e., frequency >2.5 • 10^{-2}/year), but it is highly certain that the beam will be automatically cut off after a small number of pulses when the abnormal conditions occur. The conditional probability for failure of the automatic beam cut-off system is estimated at less than 10^{-4} per demand because there are typically two independent signals for achieving automatic beam cutoff, e.g., focus magnet status signal and beam focus sensor signal. It is concluded that a potentially damaging beam control fault compounded by failure of prompt automatic proton beam cutoff would be an unlikely [10^{-4}/year < frequency < $2.5(10)^{-2}$/year] or extremely unlikely event (frequency 10^{-4}/year to 10^{-6}/year). If the focus fault were severe enough to cause boundary failure after failure at prompt automatic beam cutoff, the subsequent mercury leakage would result in proton beam trip by the TPS.

3.2.3 Source Term

There is no source term for any of the beam control events in the anticipated range. The source term for extremely unlikely beam control events is bounded by the worst-case source term developed in Sect. 3.3 for extremely unlikely loss of mercury system integrity events.

3.3 LOSS OF MERCURY VESSEL OR PIPE INTEGRITY: MAJOR FAULT (ACCIDENT SEQUENCE 2)

3.3.1 Sequence of Events for the Mercury Spill

This event would be initiated by a major failure in the primary mercury boundary. The failure could be in the mercury vessel itself (the actual target of the proton beam), piping between components, the mercury reservoir, the mercury pump, or the mercury/H_2O heat exchanger. The fault is assumed to occur suddenly and to have a flow area consistent with rapid spillage of mercury (e.g., over a 10-min or shorter period).

The most likely places for boundary failures are thought to be the mercury vessel itself, which is directly in the proton beam, and the two bellows sections provided to allow for thermal expansion of the long pipe that runs through the target plug. The nominal conceptual design value for total mercury inventory is 1000 L, including the target vessel, the target plug, piping, heat exchanger, and pump. The rate of pumping is on the order of about 1000-L per min, giving a very approximate loop time of about 1 min for the circulating mercury. (None of the analyses of this report are sensitive to this loop time, including the mercury radionuclide inventories given in Chap. 2). The maximum static pressure inside the mercury vessel during operation is about 0.3 Mpa (static pressure does not include the pressure pulsations that are always present during normal operation because the proton beam is actually a train of discrete pulses).

The mercury system has features designed to work together to confine any mercury that might be inadvertently spilled or spilled because of an accident (see CDR Figs. 5.3-1 and 5.3-2). These features include a collection tank to which spilled mercury drains, engineered drainage paths to ensure that any spilled mercury is directed to the collection tank, and an enclosure that surrounds much of the “rear end” part of the mercury system that protrudes into the target cell (e.g., the mercury reservoir, heat exchanger, and related piping). In addition, the water-cooled shroud separates the mercury vessel from the interior of the core vessel that houses the reflectors, moderators, and associated shielding. The water-cooled shroud would prevent mercury from flowing into the core vessel in the event of a failure of the mercury vessel.

The floor of the mercury enclosure is sloped appropriately and otherwise engineered to ensure complete drainage of the mercury to the collection tank. This enclosure is entirely inside the target hot cell. If the mercury leak were spraying outward, it would strike a surface on the inside of the enclosure, drop to the floor, and drain to the collection tank. It is not intended to be a sealed containment vessel; the target cell ventilation system will be designed to pull a slight negative pressure on the mercury enclosure to maintain inward flow of air from the target cell into the enclosure. The vent connection for this will be engineered so that mercury from a boundary failure in any component cannot stream directly into the exhaust duct. Special air treatment for the air exhausted from the mercury enclosure is currently under consideration by the project. Specifically, the need for mercury removal stage(s) is being determined, but has not been credited in any of the present accident source term estimates. As a minimum, the enclosure exhaust will include a mist elimination stage or robust prefilter that will accomplish the same purpose (i.e., the removal of entrained mercury and/or mercury-contaminated gross particulate). Downstream equipment, including HEPA filters, will accomplish the final air treatment for hot cell exhaust.

For completeness, it can be noted that the mercury enclosure serves another purpose unrelated to this discussion: it shields instrument components mounted near the mercury system from gamma irradiation. The degree of shielding provided is only that needed to ensure a reasonable lifetime for these electronic components.

Immediately upon initiation of the mercury leak, the system would continue to circulate mercury as normal, etc., but sensors (e.g., conductivity sensors) at the bottom of the stainless steel catch pan that forms the floor of the mercury enclosure and/or at other points in the system would detect rapidly the existence of the leaked mercury. The signals from these sensors, indicating spilled mercury, would initiate an automatic proton beam cut off. After some delay, other signals would confirm the spill sensors (e.g., low reservoir tank level or eventually perhaps low mercury pressure and/or flow). These other sensors can also actuate automatic alarms and/or proton beam cutoffs.

Upon detection of the leak and following verification of proton beam cutoff, the prescribed operator action would be to turn off the mercury circulation pump, and open valves that allow any mercury not spilled from the mercury system to drain to the mercury collection tank. The reason for this action is to minimize the amount of mercury leaked from the mercury system and thus minimize the subsequent cleanup efforts.

The only source of heat to the mercury after beam cutoff is the approximately 9.6 kW of decay heat distributed throughout the mercury inventory (at end of a 4 MW operating cycle). Active cooling is not required to remove decay heat from the mercury. The mercury circulation pump would, however, continue to run without operator intervention. Since the pump is at the low point in the mercury circuit, its continued running would tend to maintain circulation and force more mercury through the leak. Eventually most of the mercury inventory would have leaked from the mercury system. However, essentially all of the leaked mercury will be collected and confined by gravity drainage to the mercury collection tank.

The multiplicity of ways in which the proton beam would be cut off in this event make it incredible that the beam would not be cut off in this event. Major mercury spill with failure of multiple automatic beam cutoffs is considered in Sect. 3.17, Beyond-Design-Basis Accidents.

3.3.2 Estimated Frequency Range for the Mercury Spill

The basic initiating event, a major failure in the mercury system pressure boundary, is an unlikely event (10^{-4}/year < frequency <2.5×10^{-2}/year). Generic data on bellows,[1] the most vulnerable part of the system with the possible exception of the mercury vessel itself, indicate a failure frequency of somewhat less than 2.5×10^{-2}/year. Failure likelihood for bellows is minimized by designing the bellows for an adequate number of cycles (the bellows are provided to allow the target plug to expand without stress buildup when it is heated from ambient temperature to operating temperature, and vice versa for the cooldown that occurs after the beam is cut off). Piping flexibility analysis and other design work will be done with the objective of eliminating as many of the bellows as possible.

Potential proton and neutron irradiation effects, normal pressure pulsations, and other cyclic stresses are of concern for the mercury vessel. However, the research and development (R&D) program for the mercury vessel and evaluation of experience during initial facility operation will allow the staff to develop design and maintenance parameters, including replacement frequency, that minimize the probability of its failure.

The worst case (extremely unlikely) mercury spill source term calculated below assumes, in addition to a major mercury spill, the failure of the mercury enclosure and/or its engineered drainage paths and/or pipes that would allow any spilled mercury to drain to a collection tank in a vault below the target hot cell floor. These failures combine to put this postulated event in the extremely unlikely category.

3.3.3 Source Term for the Mercury Spill

3.3.3.1 Base case unlikely event (no additional failures)

The source term for this event consists of the mercury and I isotopes. The other spallation products dissolved in the mercury are not released because they have very low vapor pressures in the temperature range of interest (i.e., below the boiling point of mercury). There may be some creation of spray droplets if mercury is sprayed from the boundary failure, but the high surface tension and density of mercury work against that tendency, and a mist elimination step will be included in the design of the cell exhaust to remove droplets carried out of the mercury enclosure by the ventilation flow. The mercury enclosure is ventilated at a low rate such that there is not a significant amount of turbulence in the air flowing through the enclosure. If the ventilation system failed during this event, the source term with no ventilation would be lower than derived here under the assumption of continuing flow.

The mercury spill drainage features are required to ensure that all the spilled mercury drains to the collection tank or other closed location. To provide a conservative source term for analysis purposes, it is assumed that 1 L of mercury fails to drain and is in a configuration with a large surface area exposed to air, such that it can evaporate and be released. The source term for this event is calculated as follows:

1. The release of mercury vapor during the first 10 min is bounded by assuming that the leakage flow and surface area presented by the leaking mercury (e.g., as it strikes a wall and flows across the catch pan floor to the drain) are sufficient to elevate the air temperature flowing inside the mercury enclosure to 95°C (the average of 80°C the 110°C inlet and outlet temperatures of the circulating mercury). Furthermore, it is assumed that the air becomes and remains saturated with mercury vapor for the entire period. This is very conservative because it is equivalent to assuming that the evaporation rate is, in effect, instantaneous during this stage of the accident.

The equilibrium concentration of air saturated in mercury vapor is obtained as shown at bottom of page 2 and top of page 3 of Exhibit D, but utilizing the desired 90°C temperature. This concentration is then multiplied by the air bulk flow rate to give the bounding release rate. At the mercury enclosure air flow rate of 400 cfm, the bounding initial release is therefore 200 g of mercury over the 10 min (see discussion below for the accompanying iodine release).

2. After the first 10 min, all the mercury inventory has leaked from the system, or the operator takes action to stop the leak. The mercury enclosure air temperature thus returns to its normal value of less than 60°C. The release after this point is bounded by assuming that the spilled mercury occupies the whole enclosure floor and that its temperature would be 60°C (floor should actually be cooler than this). Exhibit D calculates an evaporation rate at 110°C of 87.1 g mercury/m^2/day under assumed turbulent air flow conditions. The equivalent rate at 60°C is calculated by multiplying the 110°C rate by the ratio of vapor pressures: VP(60°)/VP(110°C). Exhibit D (second page) gives a correlation for mercury vapor pressure as a function of temperature. Thus, the evaporation rate at 60°C is calculated to be 5 g/m^2/day. A somewhat lower rate would be obtained if the reduction in diffusion coefficient as a function of temperature (see last page of Exhibit D) were credited. To bound the possible geometry and mass transfer correlation uncertainties, a factor of 10 is applied to the 5 g/m^2/d estimate. To further bound the surface area for evaporation, we assume that the entire floor area of the enclosure is covered by a thin layer of mercury. The resulting bounding total mercury release rate is 1.6 kg of mercury per day. At this rate it would take more than 8 d to evaporate the entire liter. Even though the enclosure would cool significantly over this period, reducing the evaporation rate significantly, it is conservatively assumed that the release takes place over an 8-d period. With the great bulk (i.e., ~99.9%) of the mercury having drained via gravity to the collection tank, and all the undrained mercury having been evaporated, there would be essentially no releases after the 8-d period. A small fraction of the postulated 1 L of undrained mercury would, in reality, not be released because the evaporation process would tend to concentrate the normally very dilute dissolved spallation products in the mercury, leaving behind small amounts of concentrated mercury-spallation product amalgam, which would not be easily volatilized or entrained by the low air flow in the mercury enclosure.

   If such a mercury leak occurred, only a small fraction of the 1 L could be vaporized because facility operators would take actions to curtail the release rate. For example, they would ensure or enhance cell cooling, would cleanup the spilled mercury (using remote manipulators to activate and control cleanup equipment inside the hot cell) and/or would utilize a chemical agent (e.g., amalgamating compounds) to bind the mercury chemically.

The SNS target system designers are considering an mercury removal step for the cell ventilation system, but mercury removal is not credited in the present analysis. The entire 1 L of mercury and its contained iodine (as discussed below) are assumed to be released to the environment.

Since a helium purge regularly transports the gaseous spallation products from the mercury to the hot off-gas system during operation, they are not available for release in a mercury spill event. For example, the helium purge sweeps any tritium gas into a hydride bed in the hot off-gas

(HOG) system instead of allowing it to accumulate in the target mercury (see Chap. 4 for hot off-gas system events). Or, for another example, xenon spallation products are also swept to a hold-up stage in the hot off-gas system to allow for decay before release.

Iodine readily combines chemically with mercury and is therefore not immediately available for release from the 1 L of spilled mercury. With sufficient time of exposure to air, the Hg_2I_2 can oxidize slowly and release iodine (see Exhibit C). To bound the release, it is assumed that this conversion can occur over the same time scale as the mercury evaporation, and that 100% reaction occurs, releasing all the radioiodine in the 1 L of non-draining mercury. The balance of the mercury drains to, or remains within, a tank where it is not effectively exposed to oxygen, so its contained Hg_2I_2 remains unoxidized and therefore releases negligible iodine.

In conclusion, the base case loss of target mercury system integrity (unlikely event) source term consists of 1 L of mercury and its initially contained radioiodine (i.e., the entire volatile and semi-volatile content of the mercury that fails to drain to the collection tank). Since the designers are trying to improve the target system design to minimize mercury inventory, it will be assumed that the mercury inventory will be reduced from the nominal 1000 L (13,600 kg of mercury) to a value of 10,000 kg (~735 L) of mercury. Thus, the fractional release of both mercury and I nuclides is adjusted upward from 0.l% to 0.14% of the total inventory, with all but the initial (first 10 min) release occurring over the abovementioned 8-d period. The radionuclide release source term (see Table 3.4) is estimated on the basis of 40-year end-of-life radionuclide inventory. See Table 3.4 for a summary of the release fractions and the initial mercury and iodine radionuclide-specific activities present immediately before the accident.

3.3.3.2 Bounding source term for the extremely unlikely (EU) event mercury spill

If a mercury spill occurs with failures in the mercury confinement and drainage system, the bounding source term would be worse than determined above for the base case (unlikely event). The bounding EU mercury spill is a failure(s) of the mercury enclosure that allows the mercury leak to escape from the mercury enclosure into the target hot cell. A compounding failure of the cooling water system that maintains normal mercury temperature is assumed with coincident failure of the first automatic proton beam cutoff (e.g., the beam cutoff based on cooling water pump status), such that the bulk temperature of the mercury has increased by 20°C over normal values at the time of the spill (i.e., to a value consistent with the beam cutoff based on mercury temperature). The discussions in the subsection above, pertaining generally to radionuclide release and transport, etc., are all applicable to the EU spill. The assumptions regarding mercury transport are analogous but must be scaled up to the entire mercury hot cell, and to mercury temperatures consistent with this EU event. Releases tend to be larger because the entire cell air flow specified in the conceptual design is 4800 cfm (136 m^3/min). The mercury releases are calculated as follows:

1. The release of mercury vapor during the first 10 min is bounded by assuming that the leakage flow and the surface area presented by the leaking mercury (e.g., as it strikes a wall and flows down the wall and across the floor) are adequate to ensure complete thermodynamic mixing between the cell air (40°C) and the leaking mercury (with the mercury at 215°C due to the assumed heat-up before the spill). Thus, the air temperature during the initial 10-min period is elevated from 40°C to 86°C. The further bounding assumption is made that the air is saturated with mercury vapor during this entire phase of the spill. This is a very conservative assumption

(probably unrealistically conservative) because it neglects the limitations on heat transfer rate due to low temperature differences and the tendency for mercury to drain to or gather at any low point or drain opening, thus reducing exposed surface area. At the hot cell air flow rate of 4800 cfm, the bounding release during this initial 10-min period is, per the stated conservative assumptions, 1.5 kg of mercury.

Table 3.4. Source terms for the unlikely event and extremely unlikely event mercury spills

a. Radionuclide specific activities

Note 1: After 40 years of operation at 1 MW, with specific activity values given for the instant before the spill.

Note 2: Except as noted, multiply by 4 to get corresponding 4-MW values.

Radionuclide	Specific activity (Ci/g Hg)[a]	Specific activity (Ci/g I)[b]
I-119	6.76E–7	5.59
I-120	1.01E–6	8.34
I-121	2.03E–6	16.8
I-122	2.87E–6	23.7
I-123	3.72E–6	30.7
I-124	1.69E–6	14
I-125	7.43E–6	61.4
I-126	3.38E–7	2.79
I-128	3.38E–7	2.79
I-129	8.85E–13	7.31E–6
I-130	1.69E–7	1.4

[a]Specific activity in Ci/g Hg = nuclide inventory (Ci) divided by mercury mass (10^7 g Hg, constant throughout facility life)

[b]Specific activity in Ci/g I = nuclide inventory (Ci) divided by iodine mass (1.21 g I at end of facility 40-year design life). The Ci/g I specific activity after 40-year of 4-MW operations would be the same as above because not only the mass of iodine but also the radionuclide inventories would be four times as large. The total mass of iodine, dominated by stable I-127 and long-lived I-129, decreases by ~0.1% during a 30-d accident period due primarily to decay of I-125 (the shorter lived ones also decay, but their contribution to mass is negligible).

Radionuclide	**Specific activity** (Ci per gram of Hg)
Hg-180	8.45E–7
Hg-181	2.37E–6
Hg-182	3.55E–6
Hg-183	6.42E–6
Hg-184	1.2E–5
Hg-185	1.96E–5
Hg-186	5.12E–5
Hg-187	1.05E–4
Hg-188	2.4E–4
Hg-189	3.7E–4
Hg-190	5.36E–4
Hg-191	6.75E–4
Hg-192	9.01E–4
Hg-193	1.05E–3
Hg-194	1.14E–4
Hg-195	1.75E–3
Hg-197	1.17E–2
Hg-203	8.32E–3
Hg-205	3.6E–4

b. Accident release fractions (applicable to either 1-MW or 4-MW cases)-bulk mass fractions released[c]

Accident	Time period	Hg release fraction	Iodine release fraction
Hg Spill (U = unlikely)	0–10 min	2.0E–5	2.0E–5
Hg Spill (U)	10 min–8 d	1.4E–3	1.4E–3
Hg Spill (U)	>8 d	0	0
Hg Spill (EU) = extremely unlikely)	0–10 min	1.5E–4	1.5E–4
Hg Spill (EU)	10 min – 10 d	1.9E–3	3.3E–1
Hg Spill (EU)	10 days – 30 d	3.8E–4	6.7E–1
Hg Spill (EU)	>30 d	0	0

[c]Note: Release fractions for shorter-lived radionuclides would be smaller than the bulk mass release fractions provided that the release period is long in comparison to the half-life of the radionuclide.

2. After the first 10 min, all the mercury inventory has leaked from the system, or the operator takes action to stop the leak. The hot cell air temperature thus returns to its normal value of less than 40°C. The release after this point is bounded by assuming that the spilled mercury occupies the whole hot cell floor, and that its temperature would be 40°C (floor should actually be considerably colder). Based on the derivation in Exhibit D, the maximum evaporation rate of this spilled mercury is estimated to be 1.2 g $Hg/m^2/d$ at a 40°C temperature. To bound the possible geometry and mass transfer correlation uncertainties, a factor of 10 is applied to this estimate. To further bound the surface area for evaporation, we assume that the entire floor area of the hot cell is covered by a thin layer of mercury. The resulting estimated total mercury release rate is 1.9 kg of mercury per day. The release is assumed to continue at 1.9 kg of mercury/d for a 10-d prerecovery period. After this 10-d period, it is assumed that the several available accident recovery strategies would reduce the rate to 10% of the rate of the first 10 d (i.e., to 0.19 kg mercury/d). After 30 d, the release rate would be essentially terminated because of continuing cleanup efforts. As discussed in the previous section it is expected that the facility operators should be able to greatly curtail or stop the releases much sooner than either 10- or 30-days because of the several actions they would be able to take.

The bounding assumptions (discussion above, plus Table 3.5) are thought to be sufficiently conservative that the resulting source term bounds the entire spectrum of events in the EU category (10^{-6}/year < frequency < 10^{-4}/year). The only way to have greater release would be to postulate events that are beyond credible (see Sect. 3.17).

The nuclides released in this event include only the mercury and iodine radionuclides. As previously mentioned, other potentially significant volatiles (e.g., tritium gas) are swept from the reservoir tank during normal operations by the helium purge flow. Release of tritium is considered under target off-gas accidents (Chap. 4). As with the unlikely event mercury spill , the assumption is made that all the iodine contained in nondrained mercury is volatilized. Thus, since the assumed failures include nondrainage of the whole mercury inventory (i.e., the engineered drainage paths and the mercury enclosure are failed somehow), the release fraction for the iodine is 100% for the 30-d accident period.

In summary, 0.015% of the mercury and I inventories are released over the first 10 min, and 0.228% of the mercury and 99.985% of the I is released to the environment over the balance of the 30-d accident period. Source terms and initial mercury and iodine radionuclide specific activities are summarized in Table 3.4.

Table 3.5. Worst case input parameter assumptions used to derive bounding source term for extremely unlikely events (10^{-6}/year < frequency < 10^{-4}/year); based on mercury spill event with multiple additional failures

Parameter	**Nominal value** (or nominal accident value)	Bounding value	Basis
Hg surface area exposed to air, early part of spill event	Estimated at <1 m^2 surface area of Hg as it drains across the catch pan to the collection tank	Sufficient Hg exposed to air to saturate air in mercury enclosure with Hg vapor during early part of spill	Conservative assumption that the leak is sprayed vigorously enough to result in a large surface of area for Hg/air contact
Target cell mercury enclosure air flow; hot cell air flow	Hg enclosure: 11.3 m^3/min Hot cell: 136 m^3/min	11.3 m^3/min Hot cell: 136 m^3/min	Assuming the ventilation flow continues at the nominal value, will maximize Hg vapor transport during the accident (there would be little-to-no air flow and, hence, little-to-no Hg vapor transport if the ventilation system fails or is turned off)
Hg decay heat	Depends on operating time in the proton beam; after 1 year in a 4-MW proton beam, decay heat is <10 kW immediately after beam cut-off	Hold at 10 kW throughout the accident	Decay heat decreases continuously after proton beam cut-off (e.g., is at ~70% of the initial value 1-h after cut off)
Hg decay heat dissipation paths	Decay heat would be dissipated to structures and to air	Assume 100% of decay heat is transferred to air	Higher air temperature increases Hg carrying capacity of the air.
Cell air inlet temperature	14°C is the annual average outdoor air temperature for Oak Ridge, Tennessee. Building air is typically heated or cooled to ~22°C by the building HVAC system	30°C	Assuming 30°C is equivalent to assuming an A/C failure during summer months. Note: 24.8°C is the daily average temperature for hottest month of the year (July)
Duration of significant accident release	~0 days (if various systems work as designed, there is essentially no environmental release)	Bounding releases specified for short, intermediate, and long term releases, as applicable	Various factors would minimize or end the release after several days, including lower decay heat, oxide films on any exposed Hg, and possible operator actions

HVAC–heating, ventilating, and air conditioning.
A/C–air conditioning.

3.4 LOSS OF MERCURY PUMPING DURING PROTON BEAM OPERATION (ACCIDENT SEQUENCE 3)

3.4.1 Sequence of Events for Loss of Mercury Pumping

Forced circulation of the mercury is required to transport the heat deposited by the beam as it impinges upon the mercury target. If power is lost to the circulation pump or the pump fails for any other reason, the mercury flow decreases while temperature of the mercury increases. The circulation pump status and the mercury flow and/or pressure signals are utilized to initiate automatic cutoff of the proton beam whenever an abnormality is detected. If either the run permit/pulse enable [or beam permit (BP), for short] systems or the TPS discontinues the proton beam during the first few seconds, then no damage occurs in any part of the mercury system. The BP and the TPS are independent. The likelihood that both the BP and the TPS might fail is thought to be beyond extremely unlikely, but is considered in Sect. 3.17, Beyond-Design-Basis Accidents.

If ac power were lost to the facility as a whole, then the beam would inherently and rapidly be discontinued as the mercury pump coasted down.

3.4.2 Estimated Frequency of the Loss of Mercury Pumping

It is anticipated that failure of the mercury pump or its power supply will occur during the life of the facility. Failure of the BP (but not TPS) automatic beam cutoff after mercury pump failure would be an unlikely event, but simultaneous, total failure of both of these independent systems (BP and TPS) would be extremely unlikely or beyond design basis.

3.4.3 Source Term

The source term for loss of mercury circulation flow events is zero because of the multitude and independence of ways in which the proton beam can be cut off before damage can occur to the mercury boundary. The source term for loss of mercury flow with failure of both BP and TPS automatic proton beam cutoffs is developed in Sect. 3.17.

3.5 LOSS OF H_2O FLOW IN MERCURY*H_2O HEAT EXCHANGER DURING PROTON BEAM OPERATION (ACCIDENT SEQUENCE 4)

3.5.1 Sequence of Events for Loss of H_2O Flow to Mercury Heat Exchanger

A loss of cooling water flow to the mercury heat exchanger would result in increasing mercury temperature as the heat deposited by the proton beam is distributed throughout the mercury loop instead of being removed by the cooling water. Automatic beam cutoffs would detect the condition and discontinue the proton beam. If the automatic proton beam cutoff is assumed to fail, it is probable there would be sufficient time for the operators to react to alarms and cut off the beam before any damage occurred. The heat-up rate with no water in the mercury heat exchanger would be about 25°C/min for the 1-MW configuration or about 100°C/min for the 4-MW target configuration. In the worst case, without intervention, local boiling would eventually occur in the mercury vessel and the insufficiently cooled mercury vessel walls would fail (i.e., probably after >1 min even for the 4-MW configuration), causing a mercury spill event that would be similar to the sequences considered in Sect. 3.3.

3.5.2 Estimated Frequency Range for Loss of H_2O Flow to Mercury Heat Exchanger

The base case loss of cooling water flow is an anticipated event. Failure of both the BP and TPS automatic beam cutoffs and operator initiated manual cutoffs is estimated to have an annual probability of occurrence below 10^{-6}/year because the TPS and BP automatic cutoffs are independent, and because there is sufficient time to make operator-initiated cutoff very likely. An appropriate EU loss of mercury H_2O cooling water would be to have a delayed automatic proton beam cutoff following loss of the cooling water. For example, the trips based on H_2O flow and/or pump status will cut the beam off before the mercury has a chance to heat up, whereas the trip based on mercury temperature occurs only after some heat-up has occurred. To avoid spurious beam cutoffs, the high temperature–based trip will be adjusted to allow perhaps about 15°C of heat-up before preventing further beam pulsing (20°C was assumed for analysis of the EU mercury spill that bounds this event). Consistent with the EU probability level, this amount of heat-up might be the last straw for some incipient mercury boundary failure, in effect allowing this event sequence to develop into a mercury spill accident.

3.5.3 Source Term for Loss of H_2O Flow to Mercury Heat Exchanger

There is no damage and therefore no release or source term for the base case anticipated event. The source term for the EU event with failure of the more promptly occurring automatic beam cutoff(s) is bounded by the worst case EU mercury spill event source term developed in Sect. 3.3.

3.6 LOSS OF H_2O FLOW: WATER-COOLED SHROUD (ACCIDENT SEQUENCE 5)

3.6.1 Sequence of Events for Loss of H_2O Flow to the Water-Cooled Shroud

The water-cooled shroud is provided to minimize the probability for mercury contamination to enter the core vessel. It is cooled because the proton beam passes through it before striking the mercury vessel. The base case loss of cooling water flow to the water-cooled shroud is an anticipated event. Automatic beam cutoffs based on status of the cooling water system would cut off the beam before any damage. There is a possibility that the operators could react to an alarm and discontinue the proton beam manually.

In the EU event of full beam power and no water flow, the shroud would not be adequately cooled, boiling of water would occur inside the shroud, and the shroud would fail soon thereafter. Some water might be spilled inside the core vessel, but the <60°C temperature of components inside the core vessel would not be sufficient to boil enough water to actuate the core vessel relief valve (that actuates for core vessel internal pressures exceeding 2 atm). The part of the uncooled shroud remaining in the beam might overheat, possibly melting and dropping down out of the path of the beam. This would cause an increase in the energy deposition rate into the mercury vessel but not enough to be likely to fail the mercury vessel. There should also be an increase in the neutron production rate. Melting of the water-cooled shroud could cause mercury vessel failure if the molten stainless steel drips onto the core vessel.

3.6.2 Estimated Frequency Range for Loss of H_2O Flow to the Water-Cooled Shroud

Loss of cooling water flow to the water-cooled shroud is an anticipated event. The shroud fills a contamination barrier function, and its replacement would require lengthy facility shutdown; therefore, sufficiently redundant and diverse shutdown mechanisms will ensure highly reliable prompt proton beam cutoff in the event of loss of its cooling water flow. Compounding the loss of cooling water with failure of automatic beam cutoff mechanisms would make this an extremely unlikely event.

3.6.3 Source Term for Loss of H_2O Flow to the Water-Cooled Shroud

There is no source term associated with the base case anticipated event. The extremely unlikely case with failure of automatic beam cutoff and possible spillage of cooling water is bounded by the unlikely event source term developed in Sect. 3.9, Loss of D_2O or H_2O Integrity in Target Cooling Loop.

3.7 LOSS OF H_2O FLOW: PROTON BEAM WINDOW (ACCIDENT SEQUENCE 6)

3.7.1 Sequence of Events for Loss of Water Cooling Flow to Proton Beam Window

The proton beam window forms the boundary between the proton beam tube and the core vessel. Its main purpose is to protect the high vacuum that is maintained in the beam tube against the helium atmosphere maintained inside the core vessel. The sequence of events upon loss of cooling water flow would be very similar to the sequence outlined in Sect. 3.6 for loss of water flow to the water-cooled shroud. There would, however, be an additional beam cut-off mechanism that would actuate should the undercooled window fail. Loss of beam tube vacuum automatically triggers closure of an isolation valve (to protect vacuum in the beam tube farther upstream), which simultaneously and automatically initiates beam cut off.

3.7.2 Estimated Frequency Range for Loss of Water Cooling Flow to Proton Beam Window

The base case loss of coolant flow is an anticipated event. Loss of coolant flow without beam cutoff would be an extremely unlikely event. Large amounts of radioactivity are not present in the proton beam window’s cooling water, and failure of the proton beam window would not threaten a mercury spill event, but the window fills a contamination barrier and also a facility segmentation function. Therefore, sufficiently redundant and diverse shutdown mechanisms will ensure highly reliable prompt proton beam cutoff in the event of loss of its cooling water flow.

3.7.3 Source Term for Loss of Water Cooling Flow to Proton Beam Window

There is no source term associated with the base case anticipated event. The extremely unlikely case with failure of automatic beam cutoff and possible spillage of cooling water is bounded by the unlikely event source term developed in Sect. 3.9, Loss of D_2O or H_2O Integrity in Target Cooling Loop.

3.8 LOSS OF WATER FLOW TO TARGET COMPONENT COOLING LOOP (ACCIDENT SEQUENCE 7)

3.8.1 Sequence of Events for Loss of Water Flow to Target Component Cooling Loop

This event can refer to any one of the following components:

- The moderator/proton beam window H_2O cooling loop
  - proton beam window
  - ambient moderator
  - cryogenic moderator
- The D_2O cooling loop
  - Ni and Be reflectors
- The shroud H_2O cooling system
  - target water-cooled shroud
- The shield cooling H_2O cooling water loop
  - stainless steel shielding units

These components are held inside the core vessel. The conceptual design provides a separate cooling loop for each component. The loss of water flow could be caused by failure of a pump, a valve, or the electrical power supply to the pump. Sensors provide status monitor signals for each component cooling loop to ensure that proton beam cutoff would be initiated in the event of loss of cooling water flow. The amount of heat-up that can occur after the loss of flow and proton beam cutoff is small because of the relatively low power densities involved and because of the rapidity with which proton beam cutoff can be accomplished.

If automatic beam cutoff fails, the amount of time for operators to respond to abnormal indications depends on which component is under consideration. Components that are closer to the mercury vessel have higher power density and corresponding higher adiabatic heat-up rates. For example, the ambient (H_2O) moderator has the highest power density at about 12 kW/L for a beam power of 4 MW. Total loss of coolant flow to the ambient moderator at full beam power could, therefore, cause the temperature of the water inside to increase from the normal value (about 20°C) to 100°C in about 15 s. Longer times would apply for the other components because they, being further from the target mercury, have lower power densities. See Fig. 5.3-30 and Table 5.3-4 of the SNS CDR.

If the temperature in any component increased enough to cause boiling of the cooling water inside, the resulting pressure surge could cause failure of the component pressure boundary. This would release the component cooling water inside the core vessel. Loss of coolant system integrity is addressed in Sect. 3.9. If the proton beam were still not cut off after this point, the temperature of the component would continue to increase until a thermal equilibrium was reached. Extensive melting would not occur because the component would begin exchanging heat with the surrounding adjacent components and achieve thermal equilibrium before the melting point was reached. After the proton beam is cut off, active cooling is not needed by any component.

The failure modes discussed above are loss of cooling water flow in the primary cooling loop for each component. An event such as loss of deionized water system flow could affect several of the target components in the core vessel at the same time. Thus, the BP system will provide automatic cutoff of the proton beam. Nevertheless, tens of minutes would be available for the operator to respond to alarm annunciations associated with this problem because of the large thermal inertia provided by the volume of primary coolant in each loop. In its extremely unlikely conclusion, a loss of deionized water without proton beam cutoff would lead to loss of one or more component cooling loops, with source term as described in this section or in Sect. 3.9.

3.8.2 Estimated Frequency Range for Loss of Water Flow to Target Component Cooling Loop

The base event, loss of component cooling flow, is an anticipated event (2.5×10^{-2}/year < frequency < 10°/year), expected to occur during facility life. Compounding the base event with a failure of the automatic beam cut-off system(s) reduces the net sequence frequency to the unlikely range (frequency $<2.5 \times 10^{-2}$/year), or lower. Automatic beam cutoff in the event of loss of component cooling water is highly desirable from an operational point of view, but, in some cases, it is not clear that the loss of cooling water flow would cause component failure in a short period of time. Consequently, reliable beam cutoff will be provided (>99% probability of beam cutoff given occurrence of the loss of cooling water), but the degree of diversity and/or redundancy may be lower than is provided for other, more damaging events [e.g., ones that could escalate into a mercury spill event without prompt beam cutoff (see Sect. 3.4 and/or 3.5)]. In conclusion, loss of component cooling flow compounded by a failure of automatic beam cutoff is assigned to the unlikely event category. This is a very conservative assumption because components with a defined segmentation function (e.g., the proton beam window or the water-cooled shroud) will receive both TPS and BP coverage for automatic proton beam cutoff.

3.8.3 Source Term for Loss of Water Flow to Target Component Cooling Loop

There is no source term for the base event with automatic beam cutoff because there is no damage or release of material of any kind. If the automatic beam cutoff does not function, the operators may have time to initiate beam cutoff before damage. The possible source term for the extremely unlikely event with failure of automatic and manual proton beam cutoff is bounded by the source terms developed in Sect. 3.9 for loss of cooling water integrity in target component cooling loop.

3.9 LOSS OF H_2O OR D_2O INTEGRITY IN TARGET COMPONENT COOLING LOOP (ACCIDENT SEQUENCE 8)

There are four target cooling loops that will become activated during proton beam operation:

1. The proton beam window and moderator H2O cooling loop:
   - proton beam window
   - ambient moderator
   - cryogenic moderator

2. The D_2O cooling loop
   - Ni and Be reflectors
3. The shroud H_2O cooling system
   - target water-cooled shroud
4. The shield cooling H_2O cooling water loop
   - stainless steel shielding units

The pumps and heat exchangers for these systems are located in the utility vault, and the actual cooled components (listed above) are inside the core vessel.

3.9.1 Sequence of Events for Loss of Integrity of Component Cooling Loop

If there is a major loss of integrity in any component cooling water system, this would soon result in loss of cooling of the affected component. For possible thermal response, see the discussion in Sect. 3.8. If there is a minor loss of integrity, cooling of the component would continue to be effective as long as there is adequate inventory for circulation.

3.9.2 Estimated Frequency Range for Loss of Integrity of Component Cooling Loop

The base event, loss of component cooling integrity, is an anticipated event (2.5×10^{-2}/year <frequency < 10°/year) for the slow leak loss of integrity and would be an unlikely event (10^{-4}/year < frequency <2.5×10^{-2}/year) for the major failure loss of integrity. The low likelihood of major failure stems from the fact that these are low-pressure systems, with connections and leaktightness verified during installation before operation. However, since there are four of these systems, the major loss of component cooling loop integrity is assigned to the anticipated category.

3.9.3 Source Term for Loss of Integrity of Component Cooling Loop

The source term for a loss of coolant system integrity depends on the mode of failure and the location of the breach. For example, water spilled by a major failure outside the core vessel would, in general, tend to drain to sump tanks (in the utility vault except for the shroud-cooling system sump tank, which is inside the target hot cell) or floor sumps and thus not be available for evaporation and release. Nevertheless, the source terms developed for the major failure include a significant evaporation component. If the failure occurred inside the core vessel, the source term due to evaporation of water inside the warm core vessel would be as discussed below.

3.9.3.1 For slow leaks

The source term might not be sensitive to location (inside vs outside the core vessel) because such a leak outside the core vessel would evaporate before the leaked water reached the sump. The bounding source term for a slow leak would be one that causes a stack discharge rate that is high enough to exceed the allowable yearly total release (based on tritium) in a small fraction of a year (e.g., a week or a month). Since discharges are monitored, it is very unlikely that facility management would allow continued operation such that the yearly release limit would be exceeded. A source term is not specified because facility operations would be curtailed before the yearly release limit is exceeded.

3.9.3.2 For leak into core vessel

In the event of a cooling water leak or spill inside the core vessel, some fraction of the spilled water would evaporate and be carried off with the core vessel helium purge that is discharged to the target hot off-gas system (discharge point upstream from the demisters that are upstream from the HEPA filter banks). The evaporation rate would be limited by the rate of flow of the He purge that is supplied to the core vessel, (i.e., the ~10 m^3 free volume is replaced every ~100 h) (see Table 5.3-6 in the CDR. *Note*: post- CDR design work has resulted in an increase in core vessel diameter—from 2-m to 3.5-m, with a higher estimate of core vessel free volume—10 m^3 instead of 3 m^3). For the purposes of this analysis the nominal 10 m^3/100-h purge rate will be doubled to account for possible operational variation of the purge flow.

If the bounding assumption is made that the helium purge is saturated with water vapor at the temperature of the core vessel (which should average less than 55°C based on CDR information concerning cooling water temperatures, see Sect. 5.3.6), the release can be estimated conservatively, as follows:

- Helium discharge temperature: 60°C (based on the 55°C estimated maximum value)
- Helium discharge rate: 20 m^3/100-h (twice the current nominal design figure)
- Water vapor density: 0.143 kg of D_2O or 0.13 kg H_2O/m^3 @ 60°C (i.e., 100% humidity)
- Discharge rate (D_2O or H_2O, as applicable, based on the above three assumptions): 0.6 L/d

As a conservative assumption for environmental impact statement (EIS) studies, it is assumed that the discharge continues for a period of one month. This is very conservative because conditions inside the core vessel are monitored and water vapor is not an operationally desirable atmosphere for the core vessel, since radiolytic effects may lead to corrosion of components inside. The nuclides of interest for this source term are tritium (H-3) and gaseous nuclides such as N-13, N-16, and O-15. As a practical matter, the release of the N and O nuclides would be nil because they are dissolved in the cooling water and would decay before being released. Any radioactive ions in the coolant would not be transported with the evaporated water, and insufficient other agitation or energy sources are present to create a vapor fog/aerosol that would be transported to the environment.

As developed above, the bounding release is 0.6 L/d for 30 days, for a total of 18 L of water evaporated and released to the environment. The nuclide of primary interest is tritium, and it will be in the form of HTO and T_2O. The coolant loop with highest tritium content determines the maximum tritium release. That most tritiated loop is the D_2O coolant loop that circulates through the reflectors. The tritium content is estimated at less than 5 Ci/L after equilibrium 4-MW operation is achieved. The maximum tritium source term is, therefore, 90 Ci of tritiated water vapor released over a 30-d period.

The light water component cooling loops will also have tritium contamination, but at much lower concentrations than the end-of-life concentrations in the heavy water coolant loop—because they are light water and thus have much less deuterium (which becomes tritium upon absorption of a neutron), and because the light water systems are replenished with new coolant several times per year. The tritium concentration for activated light water cooling systems is estimated not to exceed 0.5 Ci/L, based on the lower production rate of tritium and periodic replenishment of the H_2O, resulting in a 9 Ci source term for evaporation of the same (18-L) volume of water.

3.9.3.3 For rapid, worst case leak into target hot cell or utility vault

The other type of leak would unfold rapidly because the leak rate would be too large for operation to continue for more than a few minutes, at most, forcing a shutdown for repair of the leak. For a bounding analysis it is assumed that the leak occurs near the pump outlet where the pressure is highest, so that the water is propelled out over a wide area of the enclosure in which it occurs [e.g., the target hot cell, the pipe chase, the target shielding enclosure, or the utility vault (inside the core vessel covered above)]. This is a very conservative assumption because the piping is typically located inside a pipe chase or trench or is behind shielding (provided to allow limited entry to the utility vault during operation). The source term for the bounding analysis would include two contributors: the water vapor that evaporates from the puddle over the floor and the small random droplets of water (e.g., formed if the leak hits an obstruction) that could be entrained in the ventilation system flow. The balance of the spilled water would gravity drain to a sump tank.

For bounding analysis, the puddle area is taken as the maximum floor area that could be wetted by any one pipe breaking in either the target hot cell or the utility vault, estimated at 50 m^2, and the puddle depth is assumed to be 3 mm, a value consistent with water lying on a flat floor. The puddle depth is limited by the surface tension of water; large floor areas cannot be flooded to greater depths because of gravity drainage to trenches and/or sump tanks. The mist contribution is assumed to be 1% of the spilled water—about 15 L (note: the total spill volume is taken to be 1500 L, but the puddle volume is limited to 150 L because of the limited floor area). The 1% mist fraction assumed here is greater than assumed for pressurized water/solution spills in the *Final EIS for the Safe Interim Storage of Hanford Tank Wastes* (DOE/EIS-0212, October 1995), and is thought to be conservative because the water pressure in these loops is relatively low (only a few atmospheres) and because the air velocities are not high in either the target hot cell or the utility vault. The amount of water becoming airborne is thus

Puddle evaporation: 150 L of H_2O or D_2O
Mist entrainment: 15-L of H_2O or D_2O

The tritium source term associated with these losses is calculated based on a concentration of 5.0 Ci/L for the D_2O cooling system and 0.5 Ci/L for the H_2O cooling systems. The source term associated with the mist entrainment depends (except for the tritium releases) primarily on how much credit is taken for the HEPA filters. If no credit is taken for the HEPA filters, then any radioactive solids or ions present in the entrained mist would be released. For conservatism, it is assumed here that the HEPAs do not function, so that the whole 15 L of H_2O or D_2O is released to the environment. The nontritium radionuclide content is estimated by modeling this as low-level liquid waste (LLLW, which is composed of used coolant); thus, the release is found by multiplying the nuclide inventories specified in List 8 of Exhibit E for 1-MW operation and a total volume of 800 gal of LLLW by the factor 15/(3.78*800) = 4.96E–3. The tritium content is determined from the same concentrations used to estimate the puddle evaporation source term. The mist release occurs over the time scale consistent with the residence time of ventilation air in the room and ducts, greater than 5 min. The puddle evaporation can occur no faster than air can carry away the water from the puddle. Air at 90°F (summertime exhaust temperature) that is saturated at 100% humidity could hold about 38 g D_2O/m^3, so the 125 m^3/min (4400 cfm) of utility exhaust flow could, theoretically, transport 4.25 kg/min of D_2O. Thus, it would take at least 35 min for the 150 L of D_2O to evaporate.

In addition to the tritium released by this event, some fraction of the gaseous radionuclides dissolved in the coolant could be released, with the bounding assumption being the immediate release of 100% of these gases to the interior space or cell in which the coolant pipe break or leak occurs. Since the residence time of air in the cells is greater than 5 min, it would take at least that long to sweep the released gaseous nuclides to the environment through the target facility ventilation exhaust stack. It is appropriate to take credit for this delay because the assumption of 100% immediate release into the indoor space is very conservative for release of dissolved gases from a low-pressure coolant system from which the immediate release would be less than 50%, with the balance requiring considerable time for the dissolved gases to diffuse out of the water. The shroud-cooling water system generates the greatest quantity of radioactive gases, and this source term (Table 3.6) can be applied conservatively to all the target cooling water release accidents.

Table 3.6. Target shroud cooling water system gaseous radionuclides inventory
[Given numbers are for 1-MW operation—multiply by 4 to get 4-MW numbers.]

Radionuclide	Half life	Inventory for 1-MW continuous proton beam operation for 1 year (Ci)	Stack release after 5 min delay (Ci)
N-13	598 s	155	109
N-16	7 s	124	0
O-14	70 s	56	6.4
O-15	122 s	786	143

s-seconds.

Source terms for the loss of cooling system integrity events can be summarized as below. The results are expressed in a manner to allow convenient bracketing of the estimated releases between that consistent with the initial 1-MW proton beam operation and the eventually planned 4-MW beam operation. The reason for listing the worst case water spill event as an anticipated event for the H_2O cooling systems is that there are three such systems (or more, considering the beam stop cooling systems—see discussion, below), which means that even though the estimated frequency of occurrence might be in the unlikely category for any one system, the aggregate frequency for three systems will probably exceed the 0.025 per year threshold for the anticipated category, considering that there are three such systems (specific design data nor currently available will be required for quantitative estimates of the failure frequencies).

Anticipated event: D_2O cooling water system (line break in utility vault)
Tritium: 750 Ci as DTO or T_2O (0.5 h-release period; bounds 4-MW operation)
Gases: See Table 3.6 (5-min release period; multiply by 4 for 4-MW operation)
Mist: 75 Ci of tritium plus 0.005 times List 8, Exhibit E (5-min release period)
(multiply List 8 by 4 for 4-MW operation)

Anticipated event : D_2O cooling water system (leak in core vessel)

Tritium: 90 Ci as DTO or T_2O (30 d-release period; bounds 4-MW operation)
Gases: negligible (decay before release)
Mist: none

Anticipated event: any of three H_2O cooling water systems (line break in utility vault)
Tritium: 75 Ci as HTO or T_2O (0.5 h-release period; bounds 4-MW operation)
Gases: See Table 3.6 (5-min release period; multiply by 4 for 4-MW operation)
Mist: 7.5 Ci of tritium plus 0.005 times List 8, Exhibit E (5-min release period) (multiply List 8 by 4 for 4-MW operation)

3.9.4 Beam Stop Cooling Water Line Breaks

Three beam stops are to be installed for the original construction and two more (beam injection and beam extraction) will be installed when the second ring is built for the upgrade to 4-MW operation. The ring injection beam stop for each ring will operate continuously at maximum power of 200 kW (during normal beam operation the estimated continuous dumped power is only 40 kW, so the 200 kW is a bounding number). The other beam stops operate at lower power and/or are used intermittently. The injection stops thus have the largest radioactivity inventories. The line break events for the beam stop H_2O coolant systems are very similar to those considered above for the target cooling systems. Since their HEPA-filtered ventilation exhaust is routed to the target station ventilation exhaust path for discharge to the environment by the target stack, and since the maximum beam dump source terms are bounded by the target facility cooling water spill accident source terms, there is no need to do a separate consequence analysis for beam stop coolant accidents.

3.10 LOSS OF INTEGRITY OF CRYOGENIC MODERATOR (ACCIDENT SEQUENCE 9)

The cryogenic moderator system circulates an ~1.5 kg inventory of ~20 K hydrogen through cryogenic moderator vessels located in the core vessel above the water-cooled shroud and back to helium-cooled heat exchangers and pumps located in the safe room, which is located on the floor level of the high bay above, and to the west of, the target hot cell. Under abnormal conditions, or for system shutdown, the cryogenic hydrogen is allowed to heat up and expand into a 4500-L expansion tank (which is located outdoors). As described in Sect. 5 of the CDR, the safe room houses the active components of the system—pump, valves, heat exchanger. The safe room is so called because of special safety features, including explosive-rated (nonsparking) electrical equipment, hydrogen detection, and special ventilation. The safe room is not normally occupied. When personnel are present, hydrogen safety protocols will be followed.

3.10.1 Sequence of Events for Loss of Cryogenic Moderator System Integrity

The cryogenic moderator is maintained under multiple barriers both for safety and for cryogenic insulation reasons. The innermost tubing is surrounded by vacuum for insulation, and the vacuum is surrounded by a helium barrier for safety. The vacuum and He barriers are continuously monitored for any loss of integrity. The sequence of events for a leak would depend on where the loss of integrity occurred and how many of the barriers were compromised (see also events 9.A, 9.B, 9.C in Table 3.2). If only the primary boundary fails, the hydrogen escapes into the vacuum system, which is vented safely. If all boundaries fail, the hydrogen is released to the immediate surroundings of the failure.

Combustion is not likely in any potential release location. Release of hydrogen into the core vessel would not involve combustion because a helium atmosphere is maintained inside the vessel. Release of hydrogen in the safe room could possibly involve combustion in this relatively small space; however, the hydrogen concentration is continuously monitored, and the safe room ventilation rate increased upon detection of airborne hydrogen. This automatic detection and accompanying actuation of a ventilation flow increase is designed to prevent combustion upon any credible hydrogen leak inside the safe room. An accompanying alarm would cause personnel present in the safe room to evacuate immediately. Credible leakage from the 4500-L expansion tank would be unlikely to lead to combustion because of the tank's outdoor location.

3.10.2 Estimated Frequency Range for Loss of Cryogenic Moderator System Integrity

Since cryogenic line and system connections are tested before use with hydrogen, failure is not an anticipated event. Monitoring of the vacuum and helium barriers during normal operation should catch any developing leaks in the early stage, making sudden, gross failures that occur during operation of the cryogenic system extremely unlikely events.

The hydrogen moderator vessel is positioned close outside the mercury vessel, but the close-fitting collimator (in the transfer tunnel upstream of the proton beam window) and the proton beam passages in the reflector plugs prevent beam directional and/or focus control failures from allowing the beam to strike the hydrogen moderator vessel.

3.10.3 Source Term for Loss of Cryogenic Moderator System Integrity

There is no source term of interest because calculations show that there is essentially no activation of the hydrogen. Combustion is a potential consequence, as discussed above, but this combustion would not initiate the release of radioactive material because the air-atmosphere locations that could receive such a leak (e.g., the safe room, the outdoor expansion tank) are not close to any other radioactive material. The accident sequence discussion provided above is for the purpose of pointing out how the accident potential for combustion of hydrogen has been considered in system and facility design. The design features and administrative controls that will be followed should make the risk of personnel injury due to combustion very small.

3.11 LOSS OF INTEGRITY: CORE VESSEL, 3.5-M DIAM TARGET CONTAINMENT VESSEL (ACCIDENT SEQUENCE 10)

3.11.1 Sequence of Events for Loss of Core Vessel Integrity

The core vessel helium atmosphere is maintained at or below atmospheric pressure. There is essentially no pressure stress, making failure probability low. The low pressure tends also to make the loss of vessel integrity a benign event. The helium atmosphere is monitored because it is desired to exclude air for two reasons: to maintain an inert atmosphere as a safety precaution against hydrogen leakage inside the vessel and to maintain an atmosphere that will have much lower activation/spallation because of the passage of the proton beam through it than would other atmospheres (e.g., air).

3.11.2 Estimated Frequency Range for Loss of Core Vessel Integrity

Loss of integrity of a vessel that is not highly stressed would be an unlikely event.

3.11.3 Source Term for Loss of Core Vessel Integrity

Considering that this is an unlikely event, leakage of the vessel's slightly radioactive atmosphere would be of minimal interest for consequence analysis.

3.12 LOSS OF HE FLOW TO CORE VESSEL (ACCIDENT SEQUENCE 11)

3.12.1 Sequence of Events for Loss of He Flow

Loss of the helium purge flow would be unlikely to result in a significant source term because the He inlet flow and core vessel atmosphere are both monitored, allowing detection of the loss of He flow before air has time to diffuse into the vessel.

3.12.2 Estimated Frequency Range for Loss of He Flow

Anticipated.

3.12.3 Source Term for Loss of He Flow

Considering the unlikelihood of such an event developing into a significant release and the resistance of helium to activation, no source term is specified for this event.

3.13 TARGET CELL VENTILATION SYSTEM FAILURES (ACCIDENT SEQUENCE 12)

3.13.1 Sequence of Events for Target Cell Ventilation System Failures

Various target cell ventilation system failures could be postulated. For example, the power supply to the cell ventilation system blowers could fail or the blowers could fail. Without blower operation, the target cell pressure, normally maintained lower than atmospheric pressure, would equilibrate with the ambient pressure outside the cell. Contamination could then begin to diffuse out of the cell through any imperfections in the cell boundary. Reestablishment of power to the blowers or repair of the blowers would restore the cell's normally negative pressure.

It could be postulated that a target cell ventilation system HEPA filter might fail, initiating a period of higher than normal radioactivity in the target system ventilation exhaust. The higher than normal stack discharges would be detected, and actions would be initiated as needed to correct the situation.

3.13.1.1 Frequency of occurrence for target cell ventilation system failures

Mishaps such as a loss of blower power are anticipated to occur during the facility lifetime. A HEPA filter could be improperly seated during installation, but post-installation testing conducted to confirm proper seating would make this unlikely. Spontaneous failure of a HEPA filter would be unlikely. The installed instrumentation and preventive and periodic maintenance make prolonged or undetected ventilation system failures unlikely.

3.13.1.2 Source terms for target cell ventilation system failures

There are no source terms of particular interest beyond the immediate confines of the facility. This is because high levels of airborne radioactivity inside the target hot cell are not necessary nor are they expected during normal operation of the hot cell. The radiological health protection and contamination control measures employed at the facility are adequate to protect the workers within the confines of the facility. These measures include ventilation system monitoring, air sampling, routine surveys, as well as administrative controls.

3.14 LOSS OF OFF-SITE POWER (ACCIDENT SEQUENCE 13)

Loss of off-site power would immediately cut off the beam because the linac and ring magnets must be powered in order to maintain a beam on the target. Since the mercury decay heat level (~9.6 kW after continuous 4-MW operation) is only about 0.25% of the full beam power, the decay heat removal requirements of the target facility are not demanding. For example, the mass of the target mercury combined with the relatively low decay heat means that forced circulation is not required for decay heat removal. Therefore, the loss of off-site power puts the target into a safe state in which any decay heat present is removed by passive means.

Loss of off-site power would cause a loss of target hot cell ventilation, which is discussed above in Sect. 3.13. Diesel-backed power is provided. In the event of a prolonged power outage, the diesel generator would be started to power loads like the ventilation system blowers.

There is no accident-related source term of particular interest for loss of off-site power.

3.15 FIRE (ACCIDENT SEQUENCE 14)

Fire safety is discussed in Sect. 9.2.4.1 of the SNS CDR. As stated there, the SNS facility does not involve large accumulations of particularly hazardous flammable materials. Furthermore, smoke detector systems, sprinklers, and ventilation system features that can be controlled by fire fighters for smoke control purposes are provided. It is planned to do a fire-hazards analysis under the guidance of DOE Order 420.1 during Title 1 Design. For this reason, detailed analyses of fire hazard scenarios have not been conducted at this stage of the project.

3.16 NATURAL PHENOMENA—TORNADO AND SEISMIC (ACCIDENT SEQUENCE 15)

As outlined by Table 8.4-2 of the SNS CDR, the SNS facilities have been categorized in accordance with the DOE natural phenomena performance categories for the application of the appropriate levels of seismic and wind conditions. The target building is considered to be PC-2, which is consistent with a once per 1000 years seismic event. Safety-related systems would be expected to survive or at least perform their designated safety function(s) before failing during and after a PC-2 level seismic or wind event. Thus, a significant release of radioactive material would not be expected for an unlikely natural phenomena event.

A seismic event more severe than the design level could act as an initiator for any of the events considered in Sects. 3.2 through 3.14. The resulting source term would not be different because it was initiated by a natural phenomenon; thus, the source term would also be bounded by those evaluated in Sects. 3.2 through 3.14. The frequency of such failure initiation would be low because the system is basically designed for a 10^{-3}/year level of event without significant source term. It is concluded that natural phenomena will not significantly increase either the frequency or magnitude of SNS source terms. Therefore, special natural phenomena source terms are not recommended for detailed calculation and study in the EIS.

3.17 BEYOND DESIGN-BASIS ACCIDENTS (ACCIDENT SEQUENCE 16)

The purpose of postulating these events is to determine if any risk significant source terms are present in the probability range somewhat below the 10^{-6} /year cut-off frequency used for design-basis events. The criterion selected for a BDB event selection is that the estimated frequency should be greater than 10^{-8}/year but less than 10^{-6}/year.

Table 3.7 lists the target facility accidents considered in this chapter and considers additional failures that could result in increased source terms. The results show that the mercury spill event (Sect. 3.3) and the loss of mercury circulation pump events (Sect. 3.4) provide the most significant additional source terms for residual risk evaluation. One source term that bounds both the 3.3 and the 3.4 BDB accident sequences (and also the other BDB events screened) is derived in Exhibit F. The source term is summarized below in Table 3.8.

Table 3.7. Screening for selection of limiting beyond-design-basis accident

Initiating event and section of report where considered as design basis event	Additional failures	Approx. annual probability level	Consequence assessment
Note: no sequences are postulated involving the failure of all automatic proton beam cutoffs. There are three separate automatic cut-off systems: the target protection system (TPS), the beam permit/pulse enable (BP) system(s), and the personnel protection system (PPS) that can initiate cutoff of the beam. Accident sequences with the assumption that all these fail simultaneously have annual probability below the 10^{-8}/year cutoff.			
3.2 Proton beam excessive focus density	In the worst case , this event leads to a Hg spill event. Thus, considerations under 3.3 (below, in this table) cover this event		
3.3 Hg spill	BP + TPS + mercury enclosure Hg drainage path + water-cooled shroud	$>10^{-8}$/year (but $\leq 10^{-6}$/year)	Short period of boiling of Hg may occur before PPS beam cutoff, depending on Hg spill rate. Short and long term Hg, I releases (see Exhibit E)
3.4 Loss of Hg pumping	BP + TPS + mercury enclosure Hg drainage path + water-cooled shroud	$>10^{-8}$/year (but $\leq 10^{-6}$/year)	Short period of bulk boiling of Hg may occur before PPS beam cutoff. Short and long term Hg, I releases (see Exhibit E)
3.5 Loss of Hg cooling water flow	BP + TPS + operator (>2 min available for manual beam cutoff)	$>10^{-8}$/year (but $\leq 10^{-6}$/year)	Bounded by the source term derived for 3.3 and 3.4. Additional failures (e.g., of the mercury enclosure Hg drainage path and/or water-cooled shroud would bring this event below the 10^{-8}/year screening criterion)
3.6–3.9 Loss of component cooling water, various combinations	BP + TPS + operator	$>10^{-8}$/year (but $\leq 10^{-6}$/year)	Overheating of the uncooled component. Worst case could lead to failure of water-cooled shroud and Hg spill. Bounded by 3.3/3.4 BDB event
3.10 Loss of integrity of cryogenic moderator	Core vessel relief valve and/or burst disc	$<10^{-6}$/year	Overpressurization of core vessel, release of He/H_2 mixture to shielding cavity. Negligible He/H_2 transport to hot cell. Combustion possible in shielding cavity or inside core vessel after long times (to allow air to diffuse in). No enhanced Hg source term. Consequences bounded by 3.3/3.4
3.11 Loss of core vessel integrity [seal(s) bad] + 3.12 loss of core vessel He purge flow (extended)	Loss of cryogenic moderator integrity postulated to occur at same time when core vessel atmosphere is mostly air, and the proton beam is on	$>10^{-8}$/year (but $\leq 10^{-6}$/year)	Combustion of H_2 inside the core vessel, failure of core vessel at weak points (e.g., the neutron beam windows). Conceivably could cause failure of the water-cooled shroud and the Hg vessel, with Hg spill, but not excessive Hg temperature. Source term bounded by BDB event for 3.3/3.4

Table 3.7 (continued)

Initiating event and section of report where considered as design basis event	Additional failures	Approx. Annual Probability Level	Consequence assessment
3.13 Target cell ventilation system failures	As noted in Exhibit F and other sections of this chapter, for an Hg spill accident that occurs in conjunction with ventilation system failure, the release source term would be lower because there would be much weaker mechanism(s) for transporting mercury vapor to an atmospheric release point		
3.14 Loss of off-site power	There are no significant source terms in this category because a loss of off-site power results in essentially immediate, inherent termination of the proton beam, and because the post-operation decay heat level does not require active cooling to prevent damage		
3.15 Fire	Fire could result in destruction of wiring, resulting in the long-term outage of cooling pumps and/or other active equipment. However, the TPS is designed to be fail-safe, so that loss of TPS wiring insulation integrity resulting from a fire would be expected to cause automatic shutdown of the proton beam. The SNS decay heat level (10 kW immediately after beam cutoff from 4-MW operation) is such that active cooling is not required for decay heat removal		
3.16 Natural phenomena—beyond-design-basis wind event	Roof level ventilation equipment + facility stack(s) + cooling towers	$>10^{-8}$/year (but $\leq 10^{-6}$/year)	Damage to Hg system equipment inside the heavily shielded hot cell or the core vessel would be very unlikely. The damage to outside systems could lead to higher than normal releases due to loss of a filtration stage, etc., but not a source term of interest in the BDB context
3.16 Natural phenomena—beyond-design-basis earthquake	Any active system could be failed	$>10^{-8}$/year (but $\leq 10^{-6}$/year)	Could cause loss of cryogenic H_2 moderator integrity, and subsequent combustion could cause Hg spill, but the combustion would not be in the hot cell. The Hg releases from the Hg spill would not be greater than presented for U or EU events because automatic beam cutoff would be highly likely for two reasons: (1) the TPS has fail-safe design so that loss of signal causes beam trip and (2) extreme earthquakes tend to cause loss of off-site power that would terminate the proton beam

Table 3.8. Beyond-design-basis accident source term summary-bulk mass fractions released

Radionuclide category	Fractional release of total inventory		
	Short term (~10 min)	First 7 d	7 d to 30 d
1-MW target configuration—fractional releases			
Mercury	6.6E–5	0.8E–2	3.0E–3
Iodine	1.40E–1	2.0E–1	6.6E–1
Nonvolatile solids	Negligible	Negligible	Negligible
4-MW target configuration—fractional releases			
Mercury	1.83E–3	0.8E–2	3.0E–3
Iodine	1.4E–1	2.0E–1	6.6E–1
Nonvolatile solids	Negligible	Negligible	Negligible

Note: For initial Hg and I radionuclide specific activities, see Table 3.4.a. Release fractions for shorter-lived radionuclides would be smaller than the bulk mass fractions indicated above provided that the release period is long in comparison to the half-life of the radionuclide.

3.18 REFERENCES

1. Computationally-Compatible Component Database Release 0.0, New Production Reactors Program, Reliability, Availability, Maintainability and Inspectability, Engineering Technology Division, Department of Nuclear Energy, Brookhaven National Laboratory, Upton, New York, April 1990.

4. SNS WASTE SYSTEMS ACCIDENT SCENARIOS AND SOURCE TERMS

SNS Waste Systems Description

SNS wastes consist of gaseous, liquid and solid components. Wastes are collected in the appropriate system within the facility and transferred to ORNL for processing or are packaged for off-site disposal. Accidents were analyzed only for the gaseous and liquid waste systems because these systems offer the greatest potential for radionuclide release to the environment.

Gaseous Wastes

The HVAC system will collect off-gases from systems that generate radioactive or potentially radioactive gases and discharge them to two central stacks after final filtration and radiation monitoring. The Gaseous Waste System is located between the mercury target off-gas (i.e., primarily the helium purge flow that maintains the helium atmosphere in the mercury reservoir) and the HVAC system and serves to remove mercury, noble gases, iodine, and tritium from this off-gas stream. The system consists of a chilled condenser to return mercury back to the target system, a liquid nitrogen cooled charcoal bed to remove xenon and iodine, and a circulating hydride bed system for the removal of tritium. The charcoal adsorbs the xenon and iodine spallation products and holds them for decay. It also removes any mercury that is not removed by the mercury condenser. The Tritium Removal System consists of a uranium metal bed and a circulation pump. The helium exiting the charcoal absorber system is passed through this system, and is discharged to the HVAC system.

Another system to process gaseous wastes is a set of decay tanks and a compressor for off-gas from the target, moderator, reflector, and beam stop cooling systems. During shutdown for maintenance, these cooling systems are vented. The compressors compress the vented gases into the decay tanks, where they are held for the decay of the short-lived isotopes.

Liquid Wastes

Liquid wastes from the SNS are characterized in four broad categories: low level liquid, process liquid, hazardous and conventional. Accidents concerning the hazardous and conventional wastes were not analyzed because they were thought to present significantly lower hazards that the other two categories.

The low level liquid wastes are collected from the linac, transfer line, ring, target and beam stop cooling water systems, from the target and other cells, and from the radioactive target ventilation systems. The LLLW system in the tunnels consists of a series of piping headers and a central collection tank. The waste in this tank is pumped to another set of storage tanks located in the Target building, where it is combined with target building LLLW. The waste will be pre-treated as necessary before it is transferred to a load-out station and to a 1000-gallon DOT-certified tank truck, which will transport it to the ORNL LLLW evaporator for further processing.

Process wastes are collected from clean and buffer area building floor drains, cooling water system leakage, building HVAC condensate, central services building ion exchange regeneration solutions, and groundwater in-leakage from tunnel French drains. The process waste system consists of a series of sumps, sump pumps and collection headers leading to a diversion tank system where the waste is monitored for radioactivity. Waste that exceeds a pre-set limit will be diverted to the LLLW collection system, otherwise the waste drains by gravity drainage to a set of storage tanks, from where it is transported to the ORNL treatment facilities in a 3000-gal truck tanker.

Listed below are accident scenarios for the SNS waste systems. This suite of accidents is based in nuclide inventories calculated with a beam power of 1 MW. These inventories are given by the ORIHET-calculated activity inventory at 30 years continuous irradiation, which is equivalent to 40 years of facility operation. To obtain source terms for higher power levels, these activities should be multiplied by the appropriate factor (e.g., 2 or 4) depending on the power level desired. The calculations of the source terms for these accident sequences are contained in the Excel 97 spreadsheet “SNS Waste Accident Source Terms 5 Rev 4.” The resulting source terms are presented in Exhibit E.

4.1 FAILURE TO REMOVE MERCURY FROM OFF-GAS

4.1.1 Mercury Condenser Failure (Event Sequence 17)

4.1.1.1 Sequence of events for mercury condenser failure

The mercury condenser serves to remove mercury from the helium purge applied to the mercury loop through the pump seal. The condenser is served by a refrigerated cooling system, which is operated at a temperature of –20°C. Operating at this temperature reduces the vapor pressure of mercury in the stream outlet to the maximum extent possible, without freezing. The charcoal absorber downstream of the condenser functions as a polishing filter for the removal of all traces of mercury before entering the rest of the off-gas treatment system and also serves as a backup to the condenser. This event is initiated by a failure of the cooling system to the mercury condenser.

4.1.1.2 Frequency range for mercury condenser failure

The frequency range for mercury condenser failure is an anticipated event, since no additional reliability enhancement requirements will be placed on the refrigeration system.

4.1.1.3 Source term for mercury condenser failure

The source term is calculated as the quantity of mercury that would exit the condenser under a 1 L/min flow, at the maximum temperature of the mercury loop (110°C). See Exhibit E, list 6 for the accident source term. Since the helium is added to the pump seal, it is a good assumption that the He is saturated with mercury. Therefore, the vapor pressure of mercury at this temperature is 0.56 torr (relationship between temperature and vapor pressure from the CRC handbook, p. D-212), and the resulting mercury flow is 0.0047 g/min (calculated with the ideal gas law). The mercury specific activity is given by the ORIHET-calculated activity inventory of the mercury at 30 years continuous irradiation at 1-MW beam power (equivalent to 40 years of operation), assumed to be uniformly distributed in the 1-m^3 mercury volume. This, when multiplied times the calculated flow, gives the activity release past the condenser. No plate-out or removal of mercury in the off-gas or ventilation system is conservatively assumed, since the charcoal absorber is also assumed to be ineffective, in order to bound the source term. The duration is estimated to be 48 h, or the time required for repair of the refrigeration system.

4.1.2 Mercury Charcoal Absorber Failure (Event Sequence 18)

4.1.2.1 Sequence of events for mercury charcoal adsorber failure

A design study is presently underway to determine if charcoal filtration is required for the cell ventilation system. These sulfur-impregnated charcoal adsorbers would be for final removal of mercury from the target cell ventilation air. This accident sequence assumes that the adsorbers are improperly installed or are not changed on a timely basis, and the mercury detector in the ventilation stream fails, causing mercury to exit the ventilation system.

4.1.2.2 Frequency range for mercury charcoal adsorber failure

The frequency range for mercury charcoal adsorber failure is that of an unlikely event. The principal failure mode for this component is saturation, and downstream mercury detectors would detect breakthrough of the adsorbers and permit shutdown of the system for replacement of the adsorbers before any significant loss of mercury could occur. This detector is assumed to fail. Detection is assumed to occur with the SNS stack detectors, and 10 d is estimated to be required to change the mercury adsorbers.

4.1.2.3 Source term for mercury charcoal adsorber failure (Event Sequence 2)

The source term is calculated based on a mercury release to the target cell, which is anticipated to occur every time the target end is changed. The total quantity of mercury estimated to be spilled is 10 cc, and it is assumed to be transformed into droplets of 1-mm diam. This is assumed to evaporate at a rate of 2.5 g/m^2 surface area per day. If the adsorbers were not functioning, the entire spill quantity could be ventilated out of the cell in 900 d. This means that there is a net accumulation of mercury in the target cell, equal to 900/365 × 4 target changes/year × 10 cc/change = 98.6 cc of mercury present in the cell at any one time. Cleanup of the released mercury is ignored. See Exhibit E, list 7 for the accident source term.

Note: This source term is the same as the routine release would be if the charcoal adsorbers were not present in an untreated cell air scenario.

4.2 FAILURE TO REMOVE TRITIUM FROM OFF-GAS

4.2.1 Helium Circulator Failure (Event Sequence 19)

4.2.1.1 Sequence of events for helium circulator failure

The tritium removal system consists of a getter bed with a helium circulator. Because the tritium concentration in the helium is expected to be low, the circulation rate must be large relative to the helium flow of 1 L/min. In order to provide positive off-gas relief, the system has fail-open and fail-closed valves, which bypass the tritium removal system upon detection of loss of helium flow from the circulator. This event is initiated by circulator failure, causing the loss of flow and the bypassing of the tritium removal system. This would result in the loss of tritium removal capability until the circulator could be repaired.

4.2.1.2 Frequency range for helium circulator failure

The frequency range for helium circulator failure is an anticipated event, since the helium circulator is not intended to be redundant.

4.2.1.3 Source term for helium circulator failure

The only isotope affected is tritium, and the loss of tritium removal results in the discharge of 0.46 Ci/h of tritium as triated hydrogen (HT) (the annual mercury target production of 4012 Ci/year expressed on a per hour basis). This release rate is conservative since hydrogen removal by hydriding with impurities within the mercury loop is ignored. Spallation product impurity hydriding could remove a significant fraction of the hydrogen isotopes produced. The duration of the outage is one day because the helium circulator would be designed for a direct change-out and should be relatively easy to replace.

4.2.2 Oxidation of Getter Bed (Event Sequence 20)

4.2.2.1 Sequence of events for oxidation of getter bed

The getter bed consists of a container filled with uranium metal. Hydrogen isotopes flowing over the uranium react with it to produce uranium hydride, effectively removing them from the gas stream. Oxidation of the uranium could occur over a period of time, such that the uranium surface was coated with uranium oxides, and tritium absorption rates would be greatly reduced. This effect is assumed to affect the getter bed such that it ceases to absorb tritium.

4.2.2.2 Frequency range for oxidation of getter bed

The frequency range for getter bed oxidation is considered unlikely, because of the general lack of oxygen in the helium atmosphere of the mercury off-gas system.

4.2.2.3 Source term for oxidation of getter bed

The source term is the same as in Sect. 4.2.1 above, and results in the discharge of 0.46 Ci/h or 4012 Ci/year of tritium as HT. The duration of the event is assumed to be 24 h, because the bed is designed to be easily replaceable.

4.3 RELEASE OF STORED RADIOACTIVITY

4.3.1 Failure of Getter Bed (Event Sequence 21)

4.3.1.1 Sequence of events for failure of getter bed

The getter bed is heated to remove the tritium from it for storage on an annual basis. Overheating of the getter bed is assumed to cause it to rupture, resulting in combustion of the pyrophoric metal in the bed and a release of the tritium contained in it as tritiated water (HTO). The bed would be designed for a pressure greater than its operating pressure and would have a redundant temperature control system.

Frequency range for failure of getter bed. The frequency range of failure for getter bed failure is extremely unlikely, since a catastrophic boundary failure would be required to allow free contact of oxygen to the getter bed.

Source term for failure of getter bed. Since the bed can contain up to one year's production of tritium before the tritium is removed, a source term of 4,000 Ci is expected. The duration of the event is considered to be one hour because of the required diffusion of tritium from the ruptured bed to the cell atmosphere. In addition to tritium, the oxidized uranium is a source of particulates. It is assumed that 10% of the 2 kg of uranium contained in the bed is fine particulate and is exhausted to the cell ventilation.

4.4 FAILURE TO TREAT OFF-GAS

4.4.1 Cryogenic Charcoal Absorber (Event Sequence 22)

4.4.1.1 Sequence of events for cryogenic charcoal absorber failure

Because the mass of xenon and iodine isotopes is small, an alternative method of hold-up for decay other than storage in compressed gas form is being considered. These short-lived isotopes can be absorbed on charcoal at liquid nitrogen temperatures. Since the mass is so small, replacement of the charcoal should be infrequent, and retention of the isotopes should be essentially 100% allowing for 100% decay. Such a method could have significantly reduced emissions while at the same time is more reliable and less expensive. This system consists of a charcoal absorber column cooled with liquid nitrogen. This option is currently under study.

Loss of liquid nitrogen cooling would reduce significantly the effect of charcoal for the absorption of short-lived xenon and iodine. This would result in the release of a significant portion of the off-gas undecayed. An option exists for holding the off-gas in the compressed gas storage for later release, but is assumed to be unavailable.

Frequency range for cryogenic charcoal absorber failure. The frequency range for failure for cryogenic charcoal absorber failure is in the unlikely range, since reliability enhancements to the cryogenic cooling system are anticipated. In addition, charcoal has an affinity for both xenon and iodine at room temperature, although at a reduced capacity.

Source term for cryogenic charcoal absorber failure. The source term is calculated based on ORIHET calculations of the production of volatile isotopes from the mercury target. Very short time steps (10 s) were used in the ORIHET calculations for the mercury and activated air to estimate the production rate instead. In calculating the off-gas from the mercury, consideration was also given to decay of the xenon isotopes to iodine using the Bateman equation to calculate the equilibrium daughter distributions. The xenon produced is assumed to be removed as soon as it is produced, and the off-gas produced was assumed to be vented with short period decay. See Exhibit E, list 1 for the source term. The duration is 24 h because of the ease of repairing the liquid nitrogen cooling.

4.5 OPERATOR ERROR

4.5.1 Tritium Release from Removal System (Event Sequence 23)

4.5.1.1 Sequence of events for tritium release from removal system

An operator is assumed to commit a valve sequence error when transferring one year's accumulation of tritium for recovery. It is assumed that the material is discharged through a vacuum system to ventilation and then to the stack on a short-term basis.

Frequency range for tritium release from removal system. The frequency range for a general operator error is anticipated, but the frequency range for this particular accident sequence is unlikely. This is because the control system will contain interlocks to prevent this accident, which would have to fail before this accident could happen.

Source term for tritium release from removal system. The source term is the same as in 4.3.1 above, or 4,000 Ci tritium as HT. No absorption in the vacuum pump is anticipated. The duration of the event is 20 min because the evacuation of this volume is estimated to be approximately this long.

4.5.2 Release of Off-Gas from Decay Tank (Event Sequence 24)

4.5.2.1 Sequence of events for release of off-gas from decay tank

An operator is assumed to commit a valve sequence error, resulting in sudden loss of the contents of one off-gas tank to cell ventilation system. Although this is a routine discharge, the operator is assumed to release the wrong tank. The tank released is assumed to have recently been filled.

Frequency range for release of off-gas from decay tank. The frequency range for a general operator error is anticipated, but the frequency range for this particular accident sequence is unlikely. This is because the control system will contain interlocks to prevent this accident, which would have to fail before this accident could happen.

Source term for release of off-gas from decay tank. The source term is the contents of one off-gas decay tank at initial fill-up. To bound the release, the total quantity of gas in the tank calculated to be an equilibrium mixture of the xenon and daughter isotopes that would exist after the 7-d fill time. The duration of the event is 1 h, because of the anticipated pumping rate. See Exhibit E, list 2 for the source term.

4.5.3 Spill of LLLW from Storage Tanks (Event Sequence 25)

4.5.3.1 Sequence of events for spill of LLLW from storage tanks

An operator is filling the LR-56 transport tank and fails to connect the hose properly, releasing the contents of 1 tank to the floor drain in the loading area. This floor drain is routed to the LLLW tank cell instead of process waste.

Frequency range for spill of LLLW from storage tanks. The frequency range for this operator error is anticipated, because no special equipment is provided to prevent this other than operator training and procedures.

Source term for spill of LLLW from storage tanks. The source term is a zero liquid release because tank vault provides secondary containment of the leak. Sumps are provided for pumping the liquid back into the LLLW system. A gaseous release source term is provided in list 11 in Exhibit E.

4.5.4 Airborne Release of LLLW from Storage Tanks (Event Sequence 26)

4.5.4.1 Sequence of events for airborne release of LLLW from storage tanks

The LLLW tanks are located inside a shielded cell, capable of containing the contents. This accident sequence is assumed to be an operator pumping a tanker load of LLLW into the LR-56 tanker during a loading operation, but having a crack in the fill line caused either by a defective line or poor connection. The operator is assumed to notice the spray after 20 min pumping and to shut off the pump.

Frequency range for airborne release of process waste from storage tanks. The frequency range for this operator error is anticipated, because no special equipment is provided to prevent this other than operator training and procedures.

Source term for airborne release of process waste from storage tanks. The tanker is assumed to be filled in 1.6 h at a pumping rate of 50 gpm. Curbing is assumed to contain the spray (assumed to be 5% of 50 gpm $\times$ 20 m = 50 gal), but 10% (5 gal) is assumed to become airborne as a mist. The HEPA filters are assumed to remove 99.95% of the material. See Exhibit E, list 10 for the source term. Nuclides and nuclide concentrations of representative LLLW, which are assumed to consist of a mixture of target water coolants, were obtained from the Excel-97 spreadsheets “Cooling Water Waste Volume & Activation 5 rev-2” and “SNS Waste Accident Source Terms 5 rev-4.” This is based on the total volume of the target coolants, which are assumed to represent the maximum of LLLW radionuclide concentrations.

4.5.5 Spill of Process Waste from Storage Tanks (Event Sequence 27)

4.5.5.1 Sequence of events for spill of process waste from storage tanks

The process waste tanks are located inside a diked area capable of containing the contents. This accident sequence is assumed to be an operator error spilling a tanker load of process waste into the tanker curbing during a tanker loading operation. This area is not designed to retain the entire tanker load of liquid.

Frequency range for spill of process waste from storage tanks. The frequency range for this operator error is anticipated, because no special equipment is provided to prevent this other than operator training and procedures.

Source term for spill of process waste from storage tanks. The tanker curbing is assumed to contain 10% of the spill, but 90% (13,500 gal) is assumed to overflow to the retention basin and then to the White Oak Creek headwaters. The duration of this accident is 3-1/3 h, because of the anticipated pumping rate of the process waste pumps (75 gpm). See Exhibit E, list 4 for the liquid source term. The gaseous release source term is in list 12. Nuclides and nuclide concentrations of representative process wastewater, which are assumed to consist of magnet coolant, were obtained from the Excel-97 spreadsheets “Cooling Water Waste Volume & Activation 5 rev-2” and “SNS Waste Accident Source Terms 5 rev-4.” This is based on the total volume of the linac and ring magnet coolant, which is assumed to represent the maximum of process waste radionuclide concentration.

4.5.6 Airborne Release of Process Waste from Storage Tanks (Event Sequence 28)

4.5.6.1 Sequence of events for airborne release of process waste from storage tanks

The process waste tanks are located inside a diked area capable of containing the contents. This accident sequence is assumed to be an operator pumping a tanker load of process waste into the tanker during a loading operation, but having a crack in the fill line caused either by a defective line or poor connection. The operator is assumed to notice the spray after 20 min pumping and to shut off the pump.

Frequency range for airborne release of process waste from storage tanks. The frequency range for this operator error is anticipated, because no special equipment is provided to prevent this other than operator training and procedures.

Source term for airborne release of process waste from storage tanks. The tanker is assumed to be filled in 3-1/3 h at a pumping rate of 75 gpm. Curbing is assumed to contain the spray (assumed to be 5% of 75 gpm $\times$ 20 m = 75 gal), but 10% (7.5 gal) is assumed to become airborne as a mist. See Exhibit E, list 9 for the source term. Nuclides and nuclide concentrations of representative process wastewater, which are assumed to consist of magnet coolant, were obtained from the Excel-97 spreadsheets “Cooling Water Waste Volume & Activation 5 rev-2” and “SNS Waste Accident Source Terms 5 rev-4.” This is based on the total volume of the linac and ring magnet coolant, which is assumed to represent the maximum of process waste radionuclide concentration.

4.6 EQUIPMENT FAILURE

4.6.1 Off-Gas Treatment Pipe Leak/Break (Event Sequence 29)

4.6.1.1 Sequence of events for off-gas treatment pipe leak/break

This event is a pipe leak or break resulting in the release of off-gas to cell ventilation.

Frequency range for off-gas treatment pipe leak/break. The frequency range for this is unlikely, since a boundary failure (weld crack or valve leak) would be required. The location of the off-gas piping should reduce the chance of mechanical damage during material moving operations in the target cell.

Source term for off-gas treatment pipe leak/break. Since there is no hold-up for decay, all of the isotopes released to cell ventilation would be released from the stack. See Exhibit E, list 1 for the source term. The duration is 24 h because the continuous purging of the mercury would continue past the beam-off condition, until the inventory could be expected to be exhausted. The off-gas stream is conservatively estimated to be at the production concentrations. The duration of this sequence is 24 h, because the mercury would be purged of gases during this time after beam cutoff.

4.6.2 Off-Gas Compressor Failure (Event Sequence 30)

4.6.2.1 Sequence of events for off-gas compressor failure

This sequence is the general failure of the off-gas compressor. This compressor may not be required except during cooling water system venting (cooling water systems are assumed to be operated pressurized and unvented during normal operation). This is because of the presence of the cryogenic charcoal absorber. In the event this is not the design, then the compressor would be needed for all operations.

Frequency range for off-gas compressor failure. The frequency range for this is unlikely, since reliability enhancements to the off-gas compressor, adding additional compressors, accelerator power reduction, or operations curtailment is anticipated.

Source term for off-gas compressor failure. In order to bound it, the source term is conservatively assumed to be the mercury off-gas, assuming there is no cryogenic charcoal absorber. Since there is no hold-up for decay, all of the isotopes released to cell ventilation would be released from the stack. See Exhibit E, list 1 for the source term. The duration is 1 h before operator response to the release would begin. Continuous purging of the mercury would continue, until the compressor was repaired.

4.6.3 Off-Gas Decay Tank Failure (Event Sequence 31)

4.6.3.1 Sequence of events for off-gas decay tank failure

The off-gas decay tank is assumed to fail, resulting in sudden loss of contents of one off-gas tank to the cell ventilation system.

Frequency range for off-gas decay tank failure. The frequency range for this is extremely unlikely, since a catastrophic boundary failure would be required.

Source term for off-gas decay tank failure. See Exhibit E, list 2 for the source term. The duration is 1 min because of the anticipated sudden release.

4.6.4 Iodine Filter Failure (Event Sequence 32)

4.6.4.1 Sequence of events for iodine filter failure

The iodine filter is a charcoal filter located in the off-gas filter train to provide iodine containment for decay of the longer-lived iodine isotopes. This filter could become saturated or could be improperly installed, resulting in iodine discharge to the cell ventilation. The iodine filter may not be required if there is a cryogenic charcoal absorber. This is presently under study.

Frequency range for iodine filter failure. The frequency range for this is unlikely, because similar installations have a great degree of experience with this filter type.

Source term for iodine filter failure. See Exhibit E, list 1 for the source term, but assume only the iodine is present. The duration is 24 h before the filter could be replaced.

4.6.5 LLLW Piping System Failure (Event Sequence 33)

4.6.5.1 Sequence of events for LLLW piping system failure

LLLW piping is routed through the linac tunnels to avoid the requirement for double-contained piping. In this accident sequence, the LLLW piping is assumed to break during heavy component handling, releasing LLLW to the floor of the linac or ring tunnel.

Frequency range for LLLW piping system failure. The frequency range for this is unlikely, since a boundary failure (weld crack or valve leak) would be required. The location of the piping relative to the components moved (magnets and beamline components) should preclude damage from potential falling objects that would be the principal hazard.

Source term for LLLW piping system failure. The source term is zero release because the linac tunnel provides secondary containment of the leak. Sumps are provided with pumping through a diversion tank system to the LLLW system. A gaseous release source term is provided in list 11 in Exhibit E.

4.6.6 LLLW Storage Tank Failure (Event Sequence 34)

4.6.6.1 Sequence of events for LLLW storage tank failure

An LLLW tank is assumed to leak or rupture releasing contents of one tank to the cell floor.

Frequency range for LLLW storage tank failure. The frequency range is in the extremely unlikely range, since a catastrophic boundary failure would be required.

Source term for LLLW storage tank failure. The source term is zero release to environment because tank vault provides secondary containment of the leak. Sumps are provided with pumping back to the LLLW system. A gaseous release source term is provided in list 11 in Exhibit E.

4.6.7 LLLW Pumping System Failure (Event Sequence 35)

4.6.7.1 Sequence of events for LLLW pumping system failure

This sequence is the loss of the ability to pump LLLW because of pump failure.

Frequency range for LLLW pumping system failure. The frequency range is anticipated.

Source term for LLLW pumping system failure. The source term is zero release to environment because of backup pumps and pump containment.

4.6.8 Process Waste System Piping Failure (Event Sequence 36)

4.6.8.1 Sequence of events for process waste system piping failure

This accident sequence is an underground piping leak/break resulting from damage to piping during excavation, improper installation, or corrosion over a period of time.

Frequency range for process waste system piping failure. The frequency range is anticipated, because process waste piping of this design is known to develop leaks over the design life of the piping.

Source term for process waste system piping failure. The source term is release of process waste underground to soil, assumed to be 10% of annual system flow (1.04E6 gal/year). See Exhibit E, list 3 for the source term. The duration is 1 year, assumed to be the time for detection and repair of the leak.

4.6.9 Process Waste Storage Tank Failure (Event Sequence 37)

4.6.9.1 Sequence of events for process waste storage tank failure

In this accident sequence, a process waste tank is assumed to leak or rupture, releasing the contents of one tank to the diked containment area.

Frequency range for process waste storage tank failure. The frequency range is unlikely, since a boundary failure (weld crack or valve leak) would be required.

Source term for process waste storage tank failure. The source term is zero release to the environment because the tank dike provides secondary containment of the leak. Sumps are provided with pumping back to the process waste system. A gaseous release source term is provided in list 12 in Exhibit E.

4.6.10 Process Waste Pumping System Failure (Event Sequence 38)

4.6.10.1 Sequence of events for process waste pumping system failure

This accident sequence is the loss of the ability to pump process waste because of pump failure.

Frequency range for process waste pumping system failure. The frequency range is anticipated.

Source term for process waste pumping system failure. The source term is zero release to the environment because of backup pumps and pump containment.

4.7 TRANSPORTATION

4.7.1 LLLW Transportation Accident (Event Sequence 39)

4.7.1.1 Sequence of events for LLLW transportation accident

This sequence of events is a transportation accident involving the LR-56 LLLW tanker, which releases the contents of the tanker to the environment.

Frequency range for LLLW transportation accident. The frequency range of release of radionuclides during type B shipping casks like the LR-56 is estimated to be 5×10^{-9}/mi $\times$ 3.5 mi = 1.75×10^{-8} (estimated from data given in ref.1). The frequency for this accident is therefore BDB.

Source term for LLLW transportation accident. The source term is 800 gal of LLLW released to environment. See Exhibit E, list 8 for the source term. The duration of the accident is 24 h. Nuclides and nuclide concentrations of representative LLLW wastewater, which are assumed to consist of a mixture of coolant, were obtained from the Excel-97 spreadsheets "Cooling Water Waste Volume & Activation 5 rev-2" and "SNS Waste Accident Source Terms 5 rev-4." This is based on the total volumes from the various target, linac, and beam-stop coolant systems, which are assumed to be changed with each target end change (ion exchange effectiveness is ignored).

4.7.2 Process Waste Transportation Accident (Event Sequence 40)

4.7.2.1 Sequence of events for process waste transportation accident

This sequence of events is a transportation accident involving the process waste tanker.

Frequency range for process waste transportation accident. The frequency range of truck accidents is estimated to be 5×10^{-7}/mi $\times$ 3.5 mi = 1.75×10^{-6} (estimated from data given in ref.1). The frequency for this accident is therefore extremely unlikely, since a catastrophic boundary failure would be required, and the tanker is designed to withstand the transportation environment in which it will be used.

Source term for process waste transportation accident. The source term is 15,000 gal of process waste released to environment. See Exhibit E, list 5 for the source term. The duration of the accident is 1 h.

Information source terms are summarized in Table 4.1. Other information about the individual accidents, including method of detection, system response, and mitigating actions or features, are summarized in Table 4.2.

4.8 REFERENCES

1. *Final Environmental Impact Statement*, Safe Interim Storage of Hanford Tank Wastes, Hanford Site, Richland, Washington, DOE/EIS-0212, Vol. 1, F47–48.

Table 4.1. Source term summary—waste systems
(Frequency ranges: 2.5 * 10^{-2}/year < A <10^{0}/year; 10^{-4}/year < U < 2.5 * 10^{-2}/year; 10^{-6}/year < EU < 10^{-4}/year)

Frequency category	**Event(s)** [sequence number(s) from Table 4-2]	**Recommended source term**		
		Material released	Time span	Nuclides released to environment[a]
A	35, 38	None	NA	None
A	25	LLLW	1 h	List 11
A	19	Tritium	24 h	0.46 Ci/h
A	17	Mercury	48 h	4.7 mg/min (list 6)
A	27, 36, 28	Process waste	3-1/3 h (27), 1 year (36), 20 min (28)	Lists 4 and 12 (27), list 3 (36), list 9 (28)
A	26	LLLW	20 min	List 10
U	24	Off-gas	1 h	List 2
U	22, 30	Off-gas	24 h (22), 72 h (30)	List 1 (22, 30)
U	33	LLLW	1 h	List 11
U	20, 23	Tritium	24 h (20), 20 min (23)	0.46 Ci/h (4), 4000 Ci (7)
U	18	Mercury	10 d	List 7
U	29, 32	Off-gas	24 h	List 1 (29), list 1 (32, iodine only)
EU	34	LLLW	1 h	List 11
EU	37	Process waste	1 h	List 12
EU	40	Process waste	1 h	15,000 gal (list 5)
EU	21	Tritium, uranium	1 h	4000 Ci tritium, 0.2 kg depleted U as oxide
EU	31	Off-gas	1 min	List 2
BDB	39	LLLW	24 h	800 gal (list 8)

[a]See Exhibit E for source term lists.

Table 4.2. Waste system accidents

Sequence	How detected	System response or damage	Mitigating actions or features
17. Failure to remove Hg from off-gas–Hg condenser failure	Increase in temperature in condenser	Condenser ceases to condense Hg	Charcoal absorber downstream
18. Failure to remove Hg from ventilation; Hg charcoal absorber failure	Increase in Hg in air concentration measured by Hg detector	Hg is released from cell ventilation until absorber is replaced	Detection of absorber breakthrough by Hg detector prior to last absorber saturation
19. Failure to remove tritium from off-gas–He circulator failure	Operator observation of process instrumentation	Tritium is released from off-gas until circulator is repaired or replaced	NA
20. Failure to remove tritium from off-gas–getter bed oxidation	Operator observation of tritium in off-gas	Tritium is released from off-gas until circulator is repaired or replaced	NA
21. Release of stored activity–failure of getter bed	Operator observation of conditions in cell after failure	Combustion of pyrophoric uranium and release of tritium	NA
22. Failure to treat off-gas–cryogenic charcoal absorber failure	Detection of activity in off-gas	Radioactive off-gas is released from cell ventilation until off-gas can be shut off	Off-gas contains short-lived isotopes only
23. Operator error–tritium release from removal system	Operator observation of tritium in off-gas	Tritium is released from cell ventilation	NA
24. Operator error–off-gas release from decay tank	Operator observation of activity in off-gas	Undecayed off-gas is released from cell ventilation	NA
25. Operator error–spill from LLLW storage tanks	Operator observation of liquid in sumps	LLLW drains to sump, is pumped back to LLLW system	NA
27. Operator error–spill from process waste storage tanks	Operator observation of liquid in dikes	Process waste drains to curb; 10% is pumped back to process waste system; 90% is released to environment	Process waste contains low levels of short-lived isotopes only
29. Off-gas pipe leak/break	Detection of activity in cell ventilation	Off-gas leaks to cell ventilation and is released	Off-gas contains short-lived isotopes only
30. Off-gas compressor failure	Operator observation of failure to compress off-gas	Undecayed off-gas is released from cell ventilation	Off-gas contains short-lived isotopes only

Table 4.2 (continued)

Sequence	How detected	System response or damage	Mitigating actions or features
31. Off-gas decay tank failure	Detection of activity in cell ventilation	Radioactive off-gas is released from cell ventilation	Off-gas contains short-lived isotopes only
32. Iodine filter failure	Detection of activity in off-gas	Radioactive iodine is released from cell ventilation	Iodine has been decayed partially
33. LLLW piping system failure	Detection of activity in process waste	LLLW leaking into linac tunnel is returned to LLLW system	NA
34. LLLW storage tank failure	Detection of liquid In LLLW cell sump	LLLW leaking into sump is returned to LLLW system	NA
35. LLLW pumping system failure	Operator observation of pump not operating	LLLW leaking into sump is returned to LLLW system	NA
36. Process waste piping system failure	Detection of activity In groundwater monitoring well	Process waste leaks into soil	Process waste contains low levels of short-lived isotopes only
37. Process waste storage tank failure	Operator observation of water in dike	Process waste leaking into dike is returned to process waste system	NA
38. Process waste pumping system failure	Operator observation of pump not operating	Process waste leaking into dike is returned to process waste system	NA
39. LLLW transportation accident	Driver observation of accident	LLLW leaking from LR-56 tanker spills to environment	NA
40. Process waste transportation accident	Driver observation of accident	Process waste leaking from tanker spills to environment	NA
28. Process waste airborne release	Operator observation of water spray	Airborne release of process waste	Process waste contains low levels of short-lived isotopes only
26. LLLW airborne release	Operator observation of water spray	Airborne release of LLLW	HEPA Filters on ventilation air

EXHIBIT A

A COMPARISON OF THE AIRBORNE CONCENTRATIONS OF METALLIC MERCURY ALLOWED FROM CHECMIAL TOXICITY vs RADIOLOGICAL HEALTH POINTS OF VIEW

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EXHIBITA. A COMPARISON OF THE AIRBORNE CONCENTRATIONS OF METALLIC MERCURY ALLOWED FROM CHEMICAL TOXICITY VS RADIOLOGICAL HEALTH POINTS OF VIEW

The current OSHA Standard for occupational exposure to nonradioactive metallic mercury is a ceiling limit of 0.1 mg/m^3 (29 CFR 1910.20, OSHA Regulations). The National Institute of Occupational Safety and Health (NIOSH) has recommended an alternative limit of 0.05 mg/m^3 averaged over an 8-h period. The American Congress of Government Industrial Hygienists (ACGIH) recommends a threshold limit value (TLV) of 0.025 mg/m^3 [time-weighted average (TWA)]. Adherence to these limits prevents mercury sickness in workers exposed to airborne, nonradioactive mercury.

This exhibit considers the following question: If an airspace in contact with Spallation Neutron Source irradiated mercury were at the AICGH-recommended TLV-TWA of 0.025 mg Hg/m^3, would the concentration of radioactive mercury isotopes exceed the occupational limit for radiation exposure?

It will be assumed that the SNS mercury has been irradiated by a 1-MW proton beam for a period of 1 year, allowing all the mercury radionuclides, except Hg-194, to come to equilibrium. The irradiation time of only 1 year is chosen intentionally to show that the radioactivity content becomes controlling early in life of the facility. Similarly, the proton beam (pre-upgrade) power of 1 MW is chosen because the intent is to demonstrate that the radioactivity content of this mercury is, in effect, more controlling than the toxic material content under the least radioactive scenario. As the radioactivity content of this mercury increases with each year of operation and is further increased by the planned upgrades to 2 MW and eventually to 4 MW, the conclusion will only be strengthened. The total amount of each mercury radionuclide present in the target mercury is provided by SNS HECT96/MCNP/ORIHET95 calculations (See CDR, Sect. 5.4):

Hg-193 = $1.05(10)^4$	Ci	(half life = 3.8 h)
Hg-194 = 39	Ci	(half life = 529 year)
Hg-195 = $1.75(10)^4$	Ci	(half life = 9.9 h)
Hg-197 = $1.17(10)^5$	Ci	(half life = 2.67 d)
Hg-203 = $8.28(10)^4$	Ci	(half life = 46.6 d)

The total volume of mercury in the SNS target is ~1 m^3. The concentration of each radionuclide in air with 0.025 mg/m^3 of irradiated SNS mercury is determined by simple ratios. The resulting concentrations are then multiplied by the breathing rate, and by the effective dose conversion factor given for each nuclide by ICRP-68. The hourly and yearly effective dose accumulation rates due to inhalation of each nuclide then summed in Table A.1 to give an integral comparison to the 5 rem yearly radiation dose limit specified by 10CFR835.202.

From Table A.1, we see that, if the mercury were present in air at the 0.025 mg/m^3 ACGIH recommended TLV-TWA concentration, the radioactivity of the airborne mercury would be too high to allow normal occupancy since the 19.4 rem yearly effective dose commitment would exceed the 10CFR835.202 limit by a factor of four. Considering the lower administrative limits that are routinely applied to radiation exposures would make the radioactivity content more limiting than the ACGIH TLV by a factor of approximately ten. Increasing integrated target proton beam exposure time above the 1 year assumed in the calculations above would increase the factor even further by increasing the amount of Hg-194 present. Considering volatile spallation or activation products other than the mercury isotopes included in the calculation would only further reinforce the conclusion. Since the facility features to control airborne mercury concentrations inside the facility, to separate the workers from the mercury, and to prevent airborne emissions of mercury will have to be built into the facility from the very first day of operation, it can be concluded that strong protection against the chemical toxicity of the mercury will be provided by those installed systems and radiological control procedures.

The above analysis is not intended to imply that the chemical toxicity of mercury can be ignored during operation of the SNS. The laboratory industrial hygiene department will maintain cognizance of planned SNS target facility operations and will prescribe additional controls for special situations in which chemical toxicity may be more important. Such special situations might arise infrequently, either before initial facility operation when the mercury is not irradiated at all, or after a long shutdown when the dominant nuclides have decayed (Hg-203, for example, has a 47-d half life). If the installed facility ventilation, compartmentation, and surveillance features are not totally adequate for those special situations that may arise, the hygienist will be able to prescribe additional surveillance, training, and/or ventilation as needed to control exposure to the hazard.

Table A.1. Radiation dose commitment rate due to inhalation of SNS-activated mercury, assuming that the total mercury concentration of the air is 0.025 mg/m^3 of irradiated (1 MW for 1 year) SNS mercury
(0.025 mg/m^3 is the ACGIH recommended occupational limit (TLV)[a] for nonradioactive Hg)

Hg radionuclide	Concentration Ci/m^3	DCF[b] (Rem/Ci)	Radiation Dose Rate (Rem/h)	Radiation Dose Rate (Rem/y)
Hg-193	1.93E-08	4.07E+03	9.90E-05	1.98E-01
Hg-194	7.17E-11	1.48E+05	1.34E-05	2.67E-02
Hg-195	3.22E-08	5.18E+03	2.10E-04	4.20E-01
Hg-197	2.15E-07	1.63E+04	4.41E-03	8.82E+00
Hg-203	1.52E-07	2.59E+04	4.97E-03	9.93E+00
		TOTAL	9.70E-03	1.94E+01

[a]The 0.025 mg/m^3 TLV-TWA is the limit set by the ACGIH for the maximum allowable TWA mercury vapor concentration for a normal 8-hour work day or 40-hour work week.
[b]DCF mean Dose Conversion Factor, with values taken from ICRP-68 publication (July 1994) titled "Dose Coefficients for Intakes of Radionuclides by Workers." (Annals of the ICRP, 24(4), 1994).

EXHIBIT B

TARGET MERCURY SPALLATION/ACTIVATION PRODUCT RADIONUCLUDE INVENTORY

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EXHIBIT B. TARGET MERCURY SPALLATION/ACTIVATION PRODUCT RADIONUCLUDE INVENTORY

(1-MW beam power—multiply by 4 to get 4-MW beam end-of-life inventory)

SNS target mercury decay activity after 30 years continuous irradiation (equivalent to 40 years of actual operation); 1 GeV proton energy; 1 MW beam power (decay); nuclide radioactivity during decay (curies); time units = seconds, except as otherwise noted.

Note: the column labeled “TS” gives the source of the hazard category threshold:

- A = threshold taken from DOE-STD-6003-96, “Safety of Magnetic Fusion Facilities: Guidance”
- B = threshold calculated from published dose conversion factors (DOE/EH-0071, July 1988) using the DOE-STD-1027-92 threshold definition formula
- C = threshold calculated using recently calculated dose conversion factors (K. Eckerman, ORNL, letters dated 6/18/98 and 8/24/98) and the threshold definition formula in DOE-STD-1027-92
- C* = threshold bounded by comparison to available bounding similar isotope of same element
- D = threshold taken as the generic 4.3E5 Ci value for beta-gamma emitters specified by DOE-STD-1027-92 (9/97 Change Notice No. 1)

Fraction of Cat. 2 calculated by dividing 10-min inventory by the Cat. 2 threshold (10 min is transport time between target hot cell and receptor at 300 m).

Nuclide ID	Half Life (days)	Time (s) INITIAL	6.00E+01 1 min.	6.00E+02 10 min.	1.80E+03 30 min.	3.60E+03 1 hour	Threshold (Cat 2)	TS	Fraction of Cat. 2	4.32E+04 12 hours	8.64E+04 1 day	6.05E+05 1 week	2.63E+06 1 month	1.58E+07 6 months
H3	4.50E+03	5.90E+04	5.90E+04	5.90E+04	5.90E+04	5.90E+04	3.03E+05	A	1.95E-01	5.90E+04	5.90E+04	5.90E+04	5.90E+04	5.90E+04
RH101	1.20E+03	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.69E+00	4.30E+05	A	3.92E-06	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.69E+00
AG109M	4.58E-04	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.41E+10	A	1.20E-10	1.69E+00	1.69E+00	1.67E+00	1.61E+00	1.28E+00
CD109	4.64E+02	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.69E+00	6.81E+05	A	2.48E-06	1.69E+00	1.69E+00	1.67E+00	1.61E+00	1.28E+00
CD115	2.23E+00	1.69E+00	1.69E+00	1.69E+00	1.68E+00	1.67E+00	7.35E+06	A	2.30E-07	1.45E+00	1.24E+00	1.92E-01	1.31E-04	3.41E-25
IN110	2.04E-01	1.69E+00	1.69E+00	1.65E+00	1.57E+00	1.47E+00	9.50E+07	B	1.74E-08	3.09E-01	5.67E-02	8.01E-11	0.00E+00	0.00E+00
IN111	2.83E+00	3.38E+00	3.38E+00	3.37E+00	3.36E+00	3.35E+00	3.05E+07	A	1.10E-07	2.99E+00	2.65E+00	6.08E-01	1.95E-03	1.19E-19
IN112	1.43E-02	1.69E+00	1.61E+00	1.04E+00	3.99E-01	9.41E-02	3.60E+09	B	2.89E-10	1.50E-15	1.34E-30	0.00E+00	0.00E+00	0.00E+00
IN114	8.33E-04	3.38E+00	1.90E+00	1.04E-02	9.83E-08	2.86E-15	1.57E+09	A	6.62E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IN115M	1.87E-01	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.66E+08	A	1.02E-08	1.55E+00	1.35E+00	2.09E-01	1.43E-04	3.72E-25
IN116M	3.92E-03	3.38E+00	1.81E-01	6.44E-13	0.00E+00	0.00E+00	4.30E+05	A	1.50E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IN117	3.04E-02	1.69E+00	1.66E+00	1.44E+00	1.05E+00	6.57E-01	8.20E+07	A	1.76E-08	2.00E-05	2.38E-10	0.00E+00	0.00E+00	0.00E+00
SN113	1.15E+02	3.38E+00	3.38E+00	3.38E+00	3.38E+00	3.38E+00	3.20E+06	A	1.06E-06	3.37E+00	3.36E+00	3.24E+00	2.81E+00	1.12E+00
SB113	4.63E-03	3.38E+00	3.05E+00	1.21E+00	1.55E-01	7.07E-03	4.30E+05	D	2.81E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SB115	2.23E-02	8.45E+00	8.27E+00	6.79E+00	4.39E+00	2.28E+00	5.30E+07	B	1.28E-07	1.29E-06	1.98E-13	0.00E+00	0.00E+00	0.00E+00
SB116	1.10E-02	5.07E+00	4.85E+00	3.24E+00	1.33E+00	3.46E-01	2.20E+07	B	1.47E-07	5.27E-14	5.49E-28	0.00E+00	0.00E+00	0.00E+00
SB117	1.17E-01	2.37E+01	2.36E+01	2.32E+01	2.21E+01	2.03E+01	2.97E+08	A	7.81E-08	1.56E+00	7.99E-02	2.60E-17	0.00E+00	0.00E+00
SB118	2.50E-03	2.20E+01	2.04E+01	1.47E+01	1.35E+01	1.35E+01	4.30E+05	D	3.42E-05	1.28E+01	1.20E+01	6.02E+00	4.02E-01	9.04E-09
SB119	1.59E+00	2.20E+01	2.20E+01	2.20E+01	2.19E+01	2.19E+01	2.10E+08	C	1.05E-07	2.02E+01	1.78E+01	1.60E+00	5.62E-05	0.00E+00
SB120	1.10E-02	1.52E+01	1.46E+01	9.83E+00	4.11E+00	1.11E+00	7.60E+06	B	1.29E-06	3.49E-13	8.00E-27	0.00E+00	0.00E+00	0.00E+00
SB122	2.70E+00	3.38E+00	3.38E+00	3.37E+00	3.36E+00	3.34E+00	5.84E+06	A	5.77E-07	2.98E+00	2.62E+00	5.67E-01	1.44E-03	1.95E-20
SB124	6.02E+01	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.31E+06	A	1.29E-06	1.68E+00	1.67E+00	1.56E+00	1.19E+00	2.06E-01
SB125	9.96E+02	5.02E+00	5.02E+00	5.02E+00	5.02E+00	5.02E+00	2.86E+06	A	1.76E-06	5.02E+00	5.02E+00	5.02E+00	5.02E+00	5.02E+00
TE117	4.29E-02	1.18E+01	1.17E+01	1.06E+01	8.41E+00	5.98E+00	4.30E+05	D	2.47E-05	3.31E-03	9.27E-07	0.00E+00	0.00E+00	0.00E+00
TE118	6.00E+00	1.35E+01	1.35E+01	1.35E+01	1.35E+01	1.35E+01	4.30E+05	D	3.14E-05	1.28E+01	1.20E+01	6.02E+00	4.01E-01	9.03E-09
TE119	6.69E-01	1.69E+01	1.69E+01	1.68E+01	1.66E+01	1.63E+01	4.20E+06	C	4.00E-06	1.02E+01	6.05E+00	1.20E-02	3.39E-13	0.00E+00
TE121	1.68E+01	2.70E+01	2.70E+01	2.70E+01	2.70E+01	2.70E+01	1.54E+06	A	1.75E-05	2.66E+01	2.60E+01	2.03E+01	7.72E+00	1.42E-02

Nuclide ID	Half Life (days)	Time (s) INITIAL	6.00E+01 1 min.	6.00E+02 10 min.	1.80E+03 30 min.	3.60E+03 1 hour	Threshold (Cat 2)	TS	Fraction of Cat. 2	4.32E+04 12 hours	8.64E+04 1 day	6.05E+05 1 week	2.63E+06 1 month	1.58E+07 6 months
TE125M	5.80E+01	7.76E-01	7.76E-01	7.76E-01	7.76E-01	7.76E-01	4.27E+05	A	1.82E-06	7.76E-01	7.76E-01	7.75E-01	7.72E-01	7.17E-01
TE127	3.90E-01	1.69E+00	1.69E+00	1.67E+00	1.63E+00	1.57E+00	9.78E+06	A	1.71E-07	6.94E-01	2.85E-01	6.56E-06	5.09E-24	0.00E+00
I119	1.33E-02	6.76E+00	6.63E+00	5.30E+00	2.77E+00	9.59E-01	8.50E+04	C	6.24E-05	4.88E-11	2.88E-22	0.00E+00	0.00E+00	0.00E+00
I120	5.63E-02	1.01E+01	1.01E+01	9.56E+00	8.44E+00	6.88E+00	2.00E+04	C	4.78E-04	2.84E-02	6.00E-05	0.00E+00	0.00E+00	0.00E+00
I121	8.83E-02	2.03E+01	2.02E+01	1.93E+01	1.74E+01	1.49E+01	1.00E+05	C	1.93E-04	4.16E-01	8.22E-03	2.88E-23	0.00E+00	0.00E+00
I122	2.52E-03	2.87E+01	2.58E+01	1.43E+01	1.17E+01	1.15E+01	1.10E+05	C	1.30E-04	7.84E+00	5.19E+00	3.61E-02	1.36E-10	0.00E+00
I123	5.50E-01	3.72E+01	3.72E+01	3.70E+01	3.67E+01	3.62E+01	6.60E+04	C	5.61E-04	2.16E+01	1.15E+01	5.35E-03	5.29E-16	0.00E+00
I124	4.18E+00	1.69E+01	1.69E+01	1.69E+01	1.68E+01	1.68E+01	1.30E+03	C	1.30E-02	1.55E+01	1.43E+01	5.25E+00	1.05E-01	9.18E-13
I125	6.01E+01	7.43E+01	7.43E+01	7.43E+01	7.43E+01	7.43E+01	1.10E+03	C	6.75E-02	7.42E+01	7.39E+01	6.92E+01	5.29E+01	9.16E+00
I126	1.30E+01	3.38E+00	3.38E+00	3.38E+00	3.38E+00	3.37E+00	5.80E+02	C	5.83E-03	3.29E+00	3.20E+00	2.33E+00	6.68E-01	2.00E-04
I128	1.74E-02	3.38E+00	3.29E+00	2.56E+00	1.47E+00	6.40E-01	2.10E+05	C	1.22E-05	7.23E-09	1.55E-17	0.00E+00	0.00E+00	0.00E+00
I129	5.73E+09	8.85E-06	8.85E-06	8.85E-06	8.85E-06	8.85E-06	1.60E+02	C	5.53E-08	8.85E-06	8.85E-06	8.85E-06	8.85E-06	8.85E-06
I130	5.15E-01	1.69E+00	1.69E+00	1.67E+00	1.64E+00	1.60E+00	7.20E+03	C	2.32E-04	8.64E-01	4.42E-01	1.41E-04	3.11E-18	0.00E+00
XE119	4.03E-03	3.38E+00	3.01E+00	1.06E+00	1.06E-01	3.30E-03	4.30E+05	D	2.47E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE120	2.78E-02	3.38E+00	3.34E+00	2.88E+00	2.04E+00	1.21E+00	4.30E+05	D	6.70E-06	1.31E-05	4.99E-11	0.00E+00	0.00E+00	0.00E+00
XE121	2.78E-02	1.69E+00	1.66E+00	1.41E+00	9.89E-01	5.79E-01	4.30E+05	D	3.28E-06	4.38E-06	1.14E-11	0.00E+00	0.00E+00	0.00E+00
XE122	8.38E-01	1.18E+01	1.18E+01	1.18E+01	1.16E+01	1.14E+01	1.05E+06	A	1.12E-05	7.82E+00	5.17E+00	3.60E-02	1.35E-10	0.00E+00
XE123	8.67E-02	2.03E+01	2.02E+01	1.95E+01	1.76E+01	1.49E+01	9.92E+04	A	1.97E-04	3.81E-01	6.98E-03	9.89E-24	0.00E+00	0.00E+00
XE125	7.08E-01	5.74E+01	5.74E+01	5.72E+01	5.66E+01	5.57E+01	2.52E+05	A	2.27E-04	3.61E+01	2.23E+01	6.95E-02	1.13E-11	0.00E+00
XE127	3.64E+01	1.45E+02	1.45E+02	1.45E+02	1.45E+02	1.45E+02	2.39E+05	A	6.07E-04	1.45E+02	1.43E+02	1.28E+02	8.19E+01	4.50E+00
CS120	7.01E-04	1.69E+00	8.57E-01	1.91E-03	2.45E-09	3.54E-18	4.30E+05	D	4.44E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CS123	4.08E-03	8.45E+00	7.67E+00	2.93E+00	2.86E-01	8.28E-03	4.30E+05	D	6.81E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CS124	3.56E-04	1.86E+01	8.42E+00	2.75E+00	7.36E-01	1.02E-01	4.30E+05	D	6.40E-06	1.22E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CS125	3.13E-02	2.03E+01	2.00E+01	1.75E+01	1.29E+01	8.10E+00	6.20E+06	B	2.82E-06	3.12E-04	4.76E-09	0.00E+00	0.00E+00	0.00E+00
CS126	1.14E-03	5.41E+01	4.70E+01	3.24E+01	2.79E+01	2.27E+01	5.59E+06	A	5.80E-06	2.34E-01	1.59E-03	0.00E+00	0.00E+00	0.00E+00
CS127	2.60E-01	1.20E+02	1.20E+02	1.19E+02	1.15E+02	1.09E+02	1.00E+07	B	1.19E-05	3.23E+01	8.54E+00	9.85E-07	0.00E+00	0.00E+00
CS128	2.51E-03	1.88E+02	1.76E+02	1.31E+02	1.21E+02	1.20E+02	4.30E+05	D	3.05E-04	1.06E+02	9.16E+01	1.65E+01	2.07E-02	2.71E-21
CS129	1.34E+00	2.04E+02	2.04E+02	2.04E+02	2.04E+02	2.03E+02	1.07E+07	A	1.91E-05	1.67E+02	1.30E+02	5.91E+00	3.45E-05	0.00E+00
CS130	2.08E-02	3.89E+01	3.80E+01	3.08E+01	1.94E+01	9.67E+00	8.80E+06	B	3.50E-06	2.19E-06	1.24E-13	0.00E+00	0.00E+00	0.00E+00
CS131	9.69E+00	2.59E+02	2.59E+02	2.59E+02	2.58E+02	2.58E+02	1.75E+07	A	1.48E-05	2.58E+02	2.57E+02	2.33E+02	1.03E+02	3.02E-02
CS132	6.47E+00	6.76E+00	6.76E+00	6.75E+00	6.74E+00	6.73E+00	1.87E+06	A	3.61E-06	6.41E+00	6.07E+00	3.19E+00	2.60E-01	2.12E-08
CS136	1.32E+01	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.69E+00	3.35E+05	A	5.04E-06	1.65E+00	1.60E+00	1.16E+00	3.33E-01	9.83E-05
BA123	1.88E-03	1.69E+00	1.31E+00	1.30E-01	7.64E-04	3.46E-07	4.30E+05	D	3.02E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BA124	8.22E-03	5.07E+00	4.75E+00	2.62E+00	7.00E-01	9.66E-02	4.30E+05	D	6.09E-06	1.16E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BA125	2.43E-03	1.69E+00	1.39E+00	2.33E-01	4.44E-03	1.17E-05	4.30E+05	D	5.42E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BA126	6.96E-02	3.38E+01	3.36E+01	3.15E+01	2.75E+01	2.23E+01	4.50E+07	B	7.00E-07	2.30E-01	1.56E-03	0.00E+00	0.00E+00	0.00E+00
BA127	8.82E-03	6.25E+01	6.00E+01	3.92E+01	1.35E+01	2.64E+00	4.30E+05	D	9.12E-05	6.00E-16	5.15E-33	0.00E+00	0.00E+00	0.00E+00
BA128	2.43E+00	1.22E+02	1.22E+02	1.21E+02	1.21E+02	1.20E+02	9.70E+06	B	1.25E-05	1.06E+02	9.15E+01	1.65E+01	2.07E-02	2.71E-21
BA129	9.25E-02	1.61E+02	1.60E+02	1.55E+02	1.42E+02	1.22E+02	4.30E+05	D	3.60E-04	3.82E+00	8.70E-02	1.69E-21	0.00E+00	0.00E+00
BA131	1.18E+01	2.40E+02	2.40E+02	2.40E+02	2.40E+02	2.40E+02	3.27E+07	A	7.34E-06	2.34E+02	2.27E+02	1.61E+02	4.15E+01	6.22E-03
BA133	3.84E+03	8.11E+01	8.11E+01	8.11E+01	8.11E+01	8.11E+01	4.05E+06	A	2.00E-05	8.11E+01	8.11E+01	8.10E+01	8.07E+01	7.85E+01
BA136M	3.59E-06	2.70E-01	2.70E-01	2.70E-01	2.70E-01	2.70E-01	4.30E+05	D	6.28E-07	2.63E-01	2.56E-01	1.86E-01	5.33E-02	1.57E-05
LA126	6.94E-04	1.69E+00	8.45E-01	1.65E-03	1.57E-09	1.47E-18	4.30E+05	D	3.84E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA127	2.66E-03	1.69E+01	1.41E+01	2.73E+00	7.10E-02	2.99E-04	4.30E+05	D	6.35E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA128	3.47E-03	4.90E+01	4.26E+01	1.20E+01	7.28E-01	1.08E-02	4.30E+05	D	2.79E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA129	8.06E-03	8.28E+01	7.72E+01	4.14E+01	1.04E+01	1.29E+00	4.30E+05	D	9.63E-05	1.76E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA130	6.04E-03	1.22E+02	1.16E+02	7.55E+01	3.43E+01	1.32E+01	4.30E+05	D	1.76E-04	1.44E-07	3.09E-16	0.00E+00	0.00E+00	0.00E+00
LA131	4.10E-02	1.67E+02	1.66E+02	1.53E+02	1.23E+02	8.76E+01	6.60E+07	B	2.32E-06	4.85E-02	1.36E-05	0.00E+00	0.00E+00	0.00E+00
LA132	2.00E-01	1.61E+02	1.60E+02	1.59E+02	1.55E+02	1.50E+02	1.70E+07	B	9.35E-06	4.87E+01	1.05E+01	1.17E-08	0.00E+00	0.00E+00
LA133	1.63E-01	9.12E+01	9.12E+01	9.03E+01	8.82E+01	8.46E+01	4.30E+05	D	2.10E-04	1.59E+01	1.92E+00	1.58E-11	0.00E+00	0.00E+00
LA134	4.48E-03	1.17E+02	1.14E+02	1.01E+02	9.38E+01	9.24E+01	4.30E+05	D	2.35E-04	8.35E+01	7.49E+01	2.01E+01	1.18E-01	3.65E-16
LA135	8.13E-01	2.03E+02	2.03E+02	2.03E+02	2.03E+02	2.02E+02	3.90E+08	B	5.21E-07	1.85E+02	1.54E+02	2.71E+00	9.79E-09	0.00E+00
LA136	6.85E-03	2.20E+01	2.05E+01	1.09E+01	2.67E+00	3.25E-01	4.30E+05	D	2.53E-05	2.42E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA137	2.19E+07	1.44E-01	1.44E-01	1.44E-01	1.44E-01	1.44E-01	1.50E+06	A	9.57E-08	1.44E-01	1.44E-01	1.44E-01	1.44E-01	1.44E-01
LA140	1.68E+00	1.69E+00	1.69E+00	1.68E+00	1.68E+00	1.66E+00	5.19E+06	A	3.24E-07	1.37E+00	1.12E+00	9.33E-02	5.76E-06	0.00E+00
CE130	9.99E-01	4.39E+01	4.27E+01	3.33E+01	1.91E+01	8.32E+00	4.30E+05	D	7.74E-05	9.41E-08	2.01E-16	0.00E+00	0.00E+00	0.00E+00
CE131	6.94E-03	6.76E+01	5.88E+01	1.69E+01	1.06E+00	1.65E-02	4.30E+05	D	3.93E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CE132	9.99E-01	8.96E+01	8.93E+01	8.68E+01	8.13E+01	7.36E+01	4.30E+05	D	2.02E-04	8.39E+00	7.84E-01	3.47E-13	0.00E+00	0.00E+00
CE133	2.04E-01	6.08E+01	6.05E+01	5.76E+01	5.03E+01	4.06E+01	4.30E+05	D	1.34E-04	3.64E-01	2.12E-03	0.00E+00	0.00E+00	0.00E+00
CE134	3.16E+00	9.29E+01	9.29E+01	9.28E+01	9.26E+01	9.22E+01	3.90E+06	B	2.38E-05	8.34E+01	7.47E+01	2.01E+01	1.18E-01	3.65E-16
CE135	7.37E-01	1.91E+02	1.91E+02	1.90E+02	1.89E+02	1.86E+02	1.50E+07	B	1.27E-05	1.22E+02	7.63E+01	2.76E-01	8.07E-11	0.00E+00
CE137	3.75E-01	4.14E+02	4.14E+02	4.14E+02	4.12E+02	4.09E+02	4.60E+08	B	9.00E-07	2.02E+02	8.02E+01	1.22E-03	1.87E-22	0.00E+00
CE139	1.38E+02	5.39E+02	5.39E+02	5.39E+02	5.39E+02	5.39E+02	3.78E+06	A	1.43E-04	5.38E+02	5.37E+02	5.21E+02	4.63E+02	2.14E+02
CE141	3.25E+01	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.69E+00	3.35E+06	A	5.04E-07	1.67E+00	1.65E+00	1.46E+00	8.83E-01	3.43E-02

Nuclide ID	Half Life (days)	Time (s) INITIAL	6.00E+01 1 min.	6.00E+02 10 min.	1.80E+03 30 min.	3.60E+03 1 hour	Threshold (Cat 2)	TS	Fraction of Cat. 2	4.32E+04 12 hours	8.64E+04 1 day	6.05E+05 1 week	2.63E+06 1 month	1.58E+07 6 months
CE142	1.83E+19	3.35E-10	3.35E-10	3.35E-10	3.35E-10	3.35E-10	4.30E+05	D	7.78E-16	3.35E-10	3.35E-10	3.35E-10	3.35E-10	3.35E-10
PR132	9.99E-01	2.20E+01	1.42E+01	2.89E-01	4.98E-05	1.13E-10	4.30E+05	D	6.72E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PR133	4.51E-03	2.20E+01	1.97E+01	7.56E+00	8.96E-01	3.66E-02	4.30E+05	D	1.76E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PR134	1.18E-02	3.55E+01	3.41E+01	2.36E+01	1.04E+01	3.07E+00	1.20E+07	B	1.97E-06	6.32E-12	1.13E-24	0.00E+00	0.00E+00	0.00E+00
PR135	1.67E-02	1.37E+02	1.34E+02	1.11E+02	6.98E+01	3.25E+01	4.30E+05	D	2.58E-04	5.10E-07	1.50E-15	0.00E+00	0.00E+00	0.00E+00
PR136	9.10E-03	3.06E+02	2.97E+02	2.34E+02	1.50E+02	8.88E+01	2.30E+07	B	1.02E-05	1.00E-02	5.28E-07	0.00E+00	0.00E+00	0.00E+00
PR137	5.33E-02	3.85E+02	3.84E+02	3.73E+02	3.43E+02	2.90E+02	1.10E+08	B	3.39E-06	9.88E-01	1.49E-03	0.00E+00	0.00E+00	0.00E+00
PR138	1.01E-03	4.43E+02	4.01E+02	3.31E+02	3.16E+02	2.95E+02	4.30E+05	D	7.70E-04	6.50E+01	1.25E+01	3.10E-08	0.00E+00	0.00E+00
PR139	1.84E-01	5.34E+02	5.34E+02	5.32E+02	5.23E+02	4.99E+02	2.30E+08	B	2.31E-06	9.17E+01	1.39E+01	2.04E-09	0.00E+00	0.00E+00
PR140	2.35E-03	6.47E+02	6.42E+02	6.23E+02	6.18E+02	6.16E+02	4.30E+05	D	1.45E-03	5.61E+02	5.06E+02	1.47E+02	1.19E+00	2.87E-14
PR142	7.97E-01	3.38E+00	3.38E+00	3.36E+00	3.32E+00	3.26E+00	1.05E+07	A	3.20E-07	2.19E+00	1.42E+00	7.74E-03	1.13E-11	0.00E+00
PR143	1.36E+01	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.69E+00	3.92E+06	A	4.31E-07	1.65E+00	1.61E+00	1.18E+00	3.57E-01	1.49E-04
ND135	8.56E-03	3.89E+01	3.67E+01	2.22E+01	7.27E+00	1.36E+00	4.30E+05	D	5.16E-05	1.29E-16	4.25E-34	0.00E+00	0.00E+00	0.00E+00
ND136	3.52E-02	1.40E+02	1.39E+02	1.23E+02	9.39E+01	6.23E+01	1.10E+08	B	1.12E-06	7.45E-03	3.92E-07	0.00E+00	0.00E+00	0.00E+00
ND137	2.67E-02	2.62E+02	2.59E+02	2.24E+02	1.57E+02	9.13E+01	4.30E+05	D	5.21E-04	6.31E-04	1.48E-09	0.00E+00	0.00E+00	0.00E+00
ND138	2.10E-01	3.35E+02	3.34E+02	3.29E+02	3.14E+02	2.94E+02	2.60E+07	B	1.27E-05	6.47E+01	1.24E+01	3.09E-08	0.00E+00	0.00E+00
ND139	2.06E-02	4.90E+02	4.86E+02	4.27E+02	2.82E+02	1.40E+02	1.00E+08	B	4.27E-06	2.87E-05	1.45E-12	0.00E+00	0.00E+00	0.00E+00
ND140	3.37E+00	6.20E+02	6.20E+02	6.19E+02	6.18E+02	6.15E+02	4.30E+05	D	1.44E-03	5.60E+02	5.05E+02	1.47E+02	1.19E+00	2.87E-14
ND141	1.04E-01	7.72E+02	7.72E+02	7.66E+02	7.39E+02	6.73E+02	3.49E+09	A	2.19E-07	3.30E+01	1.18E+00	5.34E-18	0.00E+00	0.00E+00
ND147	1.10E+01	3.38E+00	3.38E+00	3.38E+00	3.37E+00	3.37E+00	4.57E+06	A	7.40E-07	3.27E+00	3.17E+00	2.17E+00	4.95E-01	3.31E-05
PM136	1.24E-03	3.72E+01	2.52E+01	7.62E-01	3.21E-04	2.77E-09	4.30E+05	D	1.77E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PM137	1.67E-03	1.05E+02	7.85E+01	5.83E+00	1.81E-02	3.12E-06	4.30E+05	D	1.36E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PM138	1.16E-04	1.88E+02	1.55E+02	2.71E+01	5.44E-01	1.48E-03	4.30E+05	D	6.30E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PM139	2.88E-03	3.41E+02	3.04E+02	8.58E+01	3.38E+00	2.28E-02	4.30E+05	D	2.00E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PM140	1.06E-04	5.10E+02	2.26E+02	1.46E+02	5.71E+01	1.40E+01	4.30E+05	D	3.40E-04	4.73E-13	9.58E-28	0.00E+00	0.00E+00	0.00E+00
PM141	1.45E-02	6.91E+02	6.82E+02	5.80E+02	3.51E+02	1.42E+02	6.20E+07	B	9.35E-06	4.64E-08	1.98E-18	0.00E+00	0.00E+00	0.00E+00
PM142	4.69E-04	8.43E+02	7.35E+02	6.22E+02	5.13E+02	3.85E+02	4.30E+05	D	1.45E-03	7.00E-01	7.19E-04	0.00E+00	0.00E+00	0.00E+00
PM143	2.65E+02	9.26E+02	9.26E+02	9.26E+02	9.26E+02	9.26E+02	3.95E+06	A	2.34E-04	9.25E+02	9.24E+02	9.09E+02	8.55E+02	5.74E+02
PM144	3.63E+02	7.27E+01	7.27E+01	7.27E+01	7.27E+01	7.27E+01	6.84E+05	A	1.06E-04	7.26E+01	7.26E+01	7.17E+01	6.84E+01	5.06E+01
PM145	6.46E+03	6.22E+02	6.22E+02	6.22E+02	6.22E+02	6.22E+02	1.06E+06	A	5.87E-04	6.22E+02	6.22E+02	6.22E+02	6.23E+02	6.27E+02
PM146	2.02E+03	7.76E+00	7.76E+00	7.76E+00	7.76E+00	7.76E+00	2.59E+05	A	3.00E-05	7.76E+00	7.76E+00	7.74E+00	7.68E+00	7.29E+00
PM147	9.56E+02	8.41E+00	8.41E+00	8.41E+00	8.41E+00	8.41E+00	8.41E+05	A	1.00E-05	8.41E+00	8.41E+00	8.38E+00	8.26E+00	7.40E+00
PM148	5.37E+00	6.76E+00	6.76E+00	6.75E+00	6.74E+00	6.72E+00	2.78E+06	A	2.43E-06	6.34E+00	5.94E+00	2.74E+00	1.33E-01	3.80E-10
PM150	1.12E-01	3.38E+00	3.36E+00	3.24E+00	2.97E+00	2.61E+00	9.86E+07	A	3.29E-08	1.52E-01	6.81E-03	4.49E-19	0.00E+00	0.00E+00
PM153	3.75E-03	1.69E+00	1.49E+00	4.68E-01	3.59E-02	7.64E-04	1.66E+07	A	2.82E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM138	2.08E-03	5.07E+00	4.02E+00	5.03E-01	4.94E-03	4.83E-06	4.30E+05	D	1.17E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM139	1.78E-03	1.13E+02	8.58E+01	7.08E+00	2.76E-02	6.75E-06	4.30E+05	D	1.65E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM140	1.03E-02	2.31E+02	2.21E+02	1.45E+02	5.65E+01	1.38E+01	4.30E+05	D	3.37E-04	4.69E-13	9.48E-28	0.00E+00	0.00E+00	0.00E+00
SM141	7.08E-03	4.11E+02	3.87E+02	2.11E+02	5.43E+01	7.07E+00	6.20E+07	B	3.40E-06	2.36E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM142	5.04E-02	6.78E+02	6.71E+02	6.16E+02	5.09E+02	3.82E+02	3.80E+07	B	1.62E-05	6.92E-01	7.12E-04	0.00E+00	0.00E+00	0.00E+00
SM143	6.13E-03	7.87E+02	7.56E+02	4.37E+02	9.44E+01	8.97E+00	4.30E+05	D	1.02E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SM145	3.40E+02	1.08E+03	1.08E+03	1.08E+03	1.08E+03	1.08E+03	2.80E+06	B	3.86E-04	1.08E+03	1.08E+03	1.07E+03	1.03E+03	7.53E+02
SM147	3.87E+13	1.85E-07	1.85E-07	1.85E-07	1.85E-07	1.85E-07	4.03E+02	A	4.58E-10	1.85E-07	1.85E-07	1.85E-07	1.85E-07	1.85E-07
SM151	3.24E+04	1.01E+00	1.01E+00	1.01E+00	1.01E+00	1.01E+00	9.86E+05	A	1.03E-06	1.01E+00	1.01E+00	1.01E+00	1.01E+00	1.01E+00
SM153	1.95E+00	1.69E+00	1.69E+00	1.69E+00	1.68E+00	1.67E+00	1.66E+07	A	1.02E-07	1.42E+00	1.19E+00	1.40E-01	3.30E-05	0.00E+00
EU141	4.63E-04	9.46E+01	3.35E+01	2.89E-03	2.69E-12	7.64E-26	4.30E+05	D	6.72E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EU142	2.78E-05	2.74E+02	8.16E-06	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EU143	1.83E-03	4.12E+02	3.35E+02	3.96E+01	2.16E-01	7.57E-05	4.30E+05	D	9.21E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EU144	1.18E-04	6.61E+02	2.02E+02	4.85E+01	2.23E+00	2.20E-02	4.30E+05	D	1.13E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EU145	5.93E+00	9.64E+02	9.64E+02	9.64E+02	9.63E+02	9.61E+02	8.50E+06	B	1.13E-04	9.13E+02	8.62E+02	4.27E+02	2.76E+01	5.05E-07
EU146	4.59E+00	1.05E+03	1.05E+03	1.05E+03	1.05E+03	1.05E+03	5.60E+06	B	1.88E-04	1.03E+03	1.01E+03	8.39E+02	5.54E+02	6.18E+01
EU147	2.40E+01	8.91E+02	8.91E+02	8.91E+02	8.90E+02	8.90E+02	8.70E+06	B	1.02E-04	8.87E+02	8.81E+02	7.54E+02	3.55E+02	2.61E+00
EU148	5.45E+01	1.01E+02	1.01E+02	1.01E+02	1.01E+02	1.01E+02	1.90E+06	B	5.32E-05	1.01E+02	1.00E+02	9.27E+01	6.86E+01	9.69E+00
EU149	9.31E+01	9.32E+02	9.32E+02	9.32E+02	9.32E+02	9.32E+02	1.70E+07	B	5.48E-05	9.32E+02	9.31E+02	9.18E+02	8.08E+02	2.63E+02
EU150	1.25E+04	1.93E+01	1.93E+01	1.93E+01	1.93E+01	1.93E+01	1.06E+05	A	1.82E-04	1.93E+01	1.93E+01	1.93E+01	1.93E+01	1.93E+01
EU152	4.86E+03	1.49E+01	1.49E+01	1.49E+01	1.49E+01	1.49E+01	1.29E+05	A	1.16E-04	1.49E+01	1.49E+01	1.49E+01	1.49E+01	1.49E+01
EU154	3.14E+03	3.08E+00	3.08E+00	3.08E+00	3.08E+00	3.08E+00	1.10E+05	A	2.80E-05	3.08E+00	3.08E+00	3.07E+00	3.06E+00	2.96E+00
EU155	1.81E+03	1.68E+00	1.68E+00	1.68E+00	1.68E+00	1.68E+00	7.32E+05	A	2.30E-06	1.68E+00	1.68E+00	1.67E+00	1.64E+00	1.56E+00
EU156	1.52E+01	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.69E+00	2.45E+06	A	6.90E-07	1.65E+00	1.61E+00	1.23E+00	4.22E-01	4.03E-04
GD143	4.51E-04	9.80E+01	6.67E+01	2.08E+00	9.42E-04	9.05E-09	4.30E+05	A	4.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GD144	3.13E-03	2.18E+02	1.87E+02	4.67E+01	2.15E+00	2.11E-02	4.30E+05	A	1.09E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GD145	1.60E-02	4.31E+02	4.17E+02	3.14E+02	1.66E+02	6.40E+01	2.00E+07	B	1.57E-05	4.93E-08	5.63E-18	0.00E+00	0.00E+00	0.00E+00
GD146	4.83E+01	7.73E+02	7.73E+02	7.73E+02	7.73E+02	7.73E+02	7.50E+05	B	1.03E-03	7.68E+02	7.62E+02	6.99E+02	4.99E+02	5.59E+01
GD147	1.59E+00	7.06E+02	7.06E+02	7.05E+02	7.03E+02	6.98E+02	1.30E+07	B	5.42E-05	5.78E+02	4.65E+02	3.37E+01	1.20E-03	0.00E+00

Nuclide ID	Half Life (days)	Time (s) INITIAL	6.00E+01 1 min.	6.00E+02 10 min.	1.80E+03 30 min.	3.60E+03 1 hour	Threshold (Cat 2)	TS	Fraction of Cat. 2	4.32E+04 12 hours	8.64E+04 1 day	6.05E+05 1 week	2.63E+06 1 month	1.58E+07 6 months
GD148	2.72E+04	1.89E+02	1.89E+02	1.89E+02	1.89E+02	1.89E+02	3.41E+02	A	5.55E-01	1.89E+02	1.89E+02	1.89E+02	1.89E+02	1.88E+02
GD149	9.38E+00	8.36E+02	8.36E+02	8.36E+02	8.35E+02	8.35E+02	1.10E+07	B	7.60E-05	8.14E+02	7.86E+02	5.01E+02	8.65E+01	9.47E-04
GD150	6.53E+08	1.16E-02	1.16E-02	1.16E-02	1.16E-02	1.16E-02	4.30E+05	D	2.70E-08	1.16E-02	1.16E-02	1.16E-02	1.16E-02	1.16E-02
GD151	1.24E+02	1.31E+03	1.31E+03	1.31E+03	1.31E+03	1.31E+03	3.60E+06	B	3.64E-04	1.31E+03	1.31E+03	1.27E+03	1.11E+03	4.60E+02
GD152	3.94E+16	2.14E-10	2.14E-10	2.14E-10	2.14E-10	2.14E-10	4.68E+02	A	4.57E-13	2.14E-10	2.14E-10	2.14E-10	2.14E-10	2.14E-10
GD153	2.42E+02	1.61E+03	1.61E+03	1.61E+03	1.61E+03	1.61E+03	3.38E+06	A	4.76E-04	1.61E+03	1.61E+03	1.59E+03	1.49E+03	9.59E+02
TB146	9.26E-05	1.13E+02	1.86E+01	1.59E-06	0.00E+00	0.00E+00	4.30E+05	D	3.70E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TB147	6.83E-02	2.85E+02	2.83E+02	2.66E+02	2.30E+02	1.86E+02	2.60E+07	B	1.02E-05	1.63E+00	9.29E-03	0.00E+00	0.00E+00	0.00E+00
TB148	4.17E-02	6.68E+02	5.79E+02	1.08E+02	1.55E+00	1.93E-03	4.30E+05	D	2.51E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TB149	1.72E-01	6.90E+02	6.89E+02	6.76E+02	6.40E+02	5.89E+02	3.80E+06	B	1.78E-04	9.38E+01	1.26E+01	4.49E-10	0.00E+00	0.00E+00
TB150	1.45E-01	7.87E+02	7.85E+02	7.69E+02	7.24E+02	6.56E+02	2.00E+07	B	3.85E-05	7.33E+01	6.72E+00	2.32E-12	0.00E+00	0.00E+00
TB151	7.34E-01	1.19E+03	1.19E+03	1.19E+03	1.18E+03	1.16E+03	2.60E+07	B	4.58E-05	7.53E+02	4.70E+02	1.61E+00	3.86E-10	0.00E+00
TB152	7.29E-01	1.59E+03	1.59E+03	1.59E+03	1.58E+03	1.57E+03	4.30E+05	D	3.70E-03	1.10E+03	6.90E+02	2.30E+00	4.84E-10	0.00E+00
TB153	2.34E+00	1.54E+03	1.54E+03	1.54E+03	1.54E+03	1.54E+03	3.30E+07	B	4.67E-05	1.42E+03	1.25E+03	2.06E+02	1.77E-01	1.98E-21
TB154	8.96E-01	2.35E+02	2.35E+02	2.34E+02	2.31E+02	2.27E+02	1.20E+07	B	1.95E-05	1.59E+02	1.08E+02	1.02E+00	1.24E-08	0.00E+00
TB155	5.32E+00	1.70E+03	1.70E+03	1.70E+03	1.70E+03	1.70E+03	3.70E+07	B	4.59E-05	1.67E+03	1.59E+03	7.40E+02	3.49E+01	8.28E-08
TB156	5.35E+00	6.08E+01	6.08E+01	6.08E+01	6.07E+01	6.05E+01	6.10E+06	B	9.97E-06	5.70E+01	5.34E+01	2.46E+01	1.18E+00	3.12E-09
TB157	3.59E+04	2.18E+02	2.18E+02	2.18E+02	2.18E+02	2.18E+02	3.16E+06	A	6.88E-05	2.18E+02	2.18E+02	2.18E+02	2.18E+02	2.18E+02
TB158	6.59E+04	1.79E+00	1.79E+00	1.79E+00	1.79E+00	1.79E+00	1.14E+05	A	1.57E-05	1.79E+00	1.79E+00	1.79E+00	1.79E+00	1.79E+00
DY148	2.15E-03	3.36E+02	2.79E+02	3.76E+01	4.30E-01	5.29E-04	4.30E+05	D	8.74E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
DY149	2.94E-03	3.32E+02	2.93E+02	6.75E+01	2.33E+00	1.50E-02	4.30E+05	D	1.57E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
DY150	4.98E-03	5.48E+02	5.06E+02	2.13E+02	3.05E+01	1.64E+00	6.16E+06	C	4.95E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
DY151	1.24E-02	8.74E+02	8.51E+02	5.96E+02	2.63E+02	7.67E+01	2.10E+07	C	1.39E-03	1.35E-10	2.02E-23	0.00E+00	0.00E+00	0.00E+00
DY152	9.88E-02	1.24E+03	1.24E+03	1.19E+03	1.08E+03	9.32E+02	4.30E+05	D	2.77E-03	3.73E+01	1.12E+00	5.63E-19	0.00E+00	0.00E+00
DY153	2.66E-01	1.26E+03	1.26E+03	1.24E+03	1.20E+03	1.13E+03	4.30E+05	D	2.88E-03	3.37E+02	8.99E+01	1.15E-05	0.00E+00	0.00E+00
DY154	1.04E+09	3.35E-03	3.35E-03	3.35E-03	3.35E-03	3.35E-03	4.30E+05	D	7.78E-09	3.35E-03	3.35E-03	3.35E-03	3.35E-03	3.35E-03
DY155	4.17E-01	1.57E+03	1.57E+03	1.56E+03	1.55E+03	1.52E+03	5.00E+07	B	3.12E-05	7.30E+02	3.18E+02	1.46E-02	1.71E-19	0.00E+00
DY157	3.39E-01	1.62E+03	1.62E+03	1.61E+03	1.59E+03	1.55E+03	1.25E+08	A	1.29E-05	6.08E+02	2.16E+02	9.02E-04	8.84E-25	0.00E+00
DY159	1.44E+02	1.31E+03	1.31E+03	1.31E+03	1.31E+03	1.31E+03	1.36E+07	A	9.63E-05	1.31E+03	1.31E+03	1.27E+03	1.13E+03	5.45E+02
H0150	1.02E-03	1.40E+02	5.26E+01	4.54E-03	4.23E-12	1.20E-25	4.30E+05	D	1.06E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H0151	4.07E-04	4.16E+02	2.30E+02	1.41E-01	3.19E-09	9.46E-21	4.30E+05	D	3.28E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H0152	1.88E-03	6.20E+02	3.68E+02	3.58E+00	1.00E-04	1.69E-11	4.30E+05	D	8.33E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H0153	1.39E-03	7.01E+02	5.35E+02	2.62E+01	2.56E-02	7.82E-07	4.30E+05	D	6.09E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H0154	8.22E-03	1.02E+03	9.83E+02	6.41E+02	2.06E+02	3.56E+01	4.30E+05	D	1.49E-03	5.18E-16	2.23E-34	0.00E+00	0.00E+00	0.00E+00
H0155	3.33E-02	1.19E+03	1.18E+03	1.07E+03	8.20E+02	5.38E+02	7.90E+07	B	1.35E-05	4.74E-02	1.79E-06	0.00E+00	0.00E+00	0.00E+00
H0156	3.89E-02	1.34E+03	1.14E+03	5.40E+02	2.56E+02	8.82E+01	4.30E+05	D	1.26E-03	5.71E-09	4.39E-20	0.00E+00	0.00E+00	0.00E+00
H0157	8.75E-03	1.45E+03	1.42E+03	1.18E+03	7.35E+02	3.35E+02	1.00E+08	B	1.18E-05	1.88E-06	1.75E-15	0.00E+00	0.00E+00	0.00E+00
H0158	7.64E-03	1.62E+03	1.60E+03	1.46E+03	1.26E+03	1.07E+03	4.30E+05	D	3.40E-03	4.45E+01	1.39E+00	1.19E-18	0.00E+00	0.00E+00
H0159	2.30E-02	1.28E+03	1.27E+03	1.24E+03	1.12E+03	8.63E+02	1.10E+08	B	1.13E-05	1.19E-02	1.42E-08	0.00E+00	0.00E+00	0.00E+00
H0160	9.99E-01	1.15E+03	1.15E+03	1.13E+03	1.11E+03	1.09E+03	4.30E+05	D	2.63E-03	8.30E+02	6.20E+02	1.88E+01	2.24E-05	0.00E+00
H0161	1.03E-01	9.80E+02	9.80E+02	9.78E+02	9.74E+02	9.63E+02	1.40E+09	B	6.99E-07	2.31E+02	2.33E+01	1.15E-12	0.00E+00	0.00E+00
H0162	1.04E-02	5.07E+00	4.84E+00	3.19E+00	1.27E+00	3.17E-01	3.10E+08	B	1.03E-08	1.80E-14	6.41E-29	0.00E+00	0.00E+00	0.00E+00
H0163	1.67E+06	4.14E+02	4.14E+02	4.14E+02	4.14E+02	4.14E+02	4.30E+05	D	9.63E-04	4.14E+02	4.14E+02	4.14E+02	4.14E+02	4.11E+02
ER151	2.72E-04	7.27E+01	1.24E+01	1.06E-06	0.00E+00	0.00E+00	4.30E+05	D	2.47E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ER152	1.17E-04	1.88E+02	1.51E+01	2.38E-06	0.00E+00	0.00E+00	4.30E+05	D	5.53E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ER153	4.29E-04	3.13E+02	1.50E+02	1.73E-02	2.64E-12	2.62E-27	4.30E+05	D	4.02E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ER154	2.56E-03	4.02E+02	3.34E+02	6.33E+01	1.57E+00	6.14E-03	4.30E+05	D	1.47E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ER155	3.68E-03	5.20E+02	4.57E+02	1.41E+02	1.03E+01	2.04E-01	4.30E+05	D	3.28E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ER156	1.35E-02	6.67E+02	6.44E+02	4.68E+02	2.30E+02	7.91E+01	4.30E+05	D	1.09E-03	5.13E-09	3.94E-20	0.00E+00	0.00E+00	0.00E+00
ER157	1.30E-02	9.07E+02	8.89E+02	7.11E+02	4.03E+02	1.69E+02	4.30E+05	D	1.65E-03	8.93E-07	8.33E-16	0.00E+00	0.00E+00	0.00E+00
ER158	9.38E-02	1.29E+03	1.29E+03	1.24E+03	1.13E+03	9.81E+02	4.30E+05	D	2.88E-03	4.09E+01	1.28E+00	1.09E-18	0.00E+00	0.00E+00
ER159	2.50E-02	1.13E+03	1.12E+03	1.03E+03	7.60E+02	4.40E+02	4.30E+05	D	2.40E-03	1.34E-03	1.28E-09	0.00E+00	0.00E+00	0.00E+00
ER160	1.19E+00	1.09E+03	1.09E+03	1.09E+03	1.08E+03	1.07E+03	4.30E+05	D	2.53E-03	8.17E+02	6.11E+02	1.86E+01	2.21E-05	0.00E+00
ER161	1.34E-01	9.50E+02	9.49E+02	9.43E+02	9.16E+02	8.56E+02	4.80E+07	B	1.96E-05	8.52E+01	6.54E+00	2.70E-13	0.00E+00	0.00E+00
ER163	5.21E-02	8.01E+02	8.01E+02	7.97E+02	7.83E+02	7.44E+02	4.30E+05	D	1.85E-03	2.52E+01	2.83E-01	0.00E+00	0.00E+00	0.00E+00
ER165	4.32E-01	1.11E+03	1.11E+03	1.11E+03	1.11E+03	1.11E+03	5.80E+08	B	1.91E-06	1.02E+03	8.55E+02	3.51E+01	8.17E-05	0.00E+00
TM154	9.38E-05	5.91E+01	1.44E-02	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TM155	3.94E-04	1.22E+02	4.19E+01	2.84E-03	1.55E-12	1.98E-26	4.30E+05	D	6.60E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TM156	9.72E-04	2.06E+02	1.23E+02	1.14E+00	3.48E-05	5.86E-12	4.30E+05	D	2.65E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TM157	2.43E-03	2.89E+02	2.38E+02	4.21E+01	8.96E-01	2.78E-03	4.30E+05	D	9.79E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TM158	2.79E-03	6.13E+02	5.34E+02	1.19E+02	3.80E+00	2.16E-02	4.30E+05	D	2.77E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TM159	6.35E-03	7.15E+02	6.75E+02	3.78E+02	8.81E+01	8.93E+00	4.30E+05	D	8.79E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TM160	6.53E-03	7.67E+02	7.34E+02	4.49E+02	1.14E+02	1.23E+01	4.30E+05	D	1.04E-03	3.15E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TM161	2.64E-02	8.14E+02	8.05E+02	6.90E+02	4.43E+02	2.22E+02	4.30E+05	D	1.60E-03	5.29E-05	3.16E-12	0.00E+00	0.00E+00	0.00E+00

Nuclide ID	Half Life (days)	Time (s) INITIAL	6.00E+01 1 min.	6.00E+02 10 min.	1.80E+03 30 min.	3.60E+03 1 hour	Threshold (Cat 2)	TS	Fraction of Cat. 2	4.32E+04 12 hours	8.64E+04 1 day	6.05E+05 1 week	2.63E+06 1 month	1.58E+07 6 months
TM162	1.51E-02	1.34E+03	1.33E+03	1.21E+03	8.74E+02	4.55E+02	2.90E+07	B	4.17E-05	8.79E-07	9.98E-17	0.00E+00	0.00E+00	0.00E+00
TM163	7.54E-02	7.70E+02	7.69E+02	7.49E+02	6.80E+02	5.68E+02	4.30E+05	D	1.74E-03	8.63E+00	8.94E-02	0.00E+00	0.00E+00	0.00E+00
TM164	1.39E-03	1.38E+03	1.35E+03	1.22E+03	1.02E+03	7.74E+02	4.30E+05	D	2.84E-03	1.85E+00	2.56E-03	0.00E+00	0.00E+00	0.00E+00
TM165	1.25E+00	1.10E+03	1.10E+03	1.10E+03	1.09E+03	1.08E+03	4.30E+05	D	2.56E-03	8.41E+02	6.38E+02	2.30E+01	5.36E-05	0.00E+00
TM166	3.24E-01	2.18E+03	2.18E+03	2.18E+03	2.18E+03	2.17E+03	1.90E+07	B	1.15E-04	2.04E+03	1.82E+03	3.19E+02	3.29E-01	1.24E-20
TM167	9.24E+00	1.98E+03	1.98E+03	1.98E+03	1.98E+03	1.98E+03	1.10E+07	B	1.80E-04	1.92E+03	1.85E+03	1.18E+03	2.04E+02	2.23E-03
TM168	9.31E+01	3.38E+00	3.38E+00	3.38E+00	3.38E+00	3.38E+00	4.30E+05	D	7.86E-06	3.37E+00	3.35E+00	3.21E+00	2.69E+00	8.66E-01
YB155	1.98E-05	2.03E+01	2.85E-03	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
YB156	3.02E-04	4.06E+01	8.15E+00	1.41E-06	0.00E+00	0.00E+00	4.30E+05	D	3.28E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
YB157	4.47E-04	1.20E+02	4.85E+01	8.95E-04	2.12E-14	2.46E-30	4.30E+05	D	2.08E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
YB158	1.15E-03	1.52E+02	8.10E+01	2.79E-01	9.39E-07	5.79E-15	4.30E+05	D	6.49E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
YB159	9.72E-04	1.86E+02	1.60E+02	4.12E+01	2.02E+00	2.20E-02	4.30E+05	D	9.58E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
YB160	3.33E-03	3.41E+02	2.95E+02	8.05E+01	4.49E+00	5.89E-02	4.30E+05	D	1.87E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
YB161	2.92E-03	4.46E+02	3.78E+02	8.56E+01	3.16E+00	2.23E-02	4.30E+05	D	1.99E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
YB162	1.31E-02	1.01E+03	9.86E+02	7.23E+02	3.47E+02	1.15E+02	1.90E+08	B	3.81E-06	3.41E-09	1.12E-20	0.00E+00	0.00E+00	0.00E+00
YB163	7.67E-03	5.66E+02	5.31E+02	3.01E+02	8.49E+01	1.27E+01	4.30E+05	D	7.00E-04	9.50E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00
YB164	5.25E-02	1.27E+03	1.26E+03	1.19E+03	9.91E+02	7.54E+02	4.30E+05	D	2.77E-03	1.80E+00	2.49E-03	0.00E+00	0.00E+00	0.00E+00
YB165	6.88E-03	1.04E+03	1.02E+03	7.94E+02	3.57E+02	8.29E+01	4.30E+05	D	1.85E-03	1.93E-15	8.34E-34	0.00E+00	0.00E+00	0.00E+00
YB166	2.36E+00	2.15E+03	2.15E+03	2.14E+03	2.14E+03	2.12E+03	1.00E+07	B	2.14E-04	1.86E+03	1.60E+03	2.76E+02	2.84E-01	1.07E-20
YB167	1.22E-02	1.97E+03	1.97E+03	1.92E+03	1.70E+03	1.26E+03	1.70E+08	B	1.13E-05	1.89E-01	1.17E-05	0.00E+00	0.00E+00	0.00E+00
YB169	3.20E+01	1.87E+03	1.87E+03	1.87E+03	1.87E+03	1.87E+03	4.00E+06	A	4.68E-04	1.86E+03	1.86E+03	1.67E+03	1.01E+03	3.72E+01
LU162	9.51E-04	4.26E+02	2.60E+02	3.01E+00	1.51E-04	5.35E-11	4.30E+05	D	7.00E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LU164	2.18E-03	8.09E+02	6.50E+02	9.09E+01	1.15E+00	1.62E-03	4.30E+05	D	2.11E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LU165	7.45E-03	7.62E+02	7.19E+02	4.24E+02	1.31E+02	2.25E+01	4.30E+05	D	9.86E-04	3.27E-16	1.34E-34	0.00E+00	0.00E+00	0.00E+00
LU166	5.31E-03	2.02E+03	1.85E+03	7.98E+02	1.06E+02	4.93E+00	4.30E+05	D	1.86E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LU167	3.58E-02	1.90E+03	1.89E+03	1.74E+03	1.34E+03	8.95E+02	4.30E+05	D	4.05E-03	1.24E-01	7.69E-06	0.00E+00	0.00E+00	0.00E+00
LU168	3.82E-03	2.14E+03	2.11E+03	1.80E+03	1.12E+03	5.08E+02	4.30E+05	D	4.19E-03	1.12E-05	4.99E-14	0.00E+00	0.00E+00	0.00E+00
LU169	1.42E+00	1.84E+03	1.84E+03	1.84E+03	1.83E+03	1.81E+03	1.50E+07	B	1.23E-04	1.45E+03	1.13E+03	6.05E+01	6.46E-04	0.00E+00
LU170	2.00E+00	3.24E+03	3.24E+03	3.24E+03	3.24E+03	3.24E+03	7.20E+06	B	4.50E-04	3.11E+03	2.85E+03	4.32E+02	1.39E-01	0.00E+00
LU171	8.24E+00	2.40E+03	2.40E+03	2.40E+03	2.40E+03	2.40E+03	9.60E+06	B	2.50E-04	2.37E+03	2.31E+03	1.42E+03	1.96E+02	5.13E-04
LU172	6.70E+00	3.95E+03	3.95E+03	3.95E+03	3.95E+03	3.95E+03	5.10E+06	B	7.75E-04	3.95E+03	3.95E+03	3.93E+03	3.85E+03	3.30E+03
LU173	5.00E+02	1.68E+03	1.68E+03	1.68E+03	1.68E+03	1.68E+03	1.50E+06	B	1.12E-03	1.68E+03	1.68E+03	1.67E+03	1.62E+03	1.31E+03
LU174	1.21E+03	8.30E+00	8.30E+00	8.30E+00	8.30E+00	8.30E+00	8.92E+05	A	9.30E-06	8.30E+00	8.30E+00	8.27E+00	8.16E+00	7.48E+00
LU176	1.32E+13	1.95E-09	1.95E-09	1.95E-09	1.95E-09	1.95E-09	4.50E+04	A	4.33E-14	1.95E-09	1.95E-09	1.95E-09	1.95E-09	1.95E-09
HF159	6.48E-05	3.38E+00	2.01E-03	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HF160	1.39E-04	6.76E+00	2.11E-01	6.00E-15	0.00E+00	0.00E+00	4.30E+05	D	1.40E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HF161	1.97E-04	4.73E+01	5.52E+00	1.52E-09	0.00E+00	0.00E+00	4.30E+05	D	3.53E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HF166	4.70E-03	1.34E+03	1.24E+03	4.98E+02	6.42E+01	2.98E+00	4.30E+05	D	1.16E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HF167	1.42E-03	1.51E+03	1.27E+03	2.02E+02	1.97E+00	1.55E-03	4.30E+05	D	4.70E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HF168	9.99E-01	1.87E+03	1.84E+03	1.52E+03	8.93E+02	4.01E+02	4.30E+05	D	3.53E-03	8.85E-06	3.93E-14	0.00E+00	0.00E+00	0.00E+00
HF169	2.25E-03	1.69E+03	1.57E+03	6.34E+02	4.90E+01	8.04E-01	4.30E+05	D	1.47E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HF170	6.67E-01	3.14E+03	3.14E+03	3.13E+03	3.10E+03	3.03E+03	2.10E+07	B	1.49E-04	1.88E+03	1.11E+03	2.11E+00	4.87E-11	0.00E+00
HF171	5.05E-01	2.36E+03	2.36E+03	2.35E+03	2.33E+03	2.29E+03	4.30E+05	D	5.47E-03	1.23E+03	6.17E+02	1.60E-01	1.58E-15	0.00E+00
HF172	6.83E+02	3.93E+03	3.93E+03	3.93E+03	3.93E+03	3.93E+03	1.10E+05	B	3.57E-02	3.93E+03	3.93E+03	3.90E+03	3.81E+03	3.27E+03
HF173	1.00E+00	1.66E+03	1.66E+03	1.66E+03	1.66E+03	1.66E+03	4.50E+07	B	3.69E-05	1.36E+03	9.77E+02	1.53E+01	1.35E-06	0.00E+00
HF175	7.00E+01	3.81E+03	3.81E+03	3.81E+03	3.81E+03	3.81E+03	6.35E+06	A	6.00E-04	3.80E+03	3.79E+03	3.57E+03	2.83E+03	6.26E+02
TA166	3.98E-04	5.73E+02	1.56E+02	1.30E-03	6.68E-15	7.81E-32	4.30E+05	D	3.02E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TA167	9.99E-01	7.67E+02	6.04E+02	7.03E+01	5.90E-01	4.54E-04	4.30E+05	D	1.63E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TA168	9.99E-01	1.19E+03	8.98E+02	6.97E+01	2.37E-01	4.73E-05	4.30E+05	D	1.62E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TA169	3.40E-03	1.15E+03	1.00E+03	2.88E+02	1.80E+01	2.81E-01	4.30E+05	D	6.70E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TA170	4.70E-03	2.74E+03	2.61E+03	1.39E+03	2.18E+02	1.06E+01	4.30E+05	D	3.23E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TA171	1.62E-02	2.14E+03	2.11E+03	1.79E+03	1.10E+03	4.72E+02	4.30E+05	D	4.16E-03	1.43E-06	7.11E-16	0.00E+00	0.00E+00	0.00E+00
TA172	2.56E-02	3.79E+03	3.78E+03	3.48E+03	2.54E+03	1.46E+03	2.50E+07	B	1.39E-04	6.26E-03	8.69E-09	0.00E+00	0.00E+00	0.00E+00
TA173	1.31E-01	1.57E+03	1.57E+03	1.55E+03	1.49E+03	1.37E+03	4.80E+07	B	3.23E-05	1.70E+02	1.74E+01	2.30E-11	0.00E+00	0.00E+00
TA174	4.92E-02	3.97E+03	3.96E+03	3.90E+03	3.61E+03	2.97E+03	4.90E+07	B	7.96E-05	2.47E+00	8.30E-04	0.00E+00	0.00E+00	0.00E+00
TA175	4.38E-01	3.79E+03	3.79E+03	3.78E+03	3.76E+03	3.69E+03	3.40E+07	B	1.11E-04	1.82E+03	8.24E+02	6.11E-02	4.56E-18	0.00E+00
TA176	3.37E-01	3.78E+03	3.78E+03	3.78E+03	3.77E+03	3.73E+03	1.50E+07	B	2.52E-04	1.85E+03	6.74E+02	2.90E-03	3.20E-24	0.00E+00
TA177	2.36E+00	3.62E+03	3.62E+03	3.62E+03	3.62E+03	3.62E+03	9.00E+07	B	4.02E-05	3.26E+03	2.82E+03	4.82E+02	4.92E-01	1.66E-20
TA178	6.47E-03	4.87E+03	4.86E+03	4.83E+03	4.80E+03	4.79E+03	2.00E+08	B	2.42E-05	4.72E+03	4.65E+03	3.83E+03	1.80E+03	1.32E+01
TA179	6.46E+02	4.79E+03	4.79E+03	4.79E+03	4.79E+03	4.79E+03	4.90E+06	A	9.78E-04	4.79E+03	4.78E+03	4.75E+03	4.64E+03	3.96E+03
TA182	1.15E+02	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.69E+00	7.59E+05	A	2.23E-06	1.68E+00	1.68E+00	1.62E+00	1.41E+00	5.61E-01
TA183	5.10E+00	1.69E+00	1.69E+00	1.69E+00	1.68E+00	1.68E+00	5.95E+06	A	2.84E-07	1.58E+00	1.47E+00	6.40E-01	2.48E-02	1.65E-11
W165	5.90E-05	3.21E+01	1.30E-02	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W166	1.85E-04	1.25E+02	1.12E+01	7.82E-10	0.00E+00	0.00E+00	4.30E+05	D	1.82E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Nuclide ID	Half Life (days)	Time (s) INITIAL	6.00E+01 1 min.	6.00E+02 10 min.	1.80E+03 30 min.	3.60E+03 1 hour	Threshold (Cat 2)	TS	Fraction of Cat. 2	4.32E+04 12 hours	8.64E+04 1 day	6.05E+05 1 week	2.63E+06 1 month	1.58E+07 6 months
W170	9.99E-01	1.54E+03	1.32E+03	2.77E+02	8.66E+00	4.78E-02	4.30E+05	D	6.44E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W171	9.99E-01	1.15E+03	1.06E+03	5.30E+02	1.14E+02	1.13E+01	4.30E+05	D	1.23E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W172	4.63E-03	3.07E+03	2.89E+03	1.16E+03	1.46E+02	6.57E+00	4.30E+05	D	2.70E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W173	9.99E-01	1.09E+03	1.04E+03	7.16E+02	3.09E+02	8.76E+01	4.30E+05	D	1.67E-03	7.98E-11	5.84E-24	0.00E+00	0.00E+00	0.00E+00
W174	2.04E-02	3.62E+03	3.59E+03	3.05E+03	1.90E+03	9.27E+02	4.30E+05	D	7.09E-03	1.31E-04	4.39E-12	0.00E+00	0.00E+00	0.00E+00
W175	2.36E-02	3.57E+03	3.56E+03	3.21E+03	2.22E+03	1.21E+03	4.30E+05	D	7.47E-03	1.73E-03	7.31E-10	0.00E+00	0.00E+00	0.00E+00
W176	9.63E-02	3.63E+03	3.63E+03	3.56E+03	3.26E+03	2.81E+03	8.60E+07	C	4.14E-05	1.02E+02	2.74E+00	3.84E-19	0.00E+00	0.00E+00
W177	9.38E-02	3.54E+03	3.54E+03	3.50E+03	3.30E+03	2.89E+03	4.90E+07	B	7.14E-05	9.82E+01	2.44E+00	1.30E-19	0.00E+00	0.00E+00
W178	2.16E+01	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.79E+03	1.10E+08	B	4.36E-05	4.72E+03	4.65E+03	3.83E+03	1.80E+03	1.32E+01
W179	2.60E-02	4.77E+03	4.77E+03	4.72E+03	4.36E+03	3.28E+03	8.40E+08	B	5.62E-06	2.29E-02	3.81E-08	0.00E+00	0.00E+00	0.00E+00
W179M	4.44E-03	3.33E+03	3.33E+03	3.18E+03	2.21E+03	8.91E+02	2.20E+08	C*	1.45E-05	7.57E-08	7.54E-19	0.00E+00	0.00E+00	0.00E+00
W181	1.21E+02	5.39E+03	5.39E+03	5.39E+03	5.39E+03	5.39E+03	1.74E+08	A	3.10E-05	5.39E+03	5.38E+03	5.22E+03	4.56E+03	1.90E+03
W183M	6.02E-05	8.96E-01	8.96E-01	8.95E-01	8.93E-01	8.90E-01	4.30E+05	D	2.08E-06	8.36E-01	7.80E-01	3.39E-01	1.32E-02	8.75E-12
W185	7.51E+01	6.76E+00	6.76E+00	6.76E+00	6.76E+00	6.76E+00	3.81E+07	A	1.77E-07	6.73E+00	6.70E+00	6.34E+00	5.10E+00	1.25E+00
W188	6.94E+01	1.69E+00	1.69E+00	1.69E+00	1.69E+00	1.69E+00	6.97E+06	A	2.42E-07	1.68E+00	1.67E+00	1.58E+00	1.25E+00	2.72E-01
RE170	9.26E-05	6.10E+02	4.15E+00	1.99E-20	0.00E+00	0.00E+00	4.30E+05	D	4.63E-26	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE172	1.74E-04	1.96E+03	6.16E+02	2.61E-03	2.37E-15	2.11E-33	4.30E+05	D	6.07E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE174	1.60E-03	2.74E+03	2.20E+03	1.75E+02	5.43E-01	9.38E-05	4.30E+05	D	4.07E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE175	9.99E-01	2.88E+03	2.61E+03	7.54E+02	3.72E+01	4.05E-01	4.30E+05	D	1.75E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE176	3.94E-03	3.18E+03	2.96E+03	1.25E+03	1.11E+02	2.20E+00	1.30E+08	C	9.62E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE177	9.72E-03	3.16E+03	3.08E+03	2.19E+03	8.42E+02	1.91E+02	4.90E+07	B	4.47E-05	1.23E-12	4.07E-28	0.00E+00	0.00E+00	0.00E+00
RE178	9.17E-03	4.53E+03	4.46E+03	3.37E+03	1.32E+03	2.80E+02	2.90E+07	B	1.16E-04	2.50E-13	9.51E-30	0.00E+00	0.00E+00	0.00E+00
RE179	1.35E-02	4.61E+03	4.57E+03	4.01E+03	2.34E+03	8.53E+02	4.20E+06	C*	9.55E-04	7.06E-08	7.04E-19	0.00E+00	0.00E+00	0.00E+00
RE180	1.69E-03	5.00E+03	4.81E+03	3.66E+03	1.94E+03	7.44E+02	4.20E+07	C	8.71E-05	5.20E-07	5.35E-17	0.00E+00	0.00E+00	0.00E+00
RE181	8.33E-01	5.33E+03	5.33E+03	5.33E+03	5.32E+03	5.29E+03	2.10E+07	C	2.54E-04	3.82E+03	2.52E+03	1.67E+01	5.17E-08	0.00E+00
RE182	2.67E+00	5.47E+03	5.47E+03	5.47E+03	5.46E+03	5.45E+03	9.19E+06	B	5.95E-04	4.88E+03	3.93E+03	6.42E+01	1.37E-06	0.00E+00
RE183	7.00E+01	5.60E+03	5.60E+03	5.60E+03	5.60E+03	5.60E+03	1.50E+07	B	3.73E-04	5.60E+03	5.58E+03	5.27E+03	4.19E+03	9.47E+02
RE184	3.80E+01	1.30E+02	1.30E+02	1.30E+02	1.30E+02	1.30E+02	7.11E+06	A	1.83E-05	1.29E+02	1.28E+02	1.15E+02	7.47E+01	4.63E+00
RE186	3.78E+00	6.59E+01	6.58E+01	6.58E+01	6.56E+01	6.54E+01	9.49E+06	A	6.93E-06	6.01E+01	5.48E+01	1.82E+01	2.47E-01	1.75E-13
RE188	7.08E-01	5.07E+00	5.07E+00	5.05E+00	5.00E+00	4.93E+00	1.56E+07	A	3.24E-07	3.76E+00	2.95E+00	1.60E+00	1.26E+00	2.75E-01
RE190	2.15E-03	1.69E+00	1.35E+00	1.81E-01	2.06E-03	2.51E-06	4.30E+05	D	4.21E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE192	1.85E-04	1.69E+00	1.26E-01	8.69E-12	0.00E+00	0.00E+00	4.30E+05	D	2.02E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OS169	4.05E-05	8.45E+00	8.86E-06	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OS170	8.22E-05	3.38E+01	9.67E-02	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OS171	9.26E-05	1.33E+02	8.87E-01	1.33E-20	0.00E+00	0.00E+00	4.30E+05	D	3.09E-26	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OS172	2.20E-04	3.19E+02	3.93E+01	1.09E-07	0.00E+00	0.00E+00	4.30E+05	D	2.53E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OS173	1.85E-04	5.44E+02	4.11E+01	2.85E-09	0.00E+00	0.00E+00	4.30E+05	D	6.63E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OS174	5.09E-04	8.82E+02	3.54E+02	8.68E-02	8.15E-10	7.41E-22	4.30E+05	D	2.02E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OS175	9.99E-01	1.24E+03	7.57E+02	8.79E+00	4.40E-04	1.56E-10	4.30E+05	D	2.04E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OS176	2.08E-03	1.54E+03	1.27E+03	2.24E+02	4.77E+00	1.48E-02	4.30E+05	D	5.21E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OS177	2.43E-03	1.70E+03	1.40E+03	2.35E+02	4.48E+00	1.18E-02	4.30E+05	D	5.47E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OS178	3.53E-03	3.24E+03	2.88E+03	8.29E+02	5.18E+01	8.09E-01	4.30E+05	D	1.93E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OS179	4.51E-03	3.66E+03	3.45E+03	1.74E+03	2.51E+02	1.08E+01	4.30E+05	D	4.05E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OS180	1.49E-02	4.28E+03	4.21E+03	3.27E+03	1.72E+03	6.61E+02	5.90E+08	C	5.54E-06	4.62E-07	4.75E-17	0.00E+00	0.00E+00	0.00E+00
OS181	1.88E-03	4.83E+03	4.82E+03	4.64E+03	4.10E+03	3.37E+03	1.30E+08	C	3.57E-05	4.31E+01	3.72E-01	0.00E+00	0.00E+00	0.00E+00
OS182	9.21E-01	5.14E+03	5.14E+03	5.13E+03	5.10E+03	5.03E+03	1.80E+07	B	2.85E-04	3.56E+03	2.45E+03	2.67E+01	5.81E-07	0.00E+00
OS183	5.42E-01	3.43E+03	3.43E+03	3.42E+03	3.40E+03	3.35E+03	2.10E+07	C	1.63E-04	1.98E+03	1.08E+03	5.66E-01	5.40E-14	0.00E+00
OS183M	4.12E-01	2.19E+03	2.19E+03	2.19E+03	2.18E+03	2.15E+03	4.30E+05	D	5.09E-03	1.05E+03	4.53E+02	1.89E-02	1.48E-19	0.00E+00
OS185	9.36E+01	5.31E+03	5.31E+03	5.31E+03	5.31E+03	5.31E+03	4.38E+06	A	1.21E-03	5.30E+03	5.29E+03	5.07E+03	4.26E+03	1.38E+03
OS189M	2.00E-01	8.03E+02	8.03E+02	8.03E+02	8.03E+02	8.03E+02	9.86E+08	A	8.14E-07	8.00E+02	7.90E+02	5.84E+02	1.69E+02	5.31E-02
OS191	1.54E+01	1.69E+01	1.69E+01	1.69E+01	1.69E+01	1.69E+01	7.65E+06	A	2.21E-06	1.65E+01	1.62E+01	1.23E+01	4.29E+00	4.49E-03
OS193	1.27E+00	3.38E+00	3.38E+00	3.37E+00	3.34E+00	3.30E+00	1.48E+07	A	2.28E-07	2.58E+00	1.96E+00	7.51E-02	2.20E-07	0.00E+00
OS196	2.42E-02	1.69E+00	1.66E+00	1.39E+00	9.33E-01	5.15E-01	4.30E+05	D	3.23E-06	1.08E-06	6.97E-13	0.00E+00	0.00E+00	0.00E+00
IR172	9.99E-01	8.45E+00	2.01E-10	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IR173	3.47E-05	1.35E+01	1.29E-05	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IR174	4.63E-05	1.30E+02	4.64E-03	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IR175	5.21E-05	3.12E+02	3.87E-01	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IR176	9.99E-01	5.14E+02	2.84E+00	1.36E-20	0.00E+00	0.00E+00	4.30E+05	D	3.16E-26	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IR177	2.43E-04	8.70E+02	1.29E+02	2.34E-06	0.00E+00	0.00E+00	4.30E+05	D	5.44E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IR178	1.39E-04	1.33E+03	9.28E+01	1.42E-06	0.00E+00	0.00E+00	4.30E+05	D	3.30E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IR179	9.99E-01	1.74E+03	1.49E+03	3.18E+02	9.93E+00	5.49E-02	4.30E+05	D	7.40E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IR180	1.04E-03	2.47E+03	1.72E+03	3.22E+01	3.14E-03	3.00E-09	3.00E+07	C	1.07E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IR181	3.40E-03	3.18E+03	2.87E+03	8.58E+02	5.36E+01	8.38E-01	3.40E+07	C	2.52E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IR182	1.04E-02	3.90E+03	3.79E+03	2.67E+03	1.07E+03	2.68E+02	5.60E+07	B	4.77E-05	1.52E-11	5.42E-26	0.00E+00	0.00E+00	0.00E+00

Nuclide ID	Half Life (days)	Time (s) INITIAL	6.00E+01 1 min.	6.00E+02 10 min.	1.80E+03 30 min.	3.60E+03 1 hour	Threshold (Cat 2)	TS	Fraction of Cat. 2	4.32E+04 12 hours	8.64E+04 1 day	6.05E+05 1 week	2.63E+06 1 month	1.58E+07 6 months
IR183	3.82E-02	4.38E+03	4.35E+03	4.03E+03	3.21E+03	2.21E+03	1.60E+07	C	2.52E-04	5.39E-01	6.18E-05	0.00E+00	0.00E+00	0.00E+00
IR184	1.26E-01	4.97E+03	4.96E+03	4.88E+03	4.62E+03	4.17E+03	2.40E+07	B	2.03E-04	3.37E+02	2.14E+01	9.37E-14	0.00E+00	0.00E+00
IR185	5.79E-01	4.87E+03	4.87E+03	4.85E+03	4.82E+03	4.76E+03	2.50E+07	C	1.94E-04	2.86E+03	1.58E+03	1.26E+00	1.01E-12	0.00E+00
IR186	6.93E-01	5.79E+03	5.79E+03	5.78E+03	5.76E+03	5.72E+03	1.30E+07	C	4.45E-04	3.92E+03	2.40E+03	6.29E+00	5.24E-10	0.00E+00
IR187	4.38E-01	7.12E+03	7.12E+03	7.11E+03	7.08E+03	7.03E+03	5.30E+07	C	1.34E-04	4.03E+03	1.85E+03	1.37E-01	1.03E-17	0.00E+00
IR188	1.73E+00	9.56E+03	9.56E+03	9.56E+03	9.56E+03	9.55E+03	9.90E+06	C	9.66E-04	9.42E+03	9.25E+03	6.61E+03	1.36E+03	4.31E-02
IR189	1.32E+01	1.07E+04	1.07E+04	1.07E+04	1.07E+04	1.07E+04	1.60E+07	C	6.69E-04	1.06E+04	1.04E+04	7.65E+03	2.21E+03	6.95E-01
IR190	1.18E+01	3.28E+02	3.28E+02	3.28E+02	3.27E+02	3.27E+02	4.30E+06	A	7.63E-05	3.18E+02	3.09E+02	2.17E+02	5.47E+01	6.96E-03
IR192	7.38E+01	1.69E+02	1.69E+02	1.69E+02	1.69E+02	1.69E+02	1.22E+06	A	1.39E-04	1.68E+02	1.67E+02	1.58E+02	1.27E+02	3.06E+01
IR194	7.98E-01	7.43E+01	7.43E+01	7.39E+01	7.30E+01	7.17E+01	1.04E+07	A	7.11E-06	4.82E+01	3.12E+01	1.70E-01	2.44E-10	0.00E+00
IR195	1.04E-01	7.26E+01	7.23E+01	6.91E+01	6.25E+01	5.37E+01	1.90E+08	B	3.64E-07	1.95E+00	5.25E-02	7.34E-21	0.00E+00	0.00E+00
IR196	6.02E-04	4.22E+01	1.99E+01	1.44E+00	9.56E-01	5.28E-01	4.30E+05	D	3.35E-06	1.11E-06	7.14E-13	0.00E+00	0.00E+00	0.00E+00
IR197	4.03E-03	2.03E+01	1.89E+01	1.00E+01	2.45E+00	2.97E-01	4.30E+05	D	2.33E-05	2.01E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IR198	9.26E-05	1.01E+01	5.58E-02	2.67E-22	0.00E+00	0.00E+00	4.30E+05	D	6.21E-28	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PT175	2.92E-05	1.95E+01	1.37E-06	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PT176	9.99E-01	5.58E+01	8.85E-02	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PT177	1.27E-04	1.28E+02	3.53E-01	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PT178	2.43E-04	2.16E+02	3.08E+01	6.64E-07	0.00E+00	0.00E+00	4.30E+05	D	1.54E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PT179	4.98E-04	3.66E+02	1.05E+02	1.24E-03	1.40E-14	5.33E-31	4.30E+05	D	2.88E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PT180	6.02E-04	6.61E+02	2.88E+02	1.62E-01	9.65E-09	1.40E-19	4.60E+09	C	3.52E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PT181	5.90E-04	1.17E+03	5.45E+02	3.70E-01	3.19E-08	7.72E-19	1.10E+09	C	3.36E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PT182	1.81E-03	1.77E+03	1.40E+03	1.28E+02	6.20E-01	2.08E-04	4.30E+05	D	2.98E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PT183	4.51E-03	2.30E+03	2.10E+03	8.16E+02	9.67E+01	3.94E+00	4.30E+05	D	1.90E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PT184	1.20E-02	2.93E+03	2.85E+03	2.00E+03	8.98E+02	2.70E+02	2.60E+07	C	7.69E-05	8.86E-10	2.63E-22	0.00E+00	0.00E+00	0.00E+00
PT185	4.92E-02	3.20E+03	3.18E+03	2.96E+03	2.44E+03	1.82E+03	1.60E+07	C	1.85E-04	2.87E+00	2.52E-03	0.00E+00	0.00E+00	0.00E+00
PT185M	9.99E-01	1.87E+02	1.87E+02	1.76E+02	1.26E+02	6.83E+01	4.30E+05	D	4.09E-04	6.52E-05	1.77E-11	0.00E+00	0.00E+00	0.00E+00
PT186	8.33E-02	4.65E+03	4.64E+03	4.49E+03	4.08E+03	3.46E+03	5.00E+07	C	8.98E-05	7.65E+01	1.20E+00	2.48E-22	0.00E+00	0.00E+00
PT187	9.79E-02	6.36E+03	6.35E+03	6.20E+03	5.71E+03	4.95E+03	3.60E+07	C	1.72E-04	1.93E+02	5.60E+00	1.97E-18	0.00E+00	0.00E+00
PT188	1.02E+01	8.93E+03	8.93E+03	8.93E+03	8.92E+03	8.91E+03	4.30E+06	C	2.08E-03	8.64E+03	8.35E+03	5.55E+03	1.13E+03	3.58E-02
PT189	4.54E-01	1.02E+04	1.02E+04	1.02E+04	1.00E+04	9.78E+03	3.80E+07	C	2.68E-04	4.87E+03	2.27E+03	2.32E-01	6.14E-17	0.00E+00
PT191	2.91E+00	1.31E+04	1.31E+04	1.31E+04	1.31E+04	1.31E+04	3.92E+07	A	3.34E-04	1.22E+04	1.09E+04	2.72E+03	1.21E+01	6.13E-15
PT193	1.85E+04	5.68E+03	5.68E+03	5.68E+03	5.68E+03	5.68E+03	1.36E+08	A	4.18E-05	5.68E+03	5.68E+03	5.68E+03	5.68E+03	5.64E+03
PT197	7.63E-01	5.52E+02	5.51E+02	5.48E+02	5.42E+02	5.32E+02	5.38E+07	A	1.02E-05	3.51E+02	2.23E+02	9.51E-01	5.31E-10	0.00E+00
PT197M	6.54E-02	1.01E+01	1.01E+01	9.92E+00	8.93E+00	7.26E+00	1.85E+08	A	5.36E-08	5.72E-02	2.89E-04	0.00E+00	0.00E+00	0.00E+00
PT199	2.14E-02	2.72E+02	2.66E+02	2.18E+02	1.39E+02	7.06E+01	1.90E+08	B	1.15E-06	2.50E-05	2.30E-12	0.00E+00	0.00E+00	0.00E+00
PT200	5.21E-01	1.95E+02	1.95E+02	1.93E+02	1.90E+02	1.85E+02	1.90E+07	B	1.02E-05	1.01E+02	5.21E+01	1.88E-02	6.86E-16	0.00E+00
PT201	1.74E-03	6.36E+01	4.82E+01	3.98E+00	1.55E-02	3.79E-06	4.30E+05	D	9.26E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU178	3.01E-05	1.18E+01	1.34E-06	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU179	8.68E-05	4.30E+01	1.34E-01	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU181	1.32E-04	1.98E+02	5.21E+00	2.14E-14	0.00E+00	0.00E+00	4.30E+05	D	4.98E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU182	2.43E-04	3.96E+02	6.45E+01	2.88E-06	0.00E+00	0.00E+00	4.30E+05	D	6.70E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU183	4.86E-04	5.74E+02	2.18E+02	2.95E-02	7.39E-11	9.27E-24	4.30E+05	D	6.86E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU184	6.13E-04	9.34E+02	4.59E+02	4.29E-01	6.56E-08	3.92E-18	5.80E+07	C	7.40E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU185	3.01E-03	1.14E+03	9.66E+02	2.27E+02	9.02E+00	7.16E-02	5.10E+07	C	4.45E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU185M	9.99E-01	1.87E+02	1.81E+02	7.63E+01	9.94E+00	4.67E-01	4.30E+05	D	1.77E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU186	7.41E-03	2.42E+03	2.30E+03	1.31E+03	3.58E+02	5.13E+01	5.00E+07	C	2.62E-05	1.39E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU187	5.83E-03	3.98E+03	3.74E+03	1.93E+03	3.83E+02	3.32E+01	5.30E+07	C	3.64E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU188	6.13E-03	6.24E+03	5.93E+03	3.33E+03	7.28E+02	6.95E+01	4.30E+05	D	7.74E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU189	1.99E-02	4.24E+03	4.14E+03	3.33E+03	2.06E+03	9.96E+02	2.20E+07	C	1.51E-04	1.19E-04	3.34E-12	0.00E+00	0.00E+00	0.00E+00
AU189M	3.19E-03	3.70E+03	3.68E+03	2.64E+03	6.80E+02	6.58E+01	5.00E+07	C*	5.28E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU190	2.97E-02	1.00E+04	9.97E+03	9.23E+03	7.43E+03	5.02E+03	2.30E+07	C	4.01E-04	1.28E-01	1.11E-06	0.00E+00	0.00E+00	0.00E+00
AU191	1.32E-01	1.17E+04	1.17E+04	1.15E+04	1.11E+04	1.03E+04	5.90E+07	C	1.95E-04	1.03E+03	7.52E+01	1.74E-12	0.00E+00	0.00E+00
AU191M	1.06E-05	6.75E+03	6.67E+03	5.92E+03	4.48E+03	2.93E+03	5.90E+07	C*	1.00E-04	2.59E-01	9.77E-06	0.00E+00	0.00E+00	0.00E+00
AU192	2.06E-01	1.38E+04	1.38E+04	1.37E+04	1.35E+04	1.31E+04	2.00E+07	C	6.85E-04	5.43E+03	1.54E+03	1.35E-05	0.00E+00	0.00E+00
AU193	7.35E-01	1.55E+04	1.55E+04	1.55E+04	1.54E+04	1.53E+04	6.50E+07	B	2.38E-04	1.11E+04	7.01E+03	2.34E+01	4.94E-09	0.00E+00
AU194	1.58E+00	5.64E+03	5.64E+03	5.63E+03	5.60E+03	5.56E+03	1.77E+07	A	3.18E-04	4.72E+03	3.97E+03	1.02E+03	7.61E+02	7.60E+02
AU195	1.86E+02	2.25E+04	2.25E+04	2.25E+04	2.25E+04	2.25E+04	2.37E+06	A	9.49E-03	2.25E+04	2.25E+04	2.20E+04	2.01E+04	1.13E+04
AU195M	3.53E-04	4.54E+02	4.54E+02	4.49E+02	4.40E+02	4.25E+02	3.22E+08	A	1.39E-06	1.92E+02	8.01E+01	2.18E-03	3.27E-21	0.00E+00
AU196	6.18E+00	5.11E+03	5.11E+03	5.11E+03	5.10E+03	5.09E+03	1.30E+08	B	3.93E-05	4.83E+03	4.57E+03	2.33E+03	1.68E+02	6.38E-06
AU197M	9.03E-05	3.34E-01	3.34E-01	3.28E-01	2.95E-01	2.40E-01	4.30E+05	D	7.63E-07	1.89E-03	9.56E-06	0.00E+00	0.00E+00	0.00E+00
AU198	2.70E+00	6.74E+03	6.74E+03	6.73E+03	6.70E+03	6.67E+03	1.44E+07	A	4.67E-04	5.93E+03	5.21E+03	1.11E+03	2.70E+00	2.62E-17
AU199	3.14E+00	7.43E+03	7.43E+03	7.42E+03	7.40E+03	7.36E+03	1.85E+07	A	4.01E-04	6.66E+03	5.96E+03	1.59E+03	9.12E+00	2.42E-14
AU200	3.36E-02	5.00E+03	4.93E+03	4.36E+03	3.32E+03	2.23E+03	9.90E+07	B	4.40E-05	1.08E+02	5.57E+01	2.01E-02	7.33E-16	0.00E+00
AU201	1.81E-02	5.18E+03	5.05E+03	3.97E+03	2.33E+03	1.05E+03	5.10E+08	B	7.78E-06	2.39E-05	1.10E-13	0.00E+00	0.00E+00	0.00E+00

Nuclide ID	Half Life (days)	Time (s) INITIAL	6.00E+01 1 min.	6.00E+02 10 min.	1.80E+03 30 min.	3.60E+03 1 hour	Threshold (Cat 2)	TS	Fraction of Cat. 2	4.32E+04 12 hours	8.64E+04 1 day	6.05E+05 1 week	2.63E+06 1 month	1.58E+07 6 months
AU202	3.33E-04	1.21E+03	2.89E+02	7.16E-04	2.50E-16	0.00E+00	4.30E+05	D	1.67E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU203	6.13E-04	1.06E+03	4.82E+02	4.13E-01	6.31E-08	3.77E-18	4.30E+05	D	9.60E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU204	4.61E-04	1.50E+02	5.29E+01	4.56E-03	4.25E-12	1.21E-25	4.30E+05	D	1.06E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HG180	3.47E-05	8.45E+00	5.00E-06	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HG181	4.17E-05	2.37E+01	2.27E-04	0.00E+00	0.00E+00	0.00E+00	4.30E+05	D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HG182	1.31E-04	3.55E+01	8.95E-01	3.68E-15	0.00E+00	0.00E+00	4.30E+05	D	8.56E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HG183	1.02E-04	6.42E+01	5.69E-01	1.92E-19	0.00E+00	0.00E+00	4.30E+05	D	4.47E-25	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HG184	3.54E-04	1.20E+02	3.13E+01	1.53E-04	2.39E-16	5.17E-34	7.30E+07	C	2.10E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HG185	5.67E-04	1.96E+02	8.24E+01	3.38E-02	1.01E-09	5.25E-21	2.20E+07	C	1.54E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HG186	9.58E-04	5.12E+02	3.16E+02	3.93E+00	2.26E-04	9.89E-11	1.00E+08	C	3.93E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HG187	1.67E-03	1.05E+03	7.96E+02	6.57E+01	2.57E-01	6.27E-05	7.30E+06	C	9.00E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HG188	2.26E-03	2.40E+03	1.96E+03	2.95E+02	4.15E+00	6.89E-03	7.00E+07	C	4.21E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HG189	5.28E-03	3.70E+03	3.44E+03	1.70E+03	3.45E+02	3.16E+01	4.30E+05	D	3.95E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HG190	1.39E-02	5.36E+03	5.20E+03	3.86E+03	1.93E+03	6.84E+02	1.10E+08	C	3.51E-05	7.97E-08	1.16E-18	0.00E+00	0.00E+00	0.00E+00
HG191	3.36E-02	6.75E+03	6.66E+03	5.92E+03	4.48E+03	2.93E+03	2.90E+07	C	2.04E-04	2.59E-01	9.77E-06	0.00E+00	0.00E+00	0.00E+00
HG192	2.03E-01	9.01E+03	9.00E+03	8.82E+03	8.43E+03	7.85E+03	7.40E+06	C	1.19E-03	1.63E+03	2.93E+02	3.36E-07	0.00E+00	0.00E+00
HG193	1.59E-01	1.05E+04	1.05E+04	1.02E+04	9.59E+03	8.72E+03	6.10E+05	C	1.67E-02	9.90E+02	9.19E+01	3.75E-11	0.00E+00	0.00E+00
HG194	1.90E+05	1.13E+03	1.13E+03	1.13E+03	1.13E+03	1.13E+03	1.90E+04	C	5.97E-02	1.13E+03	1.13E+03	1.13E+03	1.13E+03	1.13E+03
HG195	4.12E-01	1.75E+04	1.74E+04	1.73E+04	1.69E+04	1.63E+04	5.30E+05	C	3.26E-02	7.39E+03	3.08E+03	8.39E-02	1.26E-19	0.00E+00
HG197	2.67E+00	1.17E+05	1.17E+05	1.17E+05	1.16E+05	1.16E+05	1.80E+05	C	6.50E-01	1.03E+05	9.04E+04	1.91E+04	4.36E+01	2.95E-16
HG203	4.66E+01	8.32E+04	8.32E+04	8.32E+04	8.32E+04	8.31E+04	1.10E+05	C	7.56E-01	8.26E+04	8.20E+04	7.50E+04	5.30E+04	5.53E+03
HG205	3.61E-03	3.60E+03	3.15E+03	9.49E+02	6.60E+01	1.21E+00	4.30E+05	D	2.21E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TL184	1.27E-04	3.38E+00	7.71E-02	1.29E-16	0.00E+00	0.00E+00	4.30E+05	D	3.00E-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TL186	3.18E-04	1.18E+01	2.68E+00	4.19E-06	5.26E-19	0.00E+00	4.30E+05	D	9.74E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TL188	8.19E-04	1.52E+02	8.49E+01	4.37E-01	3.57E-06	8.33E-14	4.30E+05	D	1.02E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TL189	1.60E-03	3.53E+02	2.16E+02	2.52E+00	1.26E-04	4.47E-11	4.30E+05	D	5.86E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TL190	1.81E-03	7.03E+02	5.40E+02	4.94E+01	2.39E-01	8.03E-05	4.30E+05	D	1.15E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TL191	9.99E-01	8.97E+02	7.87E+02	2.39E+02	1.68E+01	3.12E-01	4.30E+05	D	5.56E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TL192	7.50E-03	1.17E+03	1.09E+03	6.16E+02	1.71E+02	2.49E+01	4.30E+05	D	1.43E-03	1.00E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TL193	1.50E-02	1.49E+03	1.44E+03	1.07E+03	5.56E+02	2.07E+02	4.30E+05	D	2.49E-03	7.15E-08	3.42E-18	0.00E+00	0.00E+00	0.00E+00
TL194	2.29E-02	1.79E+03	1.75E+03	1.45E+03	9.54E+02	5.08E+02	6.80E+07	B	2.13E-05	4.85E-04	1.31E-10	0.00E+00	0.00E+00	0.00E+00
TL195	4.83E-02	2.02E+03	2.00E+03	1.83E+03	1.50E+03	1.11E+03	3.90E+07	B	4.69E-05	1.55E+00	1.19E-03	0.00E+00	0.00E+00	0.00E+00
TL195M	4.17E-05	2.03E+01	1.95E+01	1.33E+01	5.73E+00	1.61E+00	4.30E+05	D	3.09E-05	1.24E-12	7.55E-26	0.00E+00	0.00E+00	0.00E+00
TL196	7.67E-02	2.28E+03	2.27E+03	2.14E+03	1.89E+03	1.56E+03	2.60E+07	B	8.23E-05	2.48E+01	2.70E-01	0.00E+00	0.00E+00	0.00E+00
TL197	1.18E-01	2.62E+03	2.61E+03	2.51E+03	2.32E+03	2.05E+03	1.00E+08	B	2.51E-05	1.40E+02	7.50E+00	4.03E-15	0.00E+00	0.00E+00
TL198	2.21E-01	2.65E+03	2.65E+03	2.60E+03	2.48E+03	2.33E+03	2.20E+07	B	1.18E-04	5.52E+02	1.15E+02	7.56E-07	0.00E+00	0.00E+00
TL199	3.09E-01	2.43E+03	2.43E+03	2.40E+03	2.32E+03	2.22E+03	1.40E+08	B	1.71E-05	7.94E+02	2.59E+02	3.70E-04	0.00E+00	0.00E+00
TL200	1.09E+00	1.86E+03	1.86E+03	1.86E+03	1.84E+03	1.81E+03	2.67E+07	A	6.97E-05	1.35E+03	9.85E+02	2.15E+01	6.99E-06	0.00E+00
TL201	3.04E+00	1.32E+03	1.32E+03	1.32E+03	1.32E+03	1.31E+03	1.06E+08	A	1.25E-05	1.18E+03	1.05E+03	2.71E+02	1.35E+00	1.40E-15
TL202	1.22E+01	7.20E+02	7.20E+02	7.19E+02	7.19E+02	7.18E+02	2.40E+07	A	3.00E-05	7.00E+02	6.80E+02	4.84E+02	1.28E+02	2.27E-02

EXHIBIT C

INITIAL LOOK AT SNS SPALLATION PRODUCT TRANSPORT

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EXHIBIT C. INITIAL LOOK AT SNS SPALLATION PRODUCT TRANSPORT

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I. General Comments About Chemical Reactions in Mercury

Liquid mercury can act like a solvent to promote the reaction of materials that are dissolved in it. The products of reaction may or may not contain mercury. For example, metals in mercury may react to form intermetallic compounds. These compounds may be the same as those that would form without mercury or they may contain mercury. Mercury could be used as a low temperature medium for making some metal alloys.

In a mercury spallation neutron source, the spallation products can react with each other and with mercury. The rare earth-mercury phase diagrams will be very similar (with the possible exception of europium). Thus, rare earth-mercury intermetallic compounds in the mercury source would most likely contain a variety of different rare earth elements: La, Nd, Gd, Sm, etc.

Material in mercury could be in different physical forms. It may be a true solution where the elements are “dissolved” in the liquid mercury and are in the liquid state (compare to salt dissolved in water). It could also be a suspension of solid particles in mercury. This form would occur when the solubility in mercury was exceeded or when a compound formed.

II. Iodine in a Mercury Spallation Neutron Source

It is not likely that iodine in a mercury spallation neutron source would be in the form of unreacted elemental iodine. In pure mercury it would react to form mercurous iodide Hg_2I_2. However, iodine forms compounds with spallation products such as cesium, barium, and the rare earths that are much more stable than Hg_2I_2.

The question: What does iodine do in a mercury spallation neutron source that is sparged with He at 110ºC can best be answered by looking at the iodides.

The vapor pressure of I_2 over Hg_2I_2 is very low. The value calculated at 110ºC for the reaction $Hg_2I_2 = 2\ Hg + I_2$ (gas) was only ~10^{-16} atmospheres. However, mercurous iodide Hg_2I_2 can dissociate into mercury and mercuric iodide, HgI_2:

$$Hg_2I_2 = Hg + HgI_2\ (\text{gas})\ .$$

At 110°C the partial pressure of the HgI_2 (gas) was calculated as ~7×10^{-6} atmospheres. This is still not very high, but some iodine could be lost. However, as noted, the spallation product iodides can be much more stable than the mercury iodides. The vapor pressure of iodine species over LaI_3 was calculated as ~4×10^{-27} atmospheres at 110°C, and the vapor pressure over CsI was only ~2×10^{-19} atmospheres at this temperature.

It should be noted that air would react with the iodides and convert them to oxides while releasing iodine as elemental iodine. This may be a concern in an accident situation. In summary, purging with He at 110°C could remove a small amount of iodine in the form of gaseous HgI_2. If equilibrium conditions prevail with the spallation products, iodine release should be very low. Mercuric iodide gas would be trapped in the off-gas system condenser. Its vapor pressure at –20°C is only ~4×10^{-11} atmospheres.

III. Gadolinium and Hafnium Spallation Products

Hafnium and gadolinium are very reactive with oxygen. This is true of the other rare earths as well. This means that any oxygen in the He purge gas would be scavenged to form an oxide. Thus, depending on the purity of the He, hafnium and gadolinium could be in the mercury as metals or as the oxides HfO_2 or Gd_2O_3. The solubility of Gd in He at 100°C has been reported as 5×10^{-2} atom%.[1] Several rare earth-mercury compounds are known. As noted, these compounds would most likely contain a variety of rare earth elements.

There are no data available for the solubility of hafnium in mercury, but by comparison with zirconium, it is very low. A hafnium-mercury compound Hf_2Hg could form.

In summary, gadolinium could be in the form of an oxide; it could be dissolved in liquid mercury; or it could form an intermetallic compound that may or may not contain mercury. I can't conceive of any mechanism where it could be airborne at 110°C. The vapor pressure of Gd would be less than the vapor pressure of elemental Gd at this temperature, which is negligibly small. Hafnium could be in the form of an oxide or an intermetallic compound. Both gadolinium and hafnium will scavenge oxygen either during normal operation if the He gas (or surrounding gas) is not purified or during an accident.

IV. Iron

Iron does not form intermetallic compounds with mercury. It may form compounds with other spallation products. Iron is not soluble in mercury so it would be in the form of small crystallites of Fe or a non-mercury containing intermetallic compound. Most likely these crystallites (as well as those containing gadolinium or hafnium) would be dispersed in the mercury or at the upper surface. The density of the crystallites would be much less than that of mercury. If the mercury evaporated, iron should remain in the residue rather than enter the gas phase.

References

1. F. Messing and O. C. Dean, *Solubilities of Selected Metals in Mercury: Hermex Process*, ORNL- 2871, Oak Ridge Natl. Lab., Union Carbide Corp., June 1960.

EXHIBIT D

MERCURY EVAPORATION IN AN SNS ACCIDENT

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EXHIBIT D. MERCURY EVAPORATION IN AN SNS ACCIDENT

C. F. Weber, CP&E Division, ORNL

The following is an attempt to quantify the evaporation behavior of liquid mercury that is spilled in a hypothetical SNS accident in the splash/shielding enclosure, which is located inside the target hot cell. Because the design is still in the conceptual stage, it is impossible to even specify the problem exactly, let alone solve it. Hence, the present analysis is only preliminary, and very approximate.

One possibility is to use the Langmuir equation to analyze this problem. This approach involves a theoretical maximum rate of evaporation into a vacuum, and is always a gross over-exaggeration of the evaporation rate.[1] Benjamin[2] performed vacuum chamber experiments and found an actual rate of between 1×10^{-5} and 4×10^{-5} $g \cdot s^{-1}$ compared to the theoretical rate of 5.8×10^{-5} $g \cdot s^{-1}$ at 20ºC. He also found that exposure to air or O_2 in the presence of water vapor produced an oxide surface film that reduced evaporation by several orders of magnitude. However, the mercury pool needs to be completely quiescent, as even the slightest motion or vibration can severely disrupt the oxide skin.

The Langmuir equation is, of course, bounding; however, its conservatism is unrealistic. To obtain an estimate more reflective of a well-ventilated room near atmospheric pressure, we turn to an approach involving molecular diffusion and interface mass transport. Assumptions regarding room and puddle geometry are somewhat arbitrary, so two different cases are examined.

1. Nominal Case

We assume a 2×2 m puddle of mercury on the floor of a rectangular room 3 m high and with floor area 4×8 m. Ventilation flow refreshes the room 5 times per hour, so the flow rate is 480 m^3/h. Assuming air flow is uniform and occurs exactly parallel to the longest room dimension (i.e., the 8-m edge), the gas superficial velocity is

$$v = \frac{480}{3 \times 4} = 40 \, \frac{m}{h} = 0.0111 \, \frac{m}{s} \quad .$$

This flow rate is painfully slow, and most mass transport is probably by molecular diffusion. However, it is possible that other factors could eventually alter this scenario, so we will develop a mass transfer coefficient approach.

The flux of mercury evaporating across the gas-liquid interface can be approximated as follows:

$$\text{Flux} = K\,(C_l - PC_g) \quad , \tag{1}$$

where

K = overall mass transfer coefficient, $\frac{1}{K} = \frac{P}{k_g} + \frac{1}{k_l}$,

k_g, k_l = gas and liquid film coefficients (m/s),

P= partition coefficient (inverse Henry's Law Constant) ,
C_g, C_l = concentrations of mercury in gas and liquid (mol/m^3) .

First, assume for now that $k_l = 0$, which implies no resistance to evaporation in the liquid. (If an oxide film needs to be considered, then k_l can be chosen to represent this.) We hope to establish a maximum reasonable evaporation rate. Hence, Eq. (1) becomes

$$\text{Flux} = \frac{k_g}{P}(C_l - PC_g) = k_g\left(\frac{C_l}{P} - C_g\right) = k_g\,(C_g^* - C_g) \qquad (2)$$

where C_g^* = equilibrium concentration in gas phase .

The gas film coefficient is determined from a correlation for forced convection parallel to an infinite flat plate:

$$\frac{k_g L}{D} = .664\ \text{Re}^{\frac{1}{2}}\ \text{Sc}^{\frac{1}{3}}, \quad (\text{valid for Re} < 2 \times 10^4) \qquad (3)$$

where L = characteristic length of flow ,
D = binary diffusion coefficient ,
Re = Lv/ν = Reynolds number ,
Sc = ν/D = Schmidt number ,
ν = kinematic viscosity .

Diffusion coefficients for many gas pairs have been correlated and can be estimated.[1] For mercury and air at 90ºC, we get (see Sect. 3 for details):

$$D = 0.192\ \frac{\text{cm}^2}{\text{s}} = 1.92 \times 10^{-5}\ \frac{\text{m}^2}{\text{s}}.$$

Assuming the flow length is the length of the mercury puddle, we have L = 2 m. From ref. 3 (p. 388), for pure air at 90ºC, $\nu = 2.195 \times 10^{-5}$ m^2/s. Hence, we have

$$\text{Re} = 1011,\ \text{Sc} = 1.14,\ \text{and}\ K_g = 2.12 \times 10^{-6}\ \frac{\text{m}}{\text{s}}.$$

The equilibrium concentration C_g^* can be determined from vapor pressure data. From ref. 4, the vapor pressure of mercury in KPa is estimated to within 1% by:

$$\log_{10} P_{Hg} = 7.150 - \frac{3212.5}{T},\ \ T < 423\ \text{K}\ .$$

Hence, at 90ºC, $P_{Hg} = 0.200$ kPa = 2×10^{-4} bar. Then assuming an ideal gas, the equilibrium concentration is

$$C_g^* = \frac{n}{v} = \frac{P_{Hg}}{RT} = .0066 \text{ mol/m}^3.$$

Now, assume $C_g << C_g^*$, so that Eq. (2) can be written

$$\text{Flux} = k_g \; C_g^* = 1.4 \times 10^{-8} \text{ mol/m}^2 \cdot \text{s (at 90ºC)} \quad . \qquad (4)$$

This is quite low, probably because the mass transfer coefficient is not reliably predicted using a forced convection correlation with such a low velocity flow. Using purely molecular diffusion, we have from Fick's law,

$$\text{Flux} = \text{-D} \; \frac{dC_g}{dy} \quad .$$

Assuming the concentration profile is $C_g = C_g^*$ at the puddle surface, and $C_g = 0$ at a height of 1 m, we then have

$$-\frac{dC_g}{dy} \cong \frac{C_g^*}{1\,\text{m}} = C_g^* .$$

Hence, the flux is

$$\text{Flux} = D\,C_g^* = 1.3 \times 10^{-7} \text{ mol/m}^2 \cdot \text{s} \qquad (5)$$

Even though it is an order of magnitude larger than Eq. (4), this value is still quite small. For example, using a volume correlation in ref. 4 and standard density from ref. 5, we calculate that a cubic meter of mercury contains:

$$n_{TOT} = 68{,}600 \text{ mol} \quad .$$

With a puddle of surface area A = 4 m^2, the time for 1 m^3 of mercury to evaporate [assuming only molecular diffusion, i.e., Eq. (5)] is

$$t = \frac{68{,}600}{4(1.3 \times 10^{-7})} = 1.32 \text{ x } 10^{11} \text{ s} = 4180 \text{ years} \quad .$$

2. Parametric Sensitivity Analysis

The previous section involved a best-guess estimate of how a mercury puddle might evaporate in a hypothetical SNS accident. This section involves some parameter adjustments so as to construct an overly conservative scenario—a worse-than-worst-case estimate. The general formulation is the same as in the previous study, but we make the following parameter adjustments:

(1) Temperature = 110°C (instead of 90°). This is the maximum possible. Generally, higher temperatures increase mass transfer processes. In this case, the effect is slight.
(2) Area. Assume the puddle surface is the entire splash-shielding enclosure: 4×8 m. The floor geometry would probably not allow this, so it is unusually conservative.
(3) Gas flow rate. Assume a slow turbulent flow parallel to the puddle surface. The forced convection correlation assumes turbulent flow for $Re \geq 2 \times 10^4$, so we assume $Re = 2 \times 10^4$, which is probably unrealistically high. Considering the entire 8-m edge parallel to flow, this is consistent with an air velocity of 6 cm/s.

From Eq. (4), the evaporative flux of mercury is:

$$\text{Flux} = k_g \, C_g^* .$$

The equilibrium gas concentration is again calculated from the ideal gas equation and the empirical vapor pressure equation:

$$C_g^* = \frac{P_{Hg}}{RT} = 0.0183 \frac{\text{mol}}{\text{m}^3} .$$

The mass transfer coefficient in Eq. (3) refers to laminar flow. Here it determined from a correlation for turbulent plane flow:

$$\frac{k_g L}{D} = .036 \ Re^{0.8} \, Sc^{.33} .$$

The characteristic length is now L = 8 m, and the kinematic viscosity of air at 110ºC is $\nu = 2.4 \times 10^{-5}$ m^2/s. The diffusion coefficient is calculated as before (see the next section for details) to give $D = 2.12 \times 10^{-5}$ m^2/s. Hence, we have

$$Sc = \frac{\nu}{D} = 1.134 \quad ,$$

$$k_g = \frac{D}{L}(.036 \ Re^{.8} \ Sc^{.33}) = 2.745 \times 10^{-4} \ \text{m s}^{-1} \quad .$$

With this flux operating over the area of 4 × 8 m, a puddle of 1 cubic meter (68,600 mol) is evaporated as follows:

$$t = \frac{68{,}600}{32(5.024 \times 10^{-6})} = 4.267 \times 10^{8}\,\text{s} = 13.52 \text{ years.}$$

Thus, in spite of the overly conservative assumptions, this estimate is still a fairly long time.

3. Calculation of Diffusion Coefficient

Over the past 50 years, the kinetic theory of gases has been developed using classical statistical mechanics, and validated on numerous binary gas pairs. The usual approach involves the following assumptions:

(1) only binary (i.e., two-particle) collisions occur,
(2) particle motion is described by classical mechanics (no quantum effects),
(3) all collisions are elastic,
(4) molecular forces operate through fixed centers of mass, and
(5) the Lennard-Jones 6–12 potential represents the intermolecular potential energy.

The theory results in the following equation[1]:

$$D_{AB} = \frac{.001858\ T^{\frac{3}{2}} \left[\frac{1}{M_A} + \frac{1}{M_B}\right]^{\frac{1}{2}}}{P\ \sigma_{AB}^2\ \Omega} \quad , \qquad (6)$$

where D_{AB} = diffusion coefficient of A in B or B in A (cm^2/s),
T = temperature (K),
M_A, M_B = molecular weights (200.59 for mercury, 28.8 for air),
P = pressure (atm),
σ_{AB} = interparticle “distance” of closest approach (Å),
Ω = collision integral.

The last parameter accounts for all potential energy terms, and is a function of kT/ε, where *k* = Boltzmann’s constant and ε is the energy parameter from the Lennard-Jones potential. For each component, ε and σ are determined by fitting thermodynamic data, and are known for a great many real gas species. For air and mercury, we have

	σ	$\frac{\varepsilon}{k}$
Air	3.711	78.6
Hg	2.969	750.0

The mixture quantities are then determined as follows:

$$\sigma_{\text{Air - Hg}} = \frac{1}{2}(\sigma_{\text{Air}} + \sigma_{\text{Hg}}) = 3.34 \quad ,$$

$$\left(\frac{\varepsilon}{k}\right)_{\text{Air}-\text{Hg}} = \frac{(\varepsilon_{\text{Air}}\ \varepsilon_{\text{Hg}})^{\frac{1}{2}}}{k} = 243 \quad .$$

For the case in Sect. 2, where T = 383 K, then $kT/\varepsilon = 1.576$, and $\Omega = 1.175$ can be obtained from tables.[1] Substituting each of these quantities into Eq. (6) yields

$$D_{\text{Air - Hg}} = 0.2117\ \frac{\text{cm}^2}{\text{s}} = 2.117 \times 10^{-5}\ \frac{\text{m}^2}{\text{s}}.$$

References

1. T. K. Sherwood, R. L. Pigford, and C. R. Wilke, *Mass Transfer*, McGraw-Hill (1975).
2. D. J. Benjamin, *Mat. Res. Bull.* **19**, 443–450 (1984).
3. W. M. Kays and M. E. Crawford, *Convective Heat and Mass Transfer*, McGraw-Hill (1980).
4. *Kirk-Othmer Encyclopedia of Chemical Technology*, 4th Ed., Vol. 16, John Wiley & Sons (1991).
5. *CRC Handbook of Chemistry and Physics*, 59th Ed., CRC Press (1978).

EXHIBIT E

SOURCE TERMS FOR THE ACCIDENT SEQUENCES IN CHAPTER 4

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EXHIBIT E. SOURCE TERMS FOR THE ACCIDENT SEQUENCES IN CHAPER 4

Source term for accident sequences 22, 29, 30 & 32		Source term for accident sequences 24 & 31		Source term for accident sequence 36		Source term for accident sequence 27		Source term for accident sequence 40	
List 1		List 2		List 3		List 4		List 5	
Nuclide	Ci/hr	Nuclide	Ci	Nuclide	Ci/y	Nuclide	Ci	Nuclide	Ci
H-3	4.58E-03	H-3	7.69E-01	H3	5.07E-01	H3	6.58E-02	H3	7.31E-02
Xe-119	1.87E+01	Xe-119	3.23E+00	BE7	3.84E-01	BE7	4.98E-02	BE7	5.53E-02
I-119	1.22E+00	I-119	3.23E+00	C14	3.47E-04	C14	4.51E-05	C14	5.01E-05
Te-119	1.09E-04	Te-119	3.23E+00	V48	4.80E-05	V48	6.23E-06	V48	6.92E-06
Sb-119	1.87E-08	Sb-119	3.23E+00	V49	3.13E-04	V49	4.07E-05	V49	4.52E-05
Xe-120	1.77E+00	Xe-120	1.78E+00	CR51	1.06E-04	CR51	1.38E-05	CR51	1.53E-05
I-120	2.55E-02	I-120	1.78E+00	MN52	1.02E-04	MN52	1.32E-05	MN52	1.47E-05
Xe-121	1.73E+00	Xe-121	1.69E+00	MN54	1.51E-08	MN54	1.95E-09	MN54	2.17E-09
I-121	1.59E-02	I-121	1.69E+00	FE55	4.12E-04	FE55	5.34E-05	FE55	5.94E-05
Te-121	4.00E-08	Te-121	1.69E+00	FE59	3.53E-02	FE59	4.58E-03	FE59	5.09E-03
Xe-122	4.01E-01	Xe-122	1.18E+01	CO56	1.09E-03	CO56	1.42E-04	CO56	1.57E-04
I-122	1.10E-01	I-122	1.18E+01	CO57	6.25E-03	CO57	8.11E-04	CO57	9.01E-04
Xe-123	3.87E+00	Xe-123	1.14E+01	CO58	1.32E-02	CO58	1.72E-03	CO58	1.91E-03
I-123	5.71E-03	I-123	1.14E+01	CO60	5.33E-03	CO60	6.92E-04	CO60	7.69E-04
Te-123	1.91E-08	Te-123	1.14E+01	NI59	3.55E-03	NI59	4.61E-04	NI59	5.12E-04
Xe-125	1.47E+00	Xe-125	3.67E+01	NI63	2.48E-04	NI63	3.22E-05	NI63	3.58E-05
I-125	1.97E-05	I-125	2.47E+01						
Xe-127	1.99E-02	Xe-127	3.17E+00						
C10	1.83E-04	C10	3.07E-02						
C11	1.35E-02	C11	2.26E+00						
C14	6.77E-06	C14	1.14E-03						
N13	5.66E-02	N13	9.51E+00						
N16	5.14E-04	N16	8.63E-02						
O14	1.37E-02	O14	2.30E+00						
O15	2.56E-01	O15	4.30E+01						
AR37	7.51E-03	AR37	1.26E+00						
AR39	7.42E-06	AR39	1.25E-03						
AR41	1.93E-04	AR41	3.24E-02						
AR42	4.00E-06	AR42	6.71E-04						

EXHIBIT E (continued)

Source term for accident sequence 17		Source term for accident sequence 18		Source term for accident sequence 39		Source term for accident sequence 28		Source term for accident sequence 26	
List 6		List 7		List 8		List 9		List 10	
Nuclide	Ci/hr	Nuclide	Ci	Nuclide	Ci	Nuclide	Ci	Nuclide	Ci
HG184	2.50E-06	HG184	1.30E-05	H3	3.97E+00	H3	3.66E-05	H3	2.84E-02
HG185	3.97E-06	HG185	2.06E-05	BE7	3.24E-01	BE7	2.77E-05	BE7	1.1E-06
HG186	1.09E-05	HG186	5.68E-05	C14	2.79E-03	C14	2.51E-08	C14	8.71E-09
HG187	2.31E-05	HG187	1.20E-04	V49	2.77E-03	V48	3.46E-09	V49	8.65E-09
HG188	5.15E-05	HG188	2.67E-04	MN54	8.78E-03	V49	2.26E-08	MN54	2.74E-08
HG189	8.93E-05	HG189	4.63E-04	FE55	2.78E-01	CR51	7.65E-09	FE55	8.68E-07
HG190	1.13E-04	HG190	5.87E-04	FE59	4.88E-04	MN52	7.33E-09	FE59	1.52E-09
HG191	1.43E-04	HG191	7.40E-04	CO56	1.05E-02	MN54	1.09E-12	CO56	3.27E-08
HG192	1.88E-04	HG192	9.74E-04	CO57	7.18E-02	FE55	2.97E-08	CO57	2.24E-07
HG193	2.04E-04	HG193	1.06E-03	CO58	7.36E-03	FE59	2.54E-06	CO58	2.30E-08
HG194	1.19E-05	HG194	6.17E-05	CO60	4.66E-03	CO56	7.87E-08	CO60	1.46E-08
HG195	3.68E-04	HG195	1.91E-03	NI63	2.47E-01	CO57	4.5E-07	NI63	7.73E-07
HG197	2.47E-03	HG197	1.28E-02			CO58	9.53E-07		
HG203	1.76E-03	HG203	9.15E-03			CO60	3.84E-07		
HG205	7.59E-05	HG205	3.94E-04			NI59	2.56E-07		
						NI63	1.79E-08		

EXHIBIT E (continued)

Source term for accident sequence 34		Source term for accident sequence 37	
List 11		List 12	
Nuclide	Ci	Nuclide	Ci
H3	4.96E-03	H3	7.31E-05
BE7	2.03E-05	BE7	5.53E-05
C14	1.74E-07	C14	5.01E-08
V49	1.73E-07	V48	6.92E-09
MN54	5.48E-07	V49	4.52E-08
FE55	1.74E-05	CR51	1.53E-08
FE59	3.04E-08	MN52	1.4E-07
CO56	6.55E-07	MN54	2.17E-12
CO57	4.49E-06	FE55	5.94E-08
CO58	4.60E-07	FE59	5.09E-06
CO60	2.91E-07	CO56	1.57E-07
NI63	1.55E-05	CO57	9.01E-07
		CO58	1.91E-06
		CO60	7.69E-07
		NI63	3.58E-08

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EXHIBIT F

SOURCE TERM FOR WORST-CASE BEYOND-DESIGN-BASIS LOSS OF FORCED MERCURY FLOW ACCIDENT

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EXHIBIT F. SOURCE TERM FOR WORST-CASE BEYOND-DESIGN-BASIS LOSS OF FORCED MERCURY FLOW ACCIDENT

This exhibit develops the source term for the limiting beyond-design-basis (BDB) accident for the Spallation Neutron Source. This BDB source term is developed for both the 1-MW configuration and the 4-MW configuration. The target plug and associated systems are currently being developed for the 1-MW configuration, and may, after proving successful, be operated at proton beam power levels as high as 2-MW. The source term for a 2-MW configuration will be bracketed between the "1-MW" and "4-MW" cases derived in this appendix. The 4-MW configuration has not actually been detailed yet because it will require redesign and reanalysis of the target plug and mercury coolant system, and that work is not planned to begin for several years. The calculations below assume that the 4-MW configuration has geometry identical to that of the 1-MW configuration, with power level 4 times as high. The geometry may change somewhat when the actual 4-MW target plug is designed, although it is expected that such changes are likely to be in the direction that would moderate the accident response (i.e., by more diffuse beam focusing or larger mercury inventory, etc.) The radionuclide inventory of the 4-MW configuration is assumed to be 4 times as high as the 1-MW configuration since the buildup of spallation products is linear with respect to beam power level.

Table F.1. Event sequence table

Time (s, unless otherwise noted)	Event or process	Assumptions	Calculation(s)
0	Pump coastdown begins		
0+	TPS trip on pump status fails	Common mode failure of all target protection system (TPS) trips	
0++	TPS trip on pump outlet pressure fails	Run permit/beam pulse enable systems (BPS) trip(s) on same or similar process variables also assumed to fail	
0+++	TPS trip on loop flow fails		
Tcd	Loop flow coast down is over.	All damage would be prevented if TPS or BPS function per design	Tcd is TBD—assume = 5 s
t > Tcd	Local Hg boiling begins, Hg vessel steel window (front face) heat-up begins	Max. Hg heat-up rate at peak local point in Hg is ~6 %C/pulse, and is ~1.25 %C/pulse in window (@1 MW, per CDR Table 5.3-2 peak energy densities)	**1 MW**: Hg local boiling begins ~1 s after coastdown. Window steel begins melting >17 s later. **4 MW:** Hg local boiling begins < 1 s after coastdown. Window steel begins melting >4 s later.

Table F.1 (continued)

Time (s, unless otherwise noted)	Event or process	Assumptions	Calculation(s)
t > Tcd	Beam heating of Hg without forced circulation causes intermittent boiling and condensation of Hg in inner ~½ of target plug; no net Hg vapor production	1. 66% of beam energy deposited in Hg (CDR Table 5.3-4). 2. Inner ½ of target plug only intermittently and partially voided during this period. 3. Inner ½ of plug holds ~ 0.1 m^3 of Hg	**1 MW**: Avg. Hg temp. of inner ½ of plug reaches bulk saturation (~360ºC) 69 s after coastdown, i.e., 69 s = (0.1 m^3) (13.3E3 kg/m^3) * (137 J/kg°C)(250°C)/ (0.66*1E6 J/s) **4 MW:** Avg. Hg temp. of inner ½ of plug reaches bulk saturation (~360ºC) ~17 s after coastdown
t < Tpps	Water-cooled shroud may fail	Water-cooled shroud can fail because of its close proximity to the Hg vessel front face, which fails on account of high temperature	N/A: effect of water-cooled shroud failure not clear. Would probably make beam cutoff by PPS occur sooner by allowing Hg to drain more rapidly out of the target plug
1 MW: Tpps = Tcd + 69 s **4 MW:** Tpps = Tcd + 17 s (Note: Tpps = time when PPS initiates beam cutoff)	Bulk boiling of Hg in target plug. PPS detects elevated neutron flux due to beam hitting shielding steel in outer part of plug	PPS cuts off the proton beam after 2 s of bulk boiling (1 s for boiling to void the target plug inboard of the shielding steel and 1 s for instrument response time)	**1 MW:** Bulk boiling does not occur because the operator would cut off the beam before 60 s **4 MW:** 2 s of bulk boiling creates: 18.1 kg of Hg vapor (~4.6 m^3 of vapor at 1 atm pressure): 18.1E3= 0.66*4 E6*2/292
t > Tpps	Hg continues to leak from failed Hg Vessel front window unless it had already leaked to below the level of the bottom of the beam envelope	1. Hg will drain until level is below the bottom edge of the proton beam: this is <1/3 of total Hg inventory (by design) 2. Some of leaked Hg drains to collection tank in hot cell floor and some may drain to core vessel	

2.0 MERCURY RELEASE CALCULATIONS

The worst case BDB loss of mercury flow accident will have two distinct phases—the initial phase in which a short period of vigorous boiling of mercury may take place and the long-term phase in which residual amounts of mercury would slowly evaporate. For this bounding analysis, the mercury vapor produced in the vigorous boiling phase is assumed to remain in vapor form and be exhausted by the mercury enclosure ventilation without being condensed. Any cooling that takes place would condense the mercury vapor and, thus, prevent its rapid release. It is possible that some of the mercury vapor could be vented to the hot off-gas (HOG) system, but the resulting releases would be lower, so the HOG is not credited here.

The transport of mercury is addressed specifically in the next two subsections. The possibility of transport of other radionuclides is discussed in a separate subsection at the end. The possible use of a low temperature condenser and/or a sulphur-impregnated activated charcoal for mercury removal from the target cell air exhaust will be examined during Title I design; none of the calculations in this section credit the ventilation system with mercury removal capability.

2.1 SHORT TERM RELEASE

A rapid release of mercury vapor occurs due to the assumed period of vigorous mercury boiling that occurs immediately before the PPS actuates cutoff of the proton beam. As noted in the table, for the 1-MW case, it takes more than 60 s for the beam to heat the mercury in the inner part of the mercury target plug to the saturation temperature. Thus, it is very likely that the operator would interrupt this event before the bulk boiling occurred for the 1-MW target configuration. For the 4-MW case, however, the bulk boiling occurs well before 1 min has elapsed, so the PPS would be more likely to interrupt the beam than would the operator. Therefore, the short term releases would be:

4-MW configuration: 18.1 kg mercury (i.e., ~4.6 m^3 of mercury vapor) released to the mercury enclosure inside the target hot cell and thence to the environment through the target hot cell ventilation exhaust. The ~4.6 m^3 of mercury vapor that is released to the mercury enclosure in a short period of time is assumed to mix with the air and be swept out of the enclosure by the ventilation system flow. It is possible that the mixing would be poor and that much of the mercury vapor would settle to the floor and condense. The assumption that mixing is good and that condensation does not occur is conservative. Since the residence time for air flowing through the mercury enclosure is longer than 5 min, it would take the enclosure ventilation system about 10 min to sweep the bulk of this mercury vapor/air mixture from the enclosure.

1-MW configuration: no bulk boiling occurs because the operator initiates manual beam cutoff in response to multiple alarms. However, the failed mercury vessel window may result in drainage of mercury across the mercury enclosure floor. The source term for the first 10 min is conservatively estimated by assuming that the mercury enclosure exhaust air is saturated with mercury vapor during the entire period.

2.2 LONG TERM RELEASE

2.2.1 Assumptions

1. Air exhausted from the mercury enclosure is saturated with mercury vapor for 7 d after the accident when the spilled mercury is cooling from its initial temperature, which for part of the spilled mercury could be as high as the saturation temperature (357ºC), back toward the normal ambient range in the enclosure.

2. After 7 d, the concentration of mercury vapor in the mercury enclosure air would be limited by evaporation from ambient temperature mercury in the catch pan sump depression. This assumption is tantamount to assuming that the drain from the catch pan sump depression to the collection tank (located below the sump depression for gravity drainage) has been inadvertently plugged. If this drain were assumed to be open, the mercury would drain to the collection tank, from which there would be negligible mercury evaporation since it has only a small opening for the drain(s) flowing into it.
3. Mercury enclosure air exhaust flow continues at the nominal 11.3 m^3/min (400 cfm) for all times after the accident. This is conservative since releases would be much lower after the accident if there were no air exhausted from the mercury enclosure.
4. Mercury enclosure air inlet temperature is 30ºC (summer temperature).
5. The bounding mercury enclosure air exhaust temperature is determined as the maximum of the following: (1) the value consistent with the assumption that 100% of the decay heat energy is transferred to the air and not to structures that would serve as heat sinks (Note: immediately after beam cutoff the decay heat values are 10 kW @ 4 MW and 2.5 kW @ 1 MW. Corresponding air exhaust temperatures are 76ºC for 4-MW proton beam configuration and 42ºC for the 1-MW proton beam configuration) or (2) the value consistent with the normal heat load plus the additional heat load due to heat transfer from a 1 m^2 surface area of mercury at 350ºC. The larger of these two choices will bound the air exit temperature for the first 7 d. By this procedure the bounding air exhaust temperature is 76ºC for the 4-MW case and 73ºC for the 1-MW case; thus, the 76ºC value will be used for both. This procedure is conservative because it does not allow the heat input to the air to decrease after the beam cutoff.

<u>Release for either the 4-MW or 1-MW configuration</u>

Release over first 7 d =(7 d * (11.3 m^3/min) * (0.61 g/m^3) * (1440 min/d)
= (7 d) * 9.9 kg mercury/d = 69.5 kg mercury

<u>Release between 7 d and 30 d for either 4-MW or 1-MW configurations</u>

After the first 24-h, the temperature of spilled mercury has cooled to <100ºC, so that mercury transport is limited by the evaporation of mercury from the catch pan sump depression (1 m^2 surface area if the catch pan drain is plugged, and the spilled mercury does not drain). As discussed in Exhibit D, this evaporation rate is estimated to be 130 g mercury/d/m^2 for evaporation from a 1 m^2 surface area at a temperature of 110ºC. Assuming no further cooling of the mercury during this period is a bounding conservatism. A factor of 10 is applied to the estimate to ensure conservatism against possible correlation or geometry uncertainties.

Release (7 d to 30 d) = 1.3 kg mercury/d

2.3 EFFECT OF WATER-COOLED SHROUD FAILURE ON SHORT AND LONG TERM RELEASES (i.e., CORE VESSEL RELEASE PATHS)

The analysis above considers mercury release paths from the mercury system to the mercury enclosure inside the target hot cell, and from there to the environment via the hot cell ventilation system. No releases from the core vessel are listed because the water-cooled shroud continues to provide separation between the mercury system/target hot cell and the core vessel. Failure of the water-cooled shroud was not postulated as part of the definition of this event, but it could fail if, for example, the mercury vessel window actually melts and molten stainless steel contacts the water-cooled shroud and softens it enough to cause its failure.

If only the inside wall of the water-cooled shroud failed, that would allow shroud cooling water to contact the mercury inside the target vessel. The water would boil, and this would displace mercury from the mercury vessel back into the mercury cooling system in the mercury enclosure. The voiding would allow the proton beam (still on because of the assumed failure of multiple TPS and BP beam cutoffs) to strike shielding steel in the outer part of the target plug. This would elevate the neutron flux levels in the target hot cell sooner and therefore bring about the PPS cutoff of the proton beam sooner. Shut-off of the beam before bulk boiling of the mercury in the target plug would result in a lower source term, or at least one without the prompt mercury vapor release resulting from a brief period of vigorous boiling.

If both walls of the double-walled, water-cooled shroud failed, this would provide an additional path for drainage of mercury from the mercury vessel, the likely effect of which would be the same as discussed in the previous paragraph for the single-wall failure; the PPS sees elevated neutron levels and cuts off the proton beam sooner than it would have otherwise and before bulk boiling of mercury occurs in the target plug.

Failure of the water-cooled shroud therefore seems to have the major beneficial effect of interrupting proton beam pulsing before bulk boiling of the mercury and thus may have a lower short term mercury release. However, the double-wall failure has another effect that must be considered—opening up an additional pathway for release of mercury and/or spallation products through the core vessel pressure relief line. As discussed in Sect. 3.1, the core vessel has a pressure relief line that actuates at 2 atm of internal pressure. Cooling water spilled from the failed shroud and mercury spilled from the target plug could mix in the bottom of the core vessel. If the water is heated too greater than 100°C, this, combined with the existing ~1 atm internal pressure of He, could create enough internal pressure to actuate the core vessel relief path (it is TBD whether this will be a rupture disc and/or relief valve). The potential for additional source term will be bounded by considering how much water a 0.1 m^3 volume of mercury at 350°C can boil (this is the volume and temperature of mercury reached just before bulk boiling occurs in the target plug, as developed in Sect. F.1 of this appendix). The answer is that there is enough thermal energy in 0.1 m^3 of mercury at 350°C mercury to boil about 17 kg of water and that the mercury is cooled to 120°C in the process. At the shroud-cooling water flow rate of 2.4 kg/s (CDR Table 5.3-5), and assuming that 100% of the shroud-cooling flow is lost through the postulated failure point, it would take about 7 s for this much water to flow into the core vessel. The corresponding volume would raise the core vessel's ~10 m^3 of internal free volume to a pressure too greater than 2 atm, so the relief path would actuate. Evaluating the volume of steam effluent at the 1 atm post-venting pressure leads to an estimated vented volume of about 31 m^3. The amount of mercury vapor that would be in this amount of steam is bounded by assuming that the water vapor is saturated with mercury at a temperature of 120°C (saturation pressure of water at the actuation pressure of the core vessel relief path). Very little else but mercury vapor would be transported by this path because the relatively open region at the top of the core vessel provides a volume for low-velocity separation of any gross entrained droplets of mercury and because (see also Sect. 3.1 of this appendix) the vent path is equipped with appropriate filtration and/or demisting features. Since the mercury saturation density at 120°C is 7.9 g mercury/m^3, the total mass of mercury vapor vented with the steam is 31 m^3 * 7.9 g/m^3= 245 g mercury. This is less than the prompt release estimated above for the case where bulk boiling of the mercury is assumed to occur. Therefore, it is concluded that failure of the water-cooled shroud would not increase the short term release estimated in Sect. 2.1 of this appendix.

The effect on long-term release can be estimated by assuming that the normal core vessel purge rate (10 m^3/100 h) continues after the accident, venting 120°C helium saturated with mercury vapor (saturation density of 7.9 g/m^3). This would release 19 g mercury per day, which is small in comparison to the long-term hot cell release estimated above.

Rather than debate whether these short- and long-term core vessel releases would occur instead of—or in addition to—the hot cell releases, they are assumed to occur in addition to the hot cell releases. The total estimated release source term for this event, therefore, has been increased to include the core vessel vent path.

3.0 RELEASE AND TRANSPORT OF OTHER THAN MERCURY RADIONUCLIDES

Besides the radioactive and nonradioactive mercury radionuclides, a range of spallation and activation products are present in the mercury. The great majority of these are nonvolatile because of their low or zero vapor pressures in the temperature range of interest (i.e., up to the boiling point of mercury). The exception to this would be any gaseous spallation products present in the mercury or any volatile nuclides such as iodine, for example. A significant inventory of gaseous nuclides is not present in the mercury before the accident because there is a continuous helium purge that removes these as they are generated. The gaseous nuclides removed include hydrogen (e.g., tritium), noble gases, and possibly some iodine(see Sect. 3.2, below). Accidents of the HOG treatment system can release the gaseous nuclides, and they are discussed in Chap. 4 of this document.

3.1 NONVOLATILE SOLIDS

Most of the spallation products are soluble in the mercury and will remain well below their solubility limits through the lifetime of the facility. The insoluble spallation products would either settle out into the bottom of the reservoir tank or would be removed by filtration. If the mercury boils in an accident, neither soluble nor insoluble spallation products would vaporize because of their very low vapor pressures (unlike iodine, discussed below). A few of the spallation product nuclides (i.e., Cs, In, Cd, Sn, I, Tl, and Pb) have melting points below the boiling point of mercury. With the exception of I (addressed as a special case in the subsection below), the amount released would be very small, however, because the boiling points for these same elements are typically over 1000°C, giving them very low vapor pressures at the mercury boiling point. The amount of nonvolatile solids released from a brief period of boiling mercury is concluded to be negligible. See also spallation product transport discussions in Sect. 3.1 and Exhibit C of this document.

Although inherent transport mechanisms are not effective for nonvolatile solids at mercury's boiling temperature, entrainment of mercury droplets in flowing gases should be considered. For the 4-MW case, a short period of vigorous bulk boiling occurs in the target plug, so it is possible that the vapor released to the mercury enclosure could entrain some small droplets of unvaporized mercury that would (being unvaporized) contain spallation products. However, there could not be an efficient droplet formation and transport process because of the high surface tension and density of mercury. The mercury enclosure is not ventilated at a high rate (residence time of air is greater than 5 min in the mercury enclosure). Furthermore, a pre-filter or demister section incorporated into the mercury enclosure ventilation should eliminate any mercury mist droplets that are created. Any droplets that do not settle out or that get past the pre-filter section would then be drawn into the ventilation ductwork and could be transported to the HEPA filters. There, the mercury droplets would be caught by the HEPA filter medium. Due to the inherent barriers against mist droplet formation (mercury density, surface tension), opportunity for droplets to settle out in the mercury enclosure (very low velocity except in exit pipe), and installed liquid and solids removal stages in the ventilation exhaust system (mist eliminator, HEPA filters), it is concluded that negligible transport of solid nonvolatile spallation/activation products would occur.

For the 1-MW configuration, there was no period of bulk boiling, so there would be no opportunity to create small airborne droplets of mercury as discussed above for the 4-MW configuration.

3.2 IODINE

The iodine produced in the mercury by the proton beam will combine chemically with the mercury to form Hg_2I_2. This is a stable compound at the normal hot leg temperature of 110°C, so the iodine will not be released immediately from any mercury that is spilled, providing it is not heated above normal temperatures first. However, after a spill, exposure to oxygen in air could displace the iodine, thereby freeing it to be released.

If the mercury boils in an accident (which it does in the accident analyzed above), the temperature will reach about 360°C and the Hg_2I_2 should be assumed to decompose, releasing iodine rapidly (mainly in the form of gaseous HgI_2). To ensure a conservative source term for this event, the iodine present in the ~0.1 m^3 of mercury that is postulated to reach the boiling point is assumed to release its iodine immediately. This 0.1 m^3 of mercury is ≤14% of the total mercury, so the fractional release of iodine during the early part of the accident would be bounded as 14% of the total iodine inventory. This number will be applied to both the 1-MW or the 4-MW case because, although the 1-MW case did not experience boiling, its temperature does come close to the boiling point.

Following the short-term release of I, it must be assumed that I will continue to be released because of oxidation of Hg-2I2 in spilled mercury. This would be a slow process, but is assumed to be complete after 30 d. For this particular event (loss of flow with consequent mercury vessel window failure), only 33% of the mercury leaks from the mercury cooling system, so it would be adequate for this particular accident sequence to postulate that a total of only 33% of the I is eventually released to the air. However, in order to make this source term applicable to similar events that might be initiated by mercury boundary failure (instead of having the mercury boundary fail as a result of the failure of two beam cut-off systems), and which could (for a leak at the bottom of the system) spill all the mercury, the iodine source term is increased to be consistent with total spillage of mercury and oxidation of all the Hg_2I_2 to release the entire iodine inventory over a period of 30 d.

4.0 SOURCE TERM SUMMARY: RELEASES TO ENVIRONMENT, WORST CASE BEYOND-DESIGN-BASIS ACCIDENT

The fractional releases are given in the following tables for a 1-MW and 4-MW target configuration. Since the releases are calculated in the previous subsections, above, in terms of mass of mercury released, it is necessary to divide by the total mercury inventory to calculate the release fraction(s). The conceptual design has a nominal 1 m^3 volume (13.6E6 kg of mercury), but continuing design activity has led to smaller volumes; a value of 10,000 kg of mercury should adequately bound the intended decrease in mercury volume.

Table F.2. Beyond-design-basis accident source term summary

Radionuclide category	Fractional release of total inventory		
	Short term (~10 min)	First 7 d	7 d through 30 d
1-MW target configuration–fractional releases			
Hg	6.6E–5	0.8E–2	3.0E–3
Iodine	1.40E–1	2.0E–1	6.6E–1
Nonvolatile solids	Negligible	Negligible	Negligible
4-MW target configuration–fractional releases			
Hg	1.83E–3	0.8E–2	3.0E–3
Iodine	1.4E–1	2.0E–1	6.6E–1
Nonvolatile solids	Negligible	Negligible	Negligible

APPENDIX B

REPORTS ON THE SELECTION OF ALTERNATIVE SITES FOR THE SNS

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B. REPORTS ON THE SELECTION OF ALTERNATIVE SITES FOR THE SNS

This appendix includes the *National Spallation Neutron Source Project Alternate Site Selection Report*, prepared by the U.S. Department of Energy, Office of Energy Research, which explains the site selection process for the proposed Spallation Neutron Source (SNS) project. It identifies the four national laboratory sites resulting from the analysis, that represent reasonable alternatives for detailed analysis for site selection of the SNS. Each of the four laboratories, Oak Ridge National Laboratory, Los Alamos National Laboratory, Argonne National Laboratory, and Brookhaven National Laboratory, were tasked with conducting an analysis to identify alternate sites within their complex for the location of the proposed SNS. This appendix also includes the four reports submitted by the laboratories that address their site specific selection process.

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NATIONAL SPALLATION NEUTRON SOURCE
SITE SELECTION REPORT

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NATIONAL SPALLATION NEUTRON SOURCE PROJECT
ALTERNATE SITE SELECTION REPORT
Rev. 6

U.S. Department of Energy
Office of Energy Research

July, 1997

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LIST OF ACRONYMS AND ABBREVIATIONS

ANL	Argonne National Laboratory
ANS	Advanced Neutron Source
BES	DOE Office of Basic Energy Science
BESAC	DOE Basic Energy Science Advisory Council
BNL	Brookhaven National Laboratory
CFR	U.S. Code of Federal Regulations
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
EIS	Environmental Impact Statement
ER	DOE Office of Energy Research
ES&H	Environment, Safety and Health
FEMA	Federal Emergency Management Agency
LANL	Los Alamos National Laboratory
NAS	National Academy of Science
NEPA	National Environmental Policy Act
NRHP	National Register of Historic Places
NSNS	National Spallation Neutron Source
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations

1.0 INTRODUCTION

Over the past 40 years, the use of neutrons for research purposes, a technology which was invented by the US at Oak Ridge National Laboratory (ORNL), has played an invaluable role in advancements in the fields of fundamental science, technology, and medicine. Neutrons provide critical investigative techniques to obtain information that is impossible to acquire by any other means. However, in the last 20 years, the U.S. has fallen behind the European scientific community in the availability of state-of-the-art neutron sources and instrumentation because of aging U.S. facilities, and because the European community has continually upgraded and added new neutron science facilities. Since the 1970's, numerous assessments have firmly established the need for new neutron sources and instrumentation in the U.S (NAS, 1984b).

Existing U.S. reactor-based neutron sources were built in the U.S. over 25 years ago. The existing spallation sources were built in the early 1980's and are based on aging accelerator facilities (DOE, 1993). These facilities have had minimal upgrading and modernization, and are not well suited to the specific areas of research to which scientific investigation has evolved. The need for a new neutron source has been recognized by every national panel investigating the status of neutron sources and science in the U.S. since the NAS study in 1977 (DOE, 1993; NAS, 1977). After reviewing the situation regarding all major domestic facilities for materials research, an NAS' panel (1984a) recommended:

1. Construction of a new high-flux, reactor-based neutron source, and;

2. Development of a plan leading to the construction of a major accelerator-based spallation neutron source.

These recommendations were reaffirmed in 1993 by the U.S. Department of Energy's (DOE) Basic Energy Science Advisory Committee (BESAC) Panel on "Neutron Sources for America's Future" (DOE, 1993). Although a reactor-based Advanced Neutron Source (ANS) Project was proposed in fiscal years 1994 and 1995, the project was not pursued in the fiscal year 1996 budget process, primarily due to the high cost (about $3 billion) of the total project. However, the need for a viable new neutron source continues, and the emphasis has shifted to a lower cost option of the proposed accelerator-based National Spallation Neutron Source (NSNS) program. According to the March 10, 1996 BESAC advisory committee recommendations (Lineberger, 1996), "there is an urgent need to build a short pulsed spallation source in the 1 MW power range dedicated to neutron scattering with sufficient design flexibility such that it can be operated at a significantly higher power in a later stage."

Design and construction of the proposed NSNS Project is a major component of the DOE Office of Energy Research's (ER) efforts to meet these goals. Such a facility would allow for advanced research in the U.S. by producing a high flux of neutrons for experiments in the physical and biological sciences for industrial application and medical research. It would provide the U.S. with a facility that meets many of the long-term needs for neutron research by the scientific community over a wide-range of disciplines, and it would be available to government, educational, and industrial users.

In the 1996 "Energy and Water Development Appropriations Bill", Congress committed funding for DOE to pursue research, design and conceptual design activities for a spallation neutron source. The preferred alternative site for this spallation source was identified as Oak Ridge National Laboratory (ORNL), "... to maximize the use of the expertise already developed through preparation of the advanced neutron source design and to take advantage of the laboratory's experience in operating particle accelerators and conducting neutron scattering research...". (Congressional Record, 1995).

2.0 THE PROPOSED NSNS PROJECT ALTERNATE SITE SELECTION PROCESS

In 1995, DOE decided to move forward with a conceptual design for the proposed NSNS Project. Accordingly, DOE ER made the determination to prepare an EIS which led to a programmatic site selection process to logically identify suitable alternatives to the DOE's "preferred alternative" (ORNL) for the proposed NSNS Project. This process consisted of a tiered, or multi-phased approach, including:

1) Identification of the basic technical/logistical requirements or needs for meeting the NSNS Project mission goals;

2) Decision to limit potential NSNS Project sites to existing DOE facilities; and

3) Preliminary exclusionary screening of DOE alternate sites based on "fatal flaws".

2.1 Technical/Logistical Requirements

The initial task in the site-selection process involved the definition of specific project requirements. This information was used to develop the various levels of technical/logistic site exclusionary criteria.

For the NSNS Project, the following basic technical and logistical requirements are necessary to meet the mission goal of supporting neutron science research, and providing neutrons for materials research:

1) A minimum 110-acre site that has a rectilinear footprint to accommodate the length of the proposed linear accelerator and possible future expansion of the facility.

2) a one-mile buffer zone around the proposed NSNS Project facility site
   - to restrict uncontrolled public occupancy
   - to insulate the public from the consequences of a postulated accident at the facility.

3) availability of/proximity to source of adequate electric power
   - regional power grid able to supply 40 megawatts of power during periods of operation
   - within one-quarter to one mile of existing transmission lines to minimize collateral construction impacts and costs.

4) presence of existing neutron science programs to provide
   - a pool of existing neutron science expertise and experience to meet the mission goals
   - major, in-place facilities and programs utilizing neutron scattering techniques.

2.2 Use of Existing DOE Facilities

In assessing potential candidate sites in the U.S., the opportunities fall into three categories:

1) existing DOE sites;

2) DOE acquisition and development of other federal property, or a new, privately-owned site; or,

3) joint use of a non-federal site (i.e., an academic facility)

The DOE is the third largest land-owner within the federal government, behind the Department of Defense (DOD) and the Department of the Interior (DOI), and is responsible for the management and/or control of 2,367,818 acres nation-wide. Although not limiting from a geographical standpoint, this approach provides an estimated 2.37 million total acres and many facilities nation-wide from which to select candidate sites (Nettle, 1996; DOE, 1996). This would include DOE Operations Offices, Site Offices, Power Administrations, and Special Purpose Offices that are not really suited to development of the proposed project, as explained later in this report. Several DOE facilities appear to meet all of the basic requirements necessary to meet the NSNS mission goal so the search within the DOE was limited primarily to facilities like national laboratories, which would likely have sufficient land holdings to accommodate the proposed project.

Other existing federal sites would include non-DOE sites such as DOD facilities (closed U.S. Air Force bases, for example), or lands managed by other federal agencies such as the DOI. The DOE could also acquire a new site that is presently privately-owned through purchase, trade or possible condemnation. Acquisition of these types of properties would require lengthy, costly, and more detailed site selection, environmental compliance, and jurisdictional transfer processes. In addition, while some of these types of candidate sites might offer some of the physical and power requirements needed to meet the NSNS Project mission goals, none of these types of sites can offer the neutron science and infrastructure support requirements. Finally, as the general public continues to express its concerns on limiting the growth of the federal government, it is unlikely that the public would support the acquisition or transfer of new lands from private or public use to simply duplicate facilities, resources, support structures, and uses available at existing DOE facilities.

A final candidate site category includes co-location of the NSNS facility at a non-federal location, such as an academic center or private research facility. This category was dropped from further consideration because, again, few if any of the non-DOE facilities can offer all of the required neutron science and infrastructure support requirements. Also, to establish a facility of the magnitude of the proposed NSNS Project would, in essence, create another national laboratory-type facility. It would not maximize the use of existing federal and/or DOE resources, would not be cost efficient, and could duplicate existing DOE missions. This would be in direct conflict with current DOE initiatives, as defined in several recently released studies and reports (DOE, 1994; DOE,1995a; DOE, 1995).

It is therefore appropriate not only to limit the designated alternate site search to federal properties, but also to further limit the proposed site search to specific types of DOE facilities (i.e. national laboratories), only.

2.3 Exclusionary Screening of Alternate Sites

After the minimum technical and logistic requirements were identified and reviewed to determine the basic aspects of the project that are all required to meet the mission goals without incurring unacceptable costs, these factors were used to define "fatal flaw," ("go-no go") or preliminary exclusionary criteria. The four requirements carried forward as exclusionary or "fatal flaw" criteria included:

1) enough space for a 110-acre, rectilinear site footprint

2) a 1-mile buffer

3) power availability/proximity

4) existing neutron science capability

Of the major DOE facilities that are DOE-owned or -operated facilities, most were immediately eliminated from serious consideration due to the nature of the site or uniqueness of the programs carried out at the site. For example, DOE Operations Offices were excluded from the list of considered facilities because they are typically located in office buildings, in or near downtown population areas, and lack sufficient land to meet project objectives. The DOE Power

Administration Offices and most Special Project Offices are so specialized that they do not have the necessary program experience or the necessary infrastructure to support an NSNS Project-type of effort. Examples would include DOE facilities such as the Petroleum Reserves in California and Louisiana, and the Oilshale Reserves in Colorado and Wyoming.

Based on these preliminary DOE facility screening criteria, 39 DOE facilities were carried forward as the "universe" of potentially available sites. These sites are shown in Table 2.1, "NSNS Alternate Site Analysis Matrix."

After reviewing each DOE facility against the four "fatal flaw" exclusionary criteria, four national laboratory sites were carried forward to the next level of analysis. As stated above, a "no" response in any of the four criteria categories resulted in the elimination of the site from further consideration. As indicated in Table 2.1, the potential sites resulting from this analysis that represent the array of reasonable alternatives for detailed analysis in the EIS are:

- Argonne National Laboratory (East) (ANL); Argonne, Illinois
- Brookhaven National Laboratory (BNL); Upton, New York
- Los Alamos National Laboratory (LANL); Los Alamos, New Mexico
- Oak Ridge National Laboratory (ORNL); Oak Ridge, Tennessee

This information was then factored into the development of the alternatives to be considered in the EIS, including:

1) The Proposed Action: siting/construction/development of the proposed NSNS Project at a DOE facility

   a) The DOE's Preferred Alternative: siting/construction/development of the

   b) Other Potentially Acceptable Siting Alternative(s): ANL; BNL; LANL

2) The No Action Alternative: no new NSNS Project; maintain the "status quo"

3) Other Alternatives To Be Considered:
   - technological alternatives (reactors/accelerator technology)

3.0 CONCLUSIONS AND RECOMMENDATIONS

Through a series of meetings, culminating in a meeting on June 22, 1996, DOE ER, BES, and Oak Ridge Operations (ORO) developed a programmatic alternate site and site location identification and selection process to logically select a suitable site. This analysis yielded identification of the preferred site (ORNL) and alternate sites (ANL, LANL, and BNL) for further evaluation. Subsequently, on March 13, 1997, BNL requested to be withdrawn as a potential alternative for the NSNS project due to a number of environmental issues the Laboratory is facing on Long Island. However, it was determined that BNL had to be evaluated because it met the programmatic screening criteria.

It is recommended that these alternatives be carried forward for use in developing the NSNS Project EIS Implementation Plan and Notice of Intent, and ultimately, in the preparation of the NSNS Project EIS.

Table 2.1
National Spallation Neutron Source
Alternate Site Analysis Matrix

Selection Criteria \ Department of Energy Facilities	Ames Laboratory; Ames, IA	Argonne National Laboratory (East); Argonne, IL	Argonne National Laboratory (West); Idaho Falls, ID	Battelle Columbus Laboratories; Columbus, OH	Bettis Atomic Power Laboratory; West Mifflin, PA	Brookhaven National Laboratory; Upton, NY	Continuous Electron Beam Accelerator Facility; Newport News, VA	Energy Technology Engineering Center; Canoga Park, CA	Environmental Measurements Lab, New York, NY	Fernald Environmental Management Facility, Fernald, OH	Fermi National Accelerator Laboratory; Batavia, IL	Hanford Site; Hanford, WA	Idaho National Engineering Laboratory; Idaho Falls, ID	Inhalation Toxicology Research Institute; Kirtland AFB, NM	Kansas City Plant; Kansas City, MO	Lawrence Berkley National Laboratory, Berley, CA	Lawrence Livermore National Laboratory; Livermore, CA	Los Alamos National Laboratory, Los Alamos, NM	Morgantown Energy Technology Center; Morgantown, WV	Mound Plant; Miamisburg, OH	National Renewable Energy Laboratory; Golden, CO
Selection Criteria No. 1: **110-acre Rectilinear Site Footprint**	Y	Y	N	N	(?)	Y	N	(?)	N	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	N
Selection Criteria No. 2: **1-mile Buffer**	N	Y	Y	N	(?)	Y	N	(?)	N	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	N
Selection Criteria No. 3: **40 MW Power Availability/Accessability**	Y	Y	Y	Y	(?)	Y	Y	(?)	N	Y	Y	Y	Y	Y	Y	Y	(?)	Y	N	N	(?)
Selection Criteria No 4: **Existing Neutron Science Capability**	N	Y	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N

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Table 2.1
National Spallation Neutron Source
Alternate Site Analysis Matrix

Selection Criteria \ Department of Energy Facilities	*Nevada Test Site; Mercury, NV*	*K-25 Plant/Site, Oak Ridge, TN*	*Oak Ridge national Laboratory; Oak Ridge, TN*	*Y-12 Plant; Oak Ridge,TN*	*Pacific Northwest National Laboratory; Richland, WA*	*Paducah Gaseous Diffusion Plant; Paducah, KY*	*Pantex Plant; Amarillo, TX*	*Pinellas Plant; St. Petersburg, FL*	*Pittsburgh Energy Technology Center; Pittsburgh, PA*	*Portsmouth Gaseous Diffusion Plant; Piketo, OH*	*Princeton Plasma Physics Laboratory; Princeton, NJ*	*Rocky Flats Environmental Technology Site; Golden, CO*	*Sandia National Laboratory/California; Livermore, CA*	*Sandia National Laboratory/New Mexico, Albuquerque, NM*	*Savannah River Site; Aiken, SC*	*Stanford Linear Accelerator Center; Stanford, CA*	*Waste Isolation Pilot Plant; Carlsbad, NM*	*West Valley Demonstration Site; West Valley, NY*
Selection Criteria No. 1: 110-acre Rectilinear Site Footprint	Y	N	Y	N	(?)	Y(?	Y	N	(?)	Y	N	N	N	Y	Y	N	Y	(?)
Selection Criteria No. 2: 1-mile Buffer	Y	Y	Y	Y	(?)	(?)	Y	N	(?)	Y	N	N	N	Y	Y	N	Y	(?)
Selection Criteria No. 3: 40 Mw Power Availability/Accessability	(?)	Y	Y	Y	Y	Y	(?)	Y	(?)	Y	Y	Y	Y	Y(?	Y	Y	(?)	(?)
Selection Criteria No 4: Existing Neutron Science Capability	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

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OAK RIDGE NATIONAL LABORATORY
SITE SELECTION REPORT

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SPALLATION NEUTRON SOURCE
OAK RIDGE NATIONAL LABORATORY
SITE SELECTION REPORT

Prepared for the
United States Department of Energy/
Oak Ridge Operations Office

October 1998

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1.0 INTRODUCTION

In 1996, Congress provided funding for the Department of Energy (DOE) to pursue the development of a short-pulsed spallation neutron source. DOE identified the Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee, as the preferred site for the Spallation Neutron Source (SNS) facility (*1996 Energy and Water Development Appropriations Bill*). The three alternative locations considered for the facility were Los Alamos National Laboratory (LANL), Argonne National Laboratory (ANL), and Brookhaven National Laboratory (BNL).

The conventional facilities design team for the SNS project was tasked to identify candidate sites for the SNS on the Oak Ridge Reservation (ORR) and designate one of these sites as the preferred location through a comparative evaluation of the candidate sites. The conventional facilities design team developed a list of siting criteria that represented the physical and sociological requirements for the facility and included functional, environmental, programmatic, health and safety, and safeguards and security criteria.

The process for selecting a site for the SNS facility on the ORR has evolved over a two-year period. The purpose of this report is to provide information used in the evaluation of potential sites and to outline the decision-making process for siting the SNS on the ORR. The site identified as the preferred site on the ORR for the SNS will be compared with potential sites at LANL, ANL, and BNL in an Environmental Impact Statement (EIS).

2.0 ORR SITE SCREENING

With the establishment of definitive criteria, the SNS project contracted with the Site and Facilities Planning (SFP) Group of Lockheed Martin Energy Systems to perform a comprehensive screening of all areas on the ORR that should be considered for placement of the SNS. The SFP Group was the organization responsible for development planning on the entire reservation. As such, SFP developed and maintained technical site information, primarily electronic maps, addressing all of the five categories of criteria developed for the SNS by the project team. The three required criteria, functional, environmental, and health and safety were mapped electronically by SFP to screen the entire ORR and rule out those areas that clearly did not meet the project requirements. These were defined as areas that should not be carried forward for evaluation of specific site characteristics. These areas were essentially “fatal flaw” areas that would preclude development of the project as currently defined because of conservation, waste management, or other land use/environmental issues.

An Intergraph MGE Geographic Information System (GIS) overlay map was created using the most current information and a report entitled, *“Candidate Site Identification for the National Spallation Neutron Source Facility,”* was prepared by SFP and issued in August 1996. Table 1 lists the data sets used for the GIS analysis, along with the information sources that were used for the most current data that was mapped. Figure 1 is the map that was included in this report; the white areas are those that could be considered as candidate areas. Because of the general nature of overall ORR mapping information, minimal data sets were input. For example, the GIS recognizes contingent areas but cannot evaluate configurations such as the hammerhead shape of the SNS. Although steep slopes may not be desirable over large areas, a confined area of steep slope within the facility footprint could be tolerated if properly configured. Therefore, these areas were not excluded from consideration at this point.

Table 1. SNS Candidate Site Identification Data Sets

Data Set	Information Source
Conservation Issues	
Natural/aquatic/reference areas, sinkholes, and a 200-foot buffer	Pat Parr, Environmental Sciences Division, ORNL
BSR2 areas and a 200-foot buffer	The Nature Conservancy, Primary Conservation Sites map (5/24/95)
Wetlands and a 200-foot buffer	Pat Parr, Environmental Sciences Division, ORNL
Environmental sciences research sites	Pat Parr, Environmental Sciences Division, ORNL
Waste Management Issues	
Waste area groupings	Nonradioactive Storage Area (NRSA)
Source control operable units (Environmental Restoration projects)	NRSA
Waste management areas	ORR Technical Site Information (MMES 1994)
Other Issues	
Historic/cultural/archaeological resources and a 200-foot buffer	Peter Souza, Office of Environmental Compliance and Documentation, ORNL
Existing structures and a 1640-foot buffer	Tennessee Valley Authority (TVA), Oak Ridge Area S-16A quadrangle map, 1994 ORR SDP/TSI updated information
Surface hydrology and a 50-foot buffer	TVA, Oak Ridge Area S-16A quadrangle map
500-year floodplains	Richard Durfee, Geographic Information Science and Technology Group, ORNL
Primary roadways and a 100-foot buffer	TVA Oak Ridge Area S-16A quadrangle map

Source: LMES 1996.

Figure 1. Spallation Neutron Source Candidate Site Map (LMES 1996).

Two other maps were included in the GIS report, one indicating Environmental Restoration watershed projects and the other indicating the current National Environmental Research Park boundaries and the proposed expansion of those boundaries to encompass virtually the entire ORR, except for the existing three plant sites. These maps were included in the GIS report as informational data only and are shown in Figures 2 and 3.

An augmented analysis was then made of the screened areas identified in the report. Using the SNS footprint criteria, general size, shape, and terrain, the ORNL site selection team identified four candidate site areas that exhibited the most favorable characteristics. A fifth area, the previously developed Clinch River Breeder Reactor (CRBR) site, was added by the SNS project even though the mapped data were not available for the GIS analysis. This site had previously been favored and studied in detail, but the property was not owned by the DOE. Figure 4 identifies the five sites selected for further evaluation.

These candidate sites include: Alternative 1 - the area south of the High Flux Isotope Reactor (HFIR); Alternative 2 - the area east of the Health Physics Research Reactor (HPRR); Alternative 3 - Freels Bend; Alternative 4 - the Chestnut Ridge site; and the CRBR site to be revisited.

3.0 CANDIDATE SITE EVALUATION

Using the original SNS general requirements, the selection team grouped the various criteria into five topical groups. These five topical groups were derived from the original requirements to be more site specific than the general criteria and provided more detailed and consistent criteria for the second phase of the evaluation. The SNS footprint was superimposed on each candidate site area and each was evaluated using the following criteria:

- **Constructibility.** The suitability of a given site to meet specified conditions for construction of the facility without exorbitant cost or effect on the environment. Here, steep slopes within the construction boundary were evaluated accordingly to the positive and/or negative impacts they may have on construction. The bulk of the original criteria fall in this group, therefore, these criteria are the most important. The key considerations under this category are:

    - site gradient and how the site contour conforms to the SNS footprint
    - utility access
    - primary and secondary road access
    - soils suitability and seismicity
    - overlapping and adjacent environmental areas such as nature areas or biological significance rated (BSR) areas
    - presence and proximity to contaminated sites
    - land use/ownership
    - security notification zones
    - distance to aquifers

Figure 2. Spallation Neutron Source Candidate Site Map with Environmental Watershed Projects (LMES 1996).

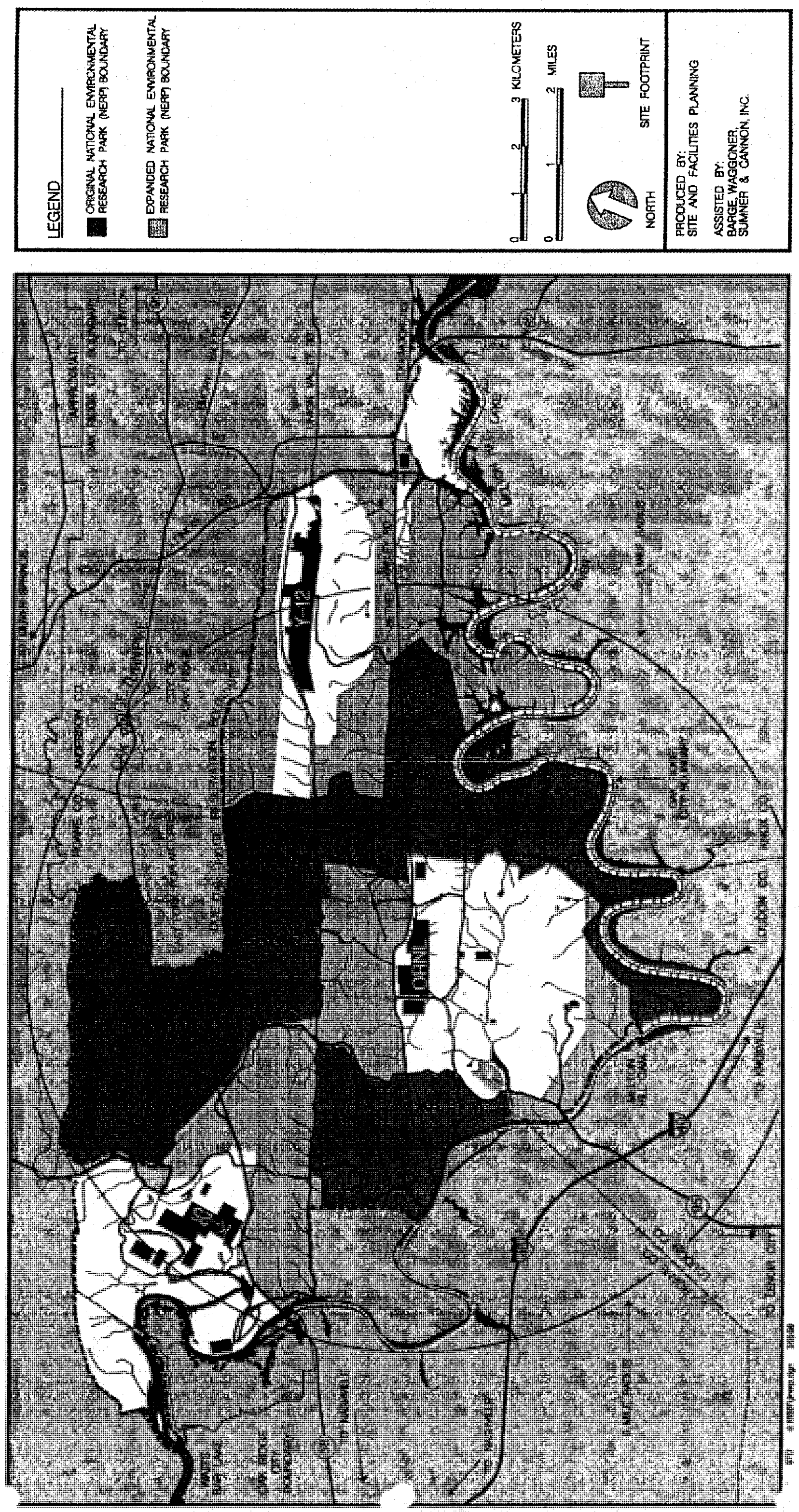


Figure 3. National Environmental Research Park (LMES 1996).

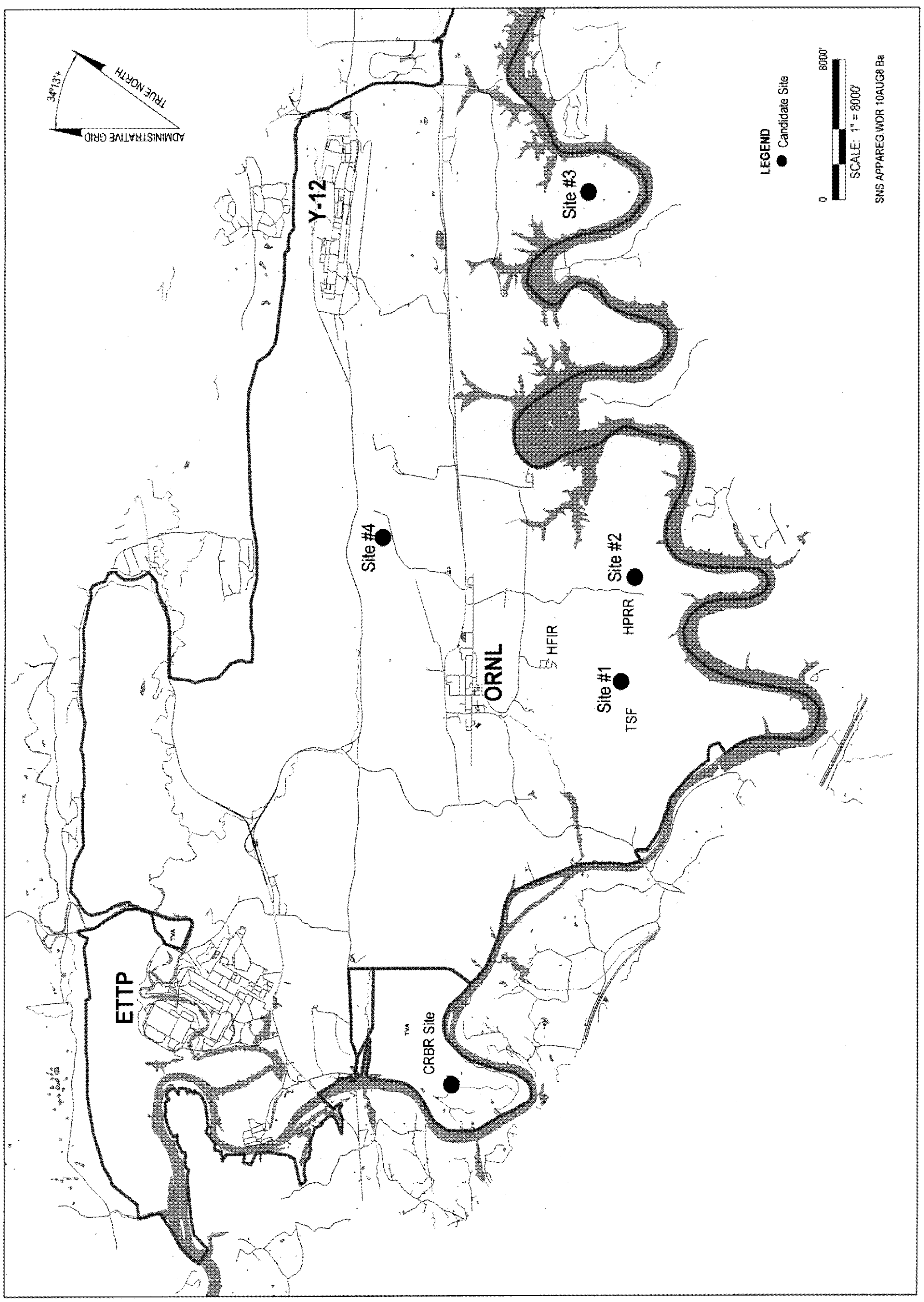


Figure 4. Location of Candidate ORNL Area Sites.

- **Flood Potential.** The likelihood of the site being affected by flooding, given that these areas are not within the 500-year flood plain, but could be adversely affected by localized flooding.

- **Proximity of Occupied Buildings/Areas.** An original criterion required a 500-meter buffer from occupied buildings. The relative closeness to permanent residential areas in comparison to the other candidate sites was considered.

- **Proximity to Historic Resources.** The relative closeness of historic resources considered limited and nonrenewable because of their association with historic events, persons, or social or historic movements. The impact that site grading may have on these sites beyond the actual SNS footprint was compared among sites.

- **Distance from ORNL/HFIR.** The GIS map indicated an approximate 5-minute-travel-distance circle as a preferable criterion. The relative proximity of each site was evaluated against the other sites.

These criteria were used for the comparative evaluation of the potential sites. Where candidate areas offered more than one potential site, only the prime site was carried forward. Desirable criteria, as well as required criteria, were considered. Table 2 presents the summary evaluation of the five potential candidate sites according to the aforementioned site-specific siting criteria. Summary descriptions of the five sites are presented below:

Area South of HFIR (Alternative 1). This site meets three of the five specific criteria groups. The site is not in danger of flooding, it is extremely close to ORNL/HFIR, and it is not in close proximity to occupied areas. However, two of the main criteria, constructibility and proximity to historic sites, were not met. The site has slopes of greater than 25 percent in areas that would not conform to the SNS footprint requirements. Much of the area is classified as fragile land, land defined in the technical site information document as best reserved for natural areas and not suitable for construction. Only electric utilities are nearby and road access is poor at best. Several areas within close proximity to this site have historical value, and the site is completely within a Biodiversity Significance Ranking (BSR) 2 area, the significance area ranked highest on the ORR by the Nature Conservancy (no BSR1 areas are present on the ORR). Use of the Alternative 1 site would involve additional expense to extend adequate utilities, improve road access, conduct assessments of historic areas, and perform grading to provide an adequately sized pad and overall site for the SNS facility.

Area East of HPRR (Alternative 2). This site also meets three of the five specific criteria groups. The site is not in danger of flooding, it is extremely close to ORNL/HFIR, and it is not in close proximity to occupied areas. The remaining two are not met, however, because this site also has slopes of greater than 25 percent in areas that would not conform to the SNS footprint requirements. Much of the area is classified as fragile land. Only electric utilities are nearby, and road access is poor. Several areas within close proximity to this site are classified as historical sites. This site, which is similar in characteristics to Alternative 1, would require additional expense to extend adequate utilities, improve road access, conduct assessments of historic areas, and perform grading to provide an adequately sized pad and overall site for the SNS facility.

Freels Bend Site (Alternative 3). This site does not meet any of the five key, site-specific criteria used in this phase of the evaluation. It has poor constructibility because there are no major utilities close by and road access is poor. It lies outside the 5-minute arc on the GIS map and could potentially be blocked

Table 2. Evaluation of Siting Criteria at Five Candidate ORNL Area Sites.

GENERAL CRITERIA	SPECIFIC CRITERIA	SITE CHARACTERISTICS				
		ALTERNATIVE 1	**ALTERNATIVE 2**	**ALTERNATIVE 3**	**ALTERNATIVE 4**	**CRBR SITE**
Functional Criteria	**Constructibility**	Slopes >25%	Slopes >25%	Slopes >25%	Slopes <25%	Slopes <25%
	Constructibility	Knox Group/Knox Residuum soil	Knox Group/Knox Residuum soil	Knox Group/Knox Residuum soil	Knox Group/Knox Residuum soil	Knox Group/Knox Residuum soil
	Constructibility	Pleistocene alluvium	Pleistocene alluvium	Pleistocene alluvium	Holocene/recent alluvial	
	Constructibility	Fragile land classification	Fragile land classification	No classification	No classification	No classification
	Constructibility	Limited utilities (electric only)	Limited utilities (electric only)	Limited utilities (gas and electric only)	Close proximity/access to utilities (gas, electric, water)	Close proximity to utilities (gas, electric, water)
	Distance from ORNL/HFIR	Close proximity to ORNL/HFIR	Close proximity to ORNL/HFIR	Not within close proximity to ORNL/HFIR	Close proximity to ORNL/HFIR	Not within close proximity to ORNL/HFIR
	Constructibility	Poor proximity to primary and/or secondary paved roads	Poor proximity to primary and/or secondary paved roads	Poor proximity to primary and/or secondary paved roads	Good proximity to primary and/or secondary paved roads	Good proximity to primary and/or secondary paved roads
Environmental Criteria	**Constructibility**	Completely within BSR2 Area	Within BSR3 Area	Close proximity to BSR3-7 and BSR3-13 areas	Within BSR3-16 area; Close proximity to BSR2-10	Within BSR2 area
	Constructibility	Close proximity to a contaminated site	Close proximity to a contaminated site	Close proximity to a contaminated site	Not in close proximity to a contaminated site	Relatively close proximity to a contaminated site
	Historic Site Proximity	Close proximity to historic sites	Close proximity to historic sites	Within and in close proximity to historic sites	Not in close proximity to historic sites	Not in close proximity to historic sites
	Constructibility	Knox Aquifer at surface	Knox Aquifer at surface	Knox Aquifer at surface	Knox Aquifer at surface	Knox Aquifer at surface
Safeguards & Security Criteria	**Constructibility**	Within security administration zone (controlled area)	Within security administration zone (controlled area)	Within security administration zone (Y-12 229 area)	Within security administration zone (restricted area)	Within security administration zone (restricted area)

Table 2. Evaluation of Siting Criteria at Five Candidate ORNL Area Sites (continued).

GENERAL CRITERIA	SPECIFIC CRITERIA	SITE CHARACTERISTICS				
		ALTERNATIVE 1	**ALTERNATIVE 2**	**ALTERNATIVE 3**	**ALTERNATIVE 4**	**CRBR SITE**
Safeguards & Security Criteria (continued)	**Constructibility**	Within immediate notification zone	Within immediate notification zone	Not within immediate notification zone	Within immediate notification zone	Within immediate notification zone
	Constructibility	Within 5-mile emergency planning sector	Within 5-mile emergency planning sector	Within 5-mile emergency planning sector	Within 5-mile emergency planning sector	Within 5-mile emergency planning sector
	Constructibility	Within 2-mile public immediate notification zone	Within 2-mile public immediate notification zone	Outside 2-mile public immediate notification zone	Within 2-mile public immediate notification zone	Within 2-mile public immediate notification zone
Programmatic Criteria	**Constructibility**	Existing land use is natural area	Existing land use is natural area	Existing land use is natural area	Existing land use is multipurpose research and development area	Existing land use is waste management area
	Constructibility	Site owned by DOE	Site owned by DOE	Site owned by DOE; Recent land request from City - parcel identified as self-sufficiency parcel	Site owned by DOE	Site owned by TVA
Health & Safety Criteria	**Constructibility**	No geological faults within area	No geological faults within area	No geological faults within area	No geological faults within area	No geological faults within area
	Flood Potential	No flood danger	No flood danger	Probable maximum flood area	No flood danger	No flood danger
	Residential Proximity	Not in close proximity to residential area	Not in close proximity to residential area	Close proximity to residential area	Not in close proximity to residential area	Close proximity to residential area

off in a probable maximum flood event. Freels Bend is just across the river from a lakefront residential district and has many historic sites indicated by mapping data.

Chestnut Ridge Site (Alternative 4). This site meets or exceeds all of the five topical criteria groups. The constructibility of the site is good because the site offers all required utilities close by. The lay of the land, although containing slopes greater than 25 percent, meets SNS footprint criteria with reasonable grading. Chestnut Ridge Road currently crosses the site and ties to Bethel Valley as well as Bear Creek Roads. The site is not in danger of floods, is not close to any occupied structures or residential areas, is close to ORNL and HFIR, and encroaches on no historic sites. In addition, the existing land use characterization of this site is multipurpose research and development.

Clinch River Breeder Reactor (CRBR) Site. This site meets three of the five key evaluation criteria. The constructibility of the site is favorable because of the low slopes. It has close access to gas, water, and electricity. Road access via existing roads is good. No flood danger is associated with the site. No historic sites are located in the way of construction. However, the proposed site is not in close proximity to HFIR and lies across the river from a residential area, which is closer than such areas are to three of the other sites. Most importantly, although this site was considered as an alternative with favorable conditions for siting the SNS, DOE does not own it. Acquisition of the property from TVA would increase the time for development of the SNS by an unknown amount.

The results of the comparative evaluation of candidate sites against the siting criteria, and more specifically the five key criteria, show that the Chestnut Ridge site (Alternative 4) offers the best overall potential of the five alternative sites reviewed by the SNS site selection team. Maps with site-specific criteria used during these evaluations are included in Exhibit 1.

4.0 RECOMMENDATION OF THE PREFERRED SITE

The SNS Project Group presented a preliminary summary of the candidate site evaluation process and its results to the Reservation Management Organization (RMO) for the ORR in late 1996. During this presentation, the Chestnut Ridge site (Alternative 4) was first identified as the preferred site for the SNS. All SNS design layouts and estimates for land improvements were to be based on this site.

A more thorough presentation of the candidate site evaluation process was delivered at an RMO meeting on April 3, 1997. During this presentation, the SNS Project Group formally designated the Chestnut Ridge site as its preferred location for the SNS at ORNL. This preference was based on the results of the candidate site evaluation process. Furthermore, the SNS Project Group requested that the RMO formally recommend this site to the Federal Property Management Committee as the preferred site for construction of the SNS.

The RMO reviewed the content of this presentation and issued review comments on June 25, 1997. These comments focused primarily on environmental concerns associated with siting the SNS on the Chestnut Ridge site and at Alternatives 1, 2, and 3. The concerns with the Chestnut Ridge site included karst topography and hydrologic transport related to this topography. They also included potential impacts of the SNS on White Oak Creek and research efforts in the nearby Walker Branch Watershed (WBW). The WBW research is being conducted by the National Oceanic and Atmospheric Administration/Atmospheric Turbulence and Diffusion Division (NOAA/ATDD) and the Environmental Sciences Division (ESD) at ORNL. In addition, the comments included a recommendation to consider use of the CRBR site for the SNS. The complete comments are presented in Exhibit 2.

A key SNS Project Group representative met with the RMO on August 7, 1997, to address the environmental and alternative siting issues raised in the review comments. Two major issues regarding the Chestnut Ridge site were addressed, (1) karst topography, and (2) potential adverse impacts on environmental science research in the WBW area. In close consultation with the RMO members, resolutions to these issues were mutually agreed to by the SNS Project Group and the RMO. The karst topography proved not to be an issue since large structures have been successfully built on karst topography, such as most of Knoxville proper, including the University of Tennessee. Experts in this area are currently on board and will continue to be involved in the SNS siting process to ensure that karst topography does not impact the initial construction of the SNS nor create any environmental concerns (i.e., hydrologic transport) after construction of the facility. The SNS Project Group responded to the issue concerning the WBW by acknowledging it was aware of the potential effect construction of the SNS could have on the WBW. Every possible action will be taken to minimize effects on this area. Based on these resolutions, the RMO formally recommended the Chestnut Ridge site as the preferred location for the SNS on August 15, 1997. In making this recommendation, the RMO cited four reasons why it considered the Chestnut Ridge site to be the “best site” for the SNS:

- Cost-effectiveness, based on several factors (near existing roads, utilities, and construction borrow areas; best situation for waste transport and use of ORNL shops, security, and facilities; and most advantageous topographical configuration for site excavation and construction of berm shielding).

- Least potential impact on the environment and public, because the site avoids wetlands, blue line streams, historical sites, threatened and/or endangered species, and other environmental impacts as well or better than the alternative sites. It is the most remote of the evaluated sites from public access areas.

- Best location for supporting ORNL neutron science programs.

- Located in close proximity to the preferred site for the Joint Institute for Neutron Sciences (JINS). This proposed facility would support neutron science programs at ORNL, HFIR, and the SNS.

The resolutions of the issues raised in the review comments on the site evaluation process are documented by the memorandum in Exhibit 3. The formal recommendation of the Chestnut Ridge site as the preferred site for the SNS at ORNL is also contained in this memorandum.

5.0 REFERENCES

LMES (Lockheed Martin Energy Systems, Inc.), 1996, *Candidate Site Identification for the National Spallation Neutron Source Facility*, ES/EN/SFP-47, August, prepared for the Department of Energy, Oak Ridge Operations, Oak Ridge, Tennessee.

MMES (Martin Marietta Energy Systems, Inc.), 1994, *Oak Ridge Reservation Technical Site Information*, ES/EN/SFP-23, August, prepared for the Department of Energy, Oak Ridge Operations, Oak Ridge, Tennessee.

EXHIBIT 1

SPALLATION NEUTRON SOURCE SITE EVALUATION CRITERIA AND CANDIDATE SITES

SPALLATION NEUTRON SOURCE SITE EVALUATION CRITERIA

Functional Criteria - These criteria relate to the physical parameters of the site, including the transportation and utility systems required for construction and operation.

- Site area requirement: 500 meters × 500 meters (1640 feet × 1640 feet) with a 100 meter × 500 meter (328 × 1640 feet) tail centered on the main square (hammer-head-shaped), all at the same elevation after excavation and preferably founded on solid rock. However, karst formations are not to be eliminated.

- Must have a stable foundation (capable of supporting 15,000 lbs/ft^2) that permits beam alignment along the entire beam line path.

- Must have an adjacent area, which can be at different elevations, measuring 100,000 square meters (24.7 acres) for support facilities, roads, buffer, etc.

- Reasonable proximity to a borrow area capable of supplying sufficient fill material for earthen shielding and a spoils area for storage or disposal of excess excavation material.

- Close proximity to ORNL (within 5 road minutes of ORNL proper)/HFIR.

- Avoid contaminated soils.

- Avoid relocating significant overhead and underground utilities (e.g., power lines, water line mains, and gas transmission lines).

- Minimize surface water runoff to or through the site.

- Proximity/access to existing utility systems:
  - 30 MW power required
  - Potable water required
  - Compressed air, natural gas, sanitary sewer, steam, and chilled water desirable but can be provided by on-site facilities
  - Availability of construction power within one mile strongly desirable

- Proximity to primary and/or secondary paved roads for users, researchers, materials, supplies; target transport; and waste and irradiated material removal.

Environmental Criteria - These criteria are used to minimize the effect of a site's development on the environment.

- Avoid disturbance of wetlands and streams.

- Avoid locations with a high significance ranking of threatened or endangered animal or plant species, specifically BSR 1 and 2 areas. (The Nature Conservancy BSRs are from a high of 1 for outstanding significance to a low of 5 for general biodiversity interest. BSR 1 and 2 areas are more critical and have a higher priority than BSR 3, 4, and 5 areas.)

- Avoid historic, cultural, or archaeological resources.

- Minimize impacts on natural reference and natural research areas in the National Environmental Research Park.

Safeguards and Security Criteria - These criteria relate to the ability of the site to provide physical safeguarding and security of the facility.

- Site maximizes use of existing physical security systems.

- Site maximizes use of existing programmatic security systems.

Programmatic Criteria - These criteria are used to ensure that the site considers appropriate site development and land use plans.

- Site maximizes use of existing land use areas.

- Site conforms to site development plans.

Health and Safety Criteria - These criteria provide a basis for candidate site selection in terms of protecting the public, facility personnel, and the facility from hazards during both construction and operation of the facility.

- Site construction and operation should minimize adverse impacts on traffic flow and traffic hazards adjacent to the site.

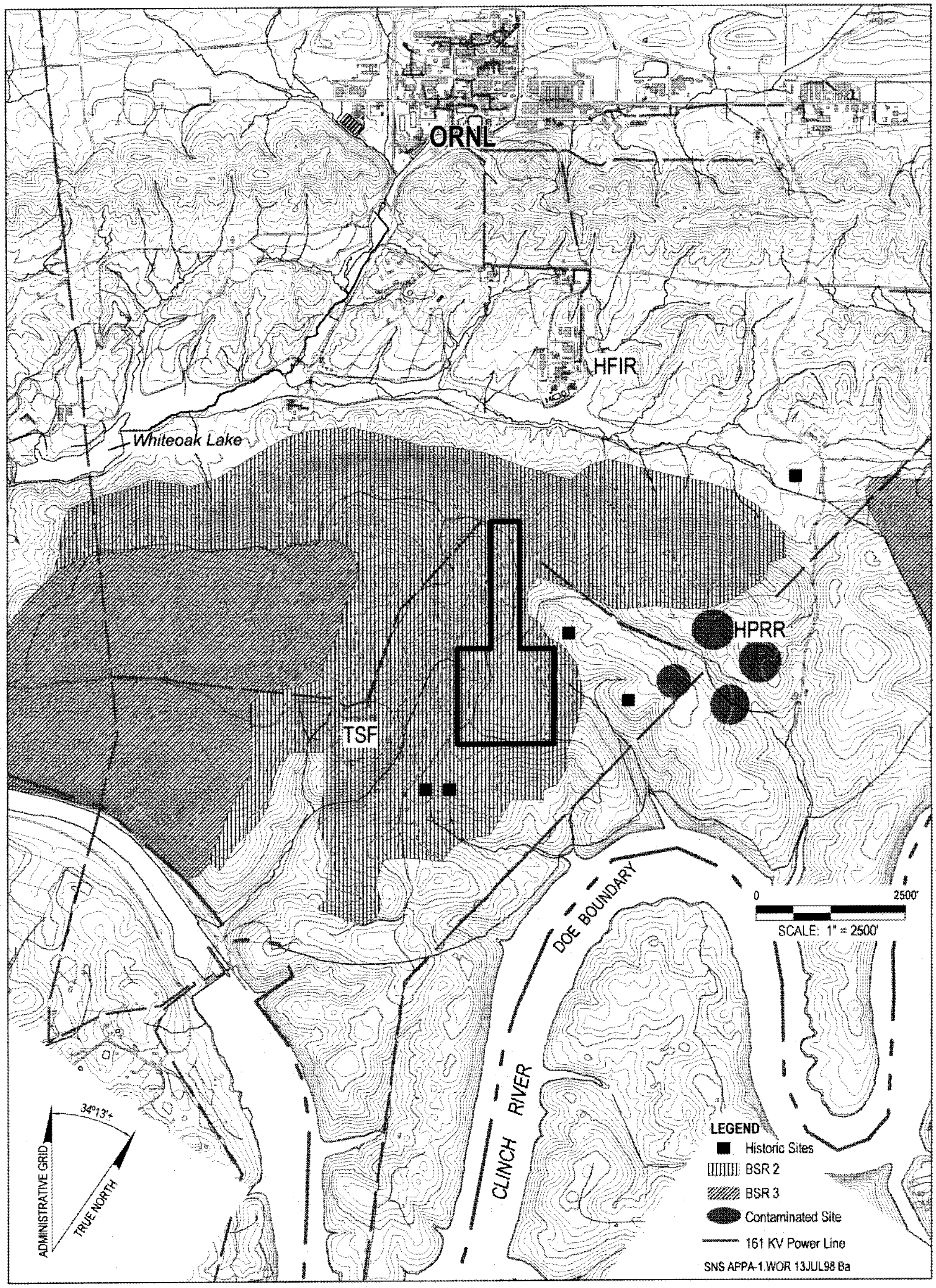
- Site should minimize adverse impacts on existing streams and groundwater.

- Site must not be located within the 500-year floodplain elevation.

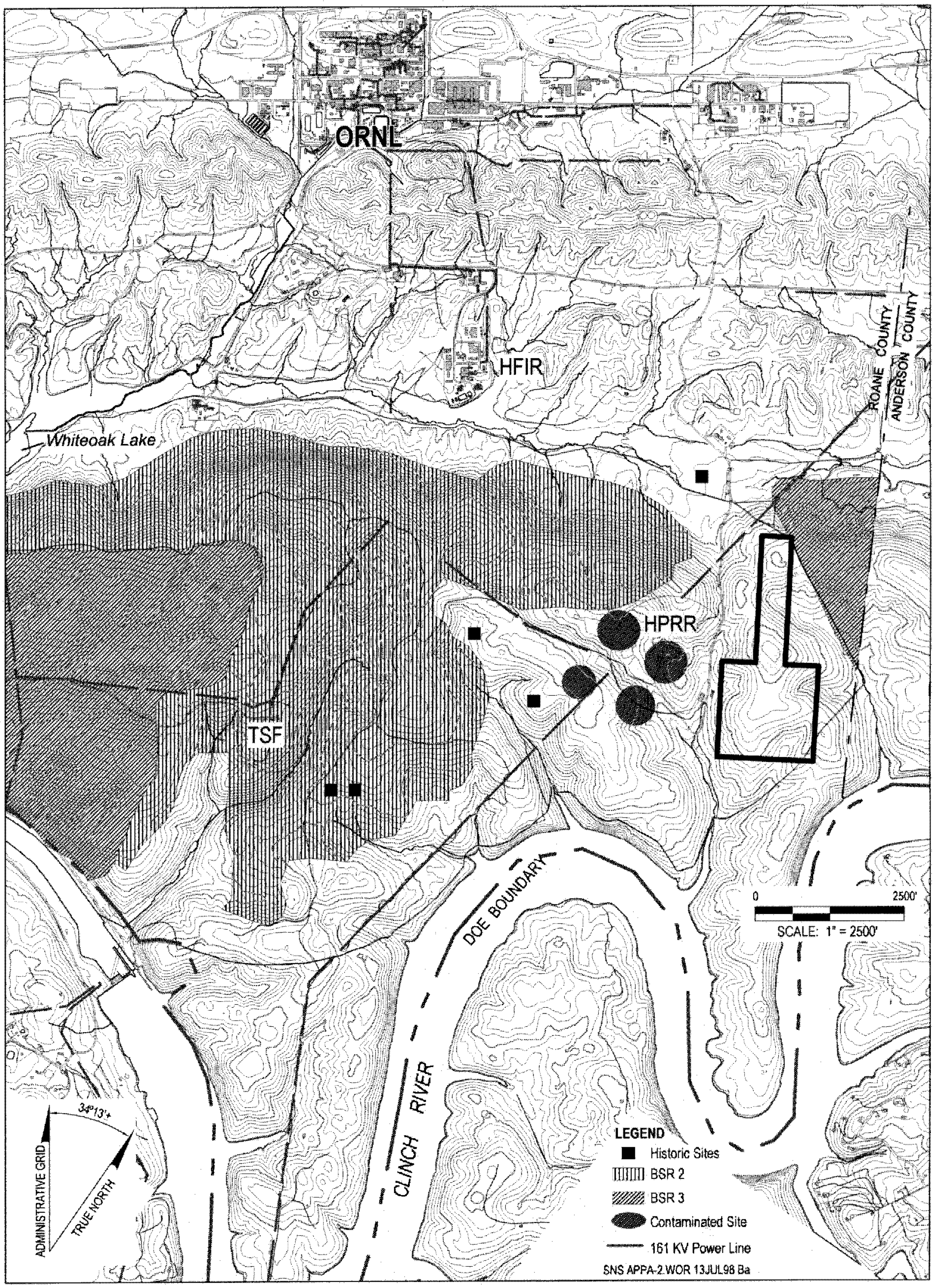
- Site avoids existing hazardous materials areas and waste areas [i.e., Waste Area Groups (WAGs) and Resource Conservation and Recovery Act (RCRA)].

- Site must not be on a geologic fault (seismic).

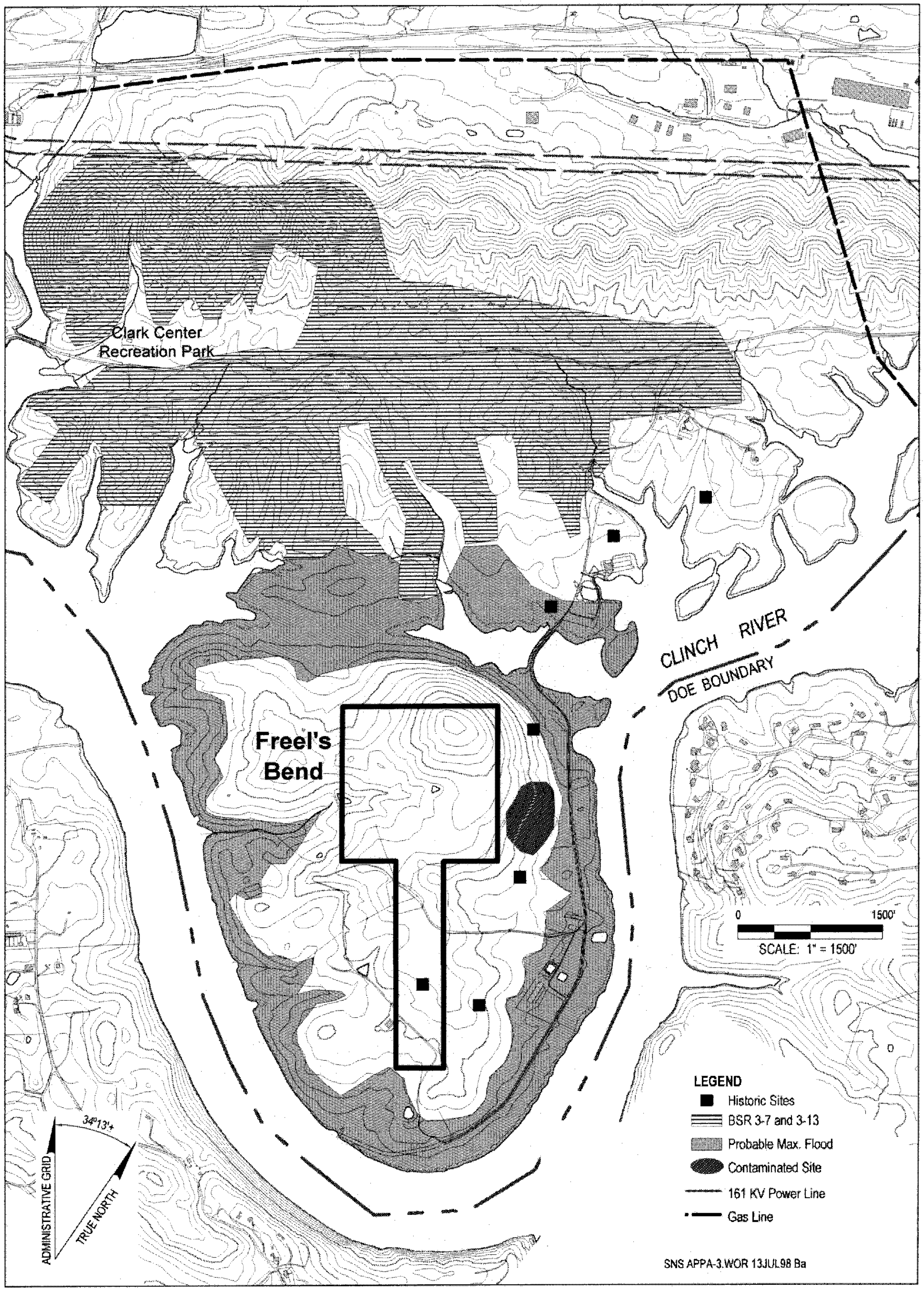
- Site provides a minimum 500-meter (1640 feet) separation from existing occupied structures (1000 meters desirable). Avoid close proximity to residential areas.



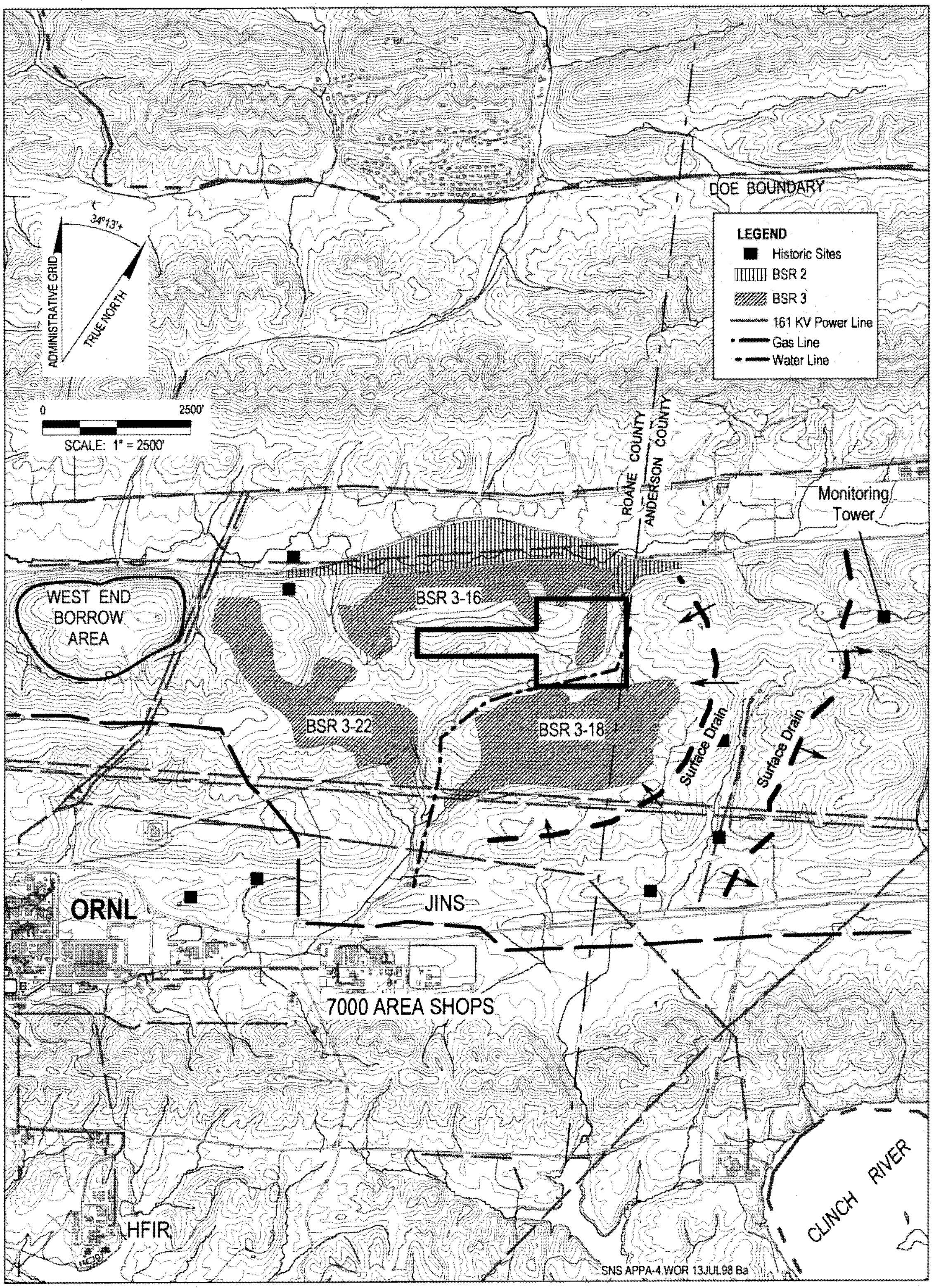
Area South of HFIR (Alternative 1)



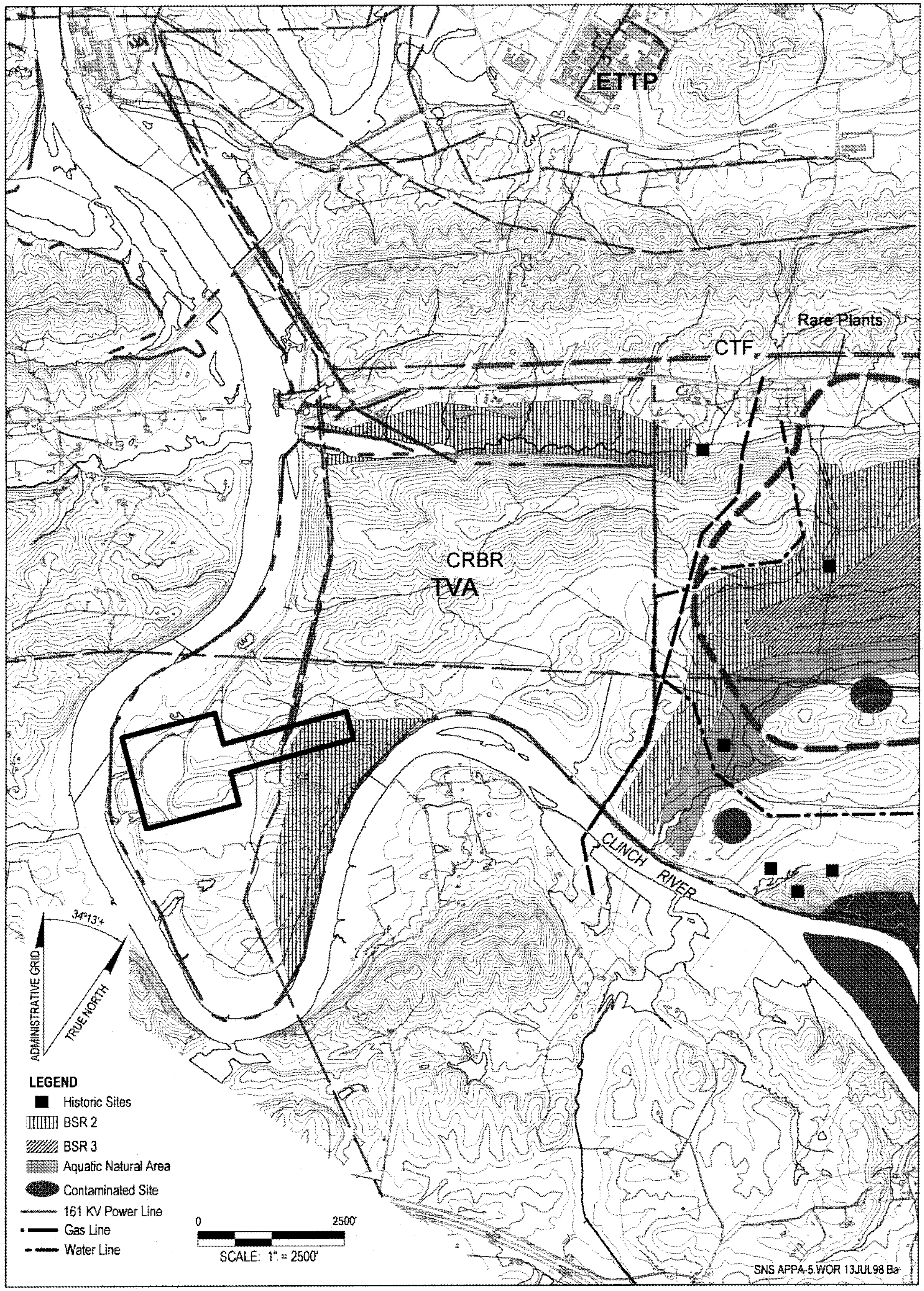
Area East of HPRR (Alternative 2)



Freels Bend Site (Alternative 3)



Chestnut Ridge Site (Alternative 4)



Clinch River Breeder Reactor (CRBR) Site

EXHIBIT 2

RESERVATION MANAGEMENT ORGANIZATION REVIEW COMMENTS ON THE SNS FACILITY SITING STUDY

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LOCKHEED MARTIN

Memorandum

Date: June 25, 1997

To: Fred R. Mynatt

c: H. M. Braunstein, J. B. Bussell (ETMC), T. R. Butz, R. Cox (ORAU), J. E. Cleaves, L. T. Cusick, S. G. Garland, R. P. Hosker, Jr. (NOAA/ATDD), D. T. Kendall, F. C. Kornegay, J. M. Loar, A. R. Medley, J. R. Newman, J. B. Overly, K. K. Baksa, P. D. Parr, J. D. Peebles, R.C. Peters, J. G. Rogers, W. K. Simon, D. S. Shriner, W. W. Thompson, Jr.

From: W. W. Teer, Jr., 1009COM, MS-8320 (6-0102)

Subject: **Reservation Management Organization (RMO) Review of Siting Study - National Spallation Neutron Source Facility**

On April 3, 1997, Mr. John E. Cleaves, Project Manager, National Spallation Neutron Source (NSNS) Facility presented the subject siting study (attached as Exhibit "1") to the RMO for review and comment. The RMO's review of the siting study has been completed and its' comments and recommendations concerning the four proposed sites (one preferred and three alternates) are summarized below:

GENERAL COMMENTS

1. The RMO recognizes the importance of the NSNS project to the Oak Ridge area and supports it.

2. Significant geologic concerns have been raised questioning the karst topography and related hydrologic transport on the preferred Chestnut Ridge Site. Flow paths from releases at this site have been traced to springs along Scarboro Creek and to the west of the site. The RMO strongly recommends a similar confirmation of flowpaths.

3. A detailed and time consuming preliminary analysis was done by the National Oceanic and Atmospheric Administration (NOAA) to evaluate potential impacts of the NSNS siting on their research site adjacent to Walker Branch Watershed resulted in prolonged response time for this RMO review.

This preliminary analysis indicates that NOAA measurements will be impacted by the siting of NSNS adjacent to their monitoring facility. The level and significance of this impact, however, has not yet been determined. NOAA has made a request for additional information and time to complete more detailed modeling analyses.

The RMO recommends that NSNS project personnel work directly with NOAA researchers to minimize/mitigate any potential impacts to their research and monitoring programs if the preferred Chestnut Ridge site is selected.

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4. The RMO recommends that the CRBR site be considered. This site has many advantages over the proposed alternatives: it has been studied in detail (has an Environmental Impact Statement); it would avoid impacts to the resources on the ORR; it would provide ample space for all facilities; it would afford expansion, if desired; it is close enough to ORNL; and it apparently meets many of the NSNS site selection criteria.

CHESTNUT RIDGE (PREFERRED SITE)

Geologic and Hydrologic Concerns

Karst development and conduit-related flowpaths are most developed along the Knox outcrop belt. These are sensitive areas from a hydrology perspective since any releases are rapidly transported through the system and there is little potential for remediation after-the-fact. In this case, both the primary and secondary sites are directly atop the Knox dolomite. This unit is known to have well developed karst and this is documented in karst inventory work recently completed. Further, if one considers the potential for collapse (such as is evidenced in the Mona Lane case in Oak Ridge), structural stability is questionable and the highest occurrences of collapse occurs in the Knox. Thus if there is any need for structural integrity, NOT documented in the siting needs list, these sites are possibly poorly situated. The most favorable locations would lie in outcrop belts of the Conasauga group or Rome formation, such as Pine Ridge, Haw Ridge, Melton Valley. It would also seem that in the case of Melton Valley, there is a wealth of information and monitoring network which would allow for release detection, etc. Given that one of the criteria was the potential for anchoring into sound bedrock, the question arises as to how these sites emerged at all.

Based upon ORNL karst inventory work, there are a number of sinkholes which form a linear trend that persists all along the ridge line. There are a number of documented sinkholes that exist along the south slope of the primary site location. This suggests a well developed conduit network (to have accommodated removal of the soil/overburden mass from these sinkholes).

Further, though the candidate site is located atop a relatively flat hilltop in the Knox with incised drainages on two sides, this also suggests potential for radial releases of any contaminants should this occur. Flow in bedrock is typically strike-parallel which would either be to some of the springs that exist along westerly bounding drainage (which flows north towards Y-12) or the southerly bounding drainage (which flows towards Bethel Valley), if not beyond these. Based upon dye tracer work at the Y-12 Security Pits site located directly along strike to the east, flow paths from releases at this site have been traced to springs along Scarboro Creek and to the west of the site.

The accompanying proposal text cites a minimal demand for containing groundwater "runoff" due to its limited 'encatchment' area. In karst settings, topographic expression in no way delineates watershed and thus catchment areas. Further, as evidenced from similar settings along Black Oak Ridge, the overburden developed above the cherty Knox group bedrock consists of silty clay and gravel zones the latter of which are laterally end vertical extensive relict chert bedding zones. These zones can be shown to 1) serve as primary, quick routes of transport of contaminants to the underlying

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bedrock and 2) serve as pressure relief valves for the underlying karst network such that water from the conduits is transmitted to shallow depths along these features (sort of like fingers of higher heads extending above the average water table). This may impact shallow construction.

The criteria of encountering sound rock within reasonable depth of cut is questioned. Typically, the thickest overburden is encountered on hilltops over the Knox, such as in these two sites. Depth to rock may easily reach 60-80 ft on the ridgetop.

One resource representative has suggested that an alternate site that should possibly be considered from a hydrologic/geologic perspective (not necessarily based upon existing infrastructure elements). This alternate site would be in the relatively flat area in the 8000 area of ORNL near the Clinch River. This area is underlain by less permeable Conasauga group clastic bedrock overlain by alluvial deposits. Groundwater flow in this suggested alternate site is much more predictable and monitorable, there is electric power service, more structurally competent bedrock, and relatively good/easily improvable access from Highway 95.

Potential Research and Monitoring Impacts

A preliminary analysis by NOAA/Atmospheric Turbulence and Diffusion Division (ATDD) indicates that NOAA measurements will be impacted by the siting of NSNS adjacent to their monitoring facility. The level and significance of this impact, however, has not yet been determined. NOAA has made a request for additional information and time to complete more detailed modeling analyses.

A May 30, 1997 memorandum from Dr. R. P. Hosker, Director of NOAA/ATDD is included at the end of this response. See Exhibit 2.

At this point, there is no information on chemicals that would be used during operation of the facility, although researchers could possibly bring such things with them. Also there are no plans for a steam plant, but if one were needed it would probably be gas-fired.

Evaluation of impacts to on-going or potential future ORNL Environmental Sciences Division ecological research has concluded that the probability for negative impacts is minimal, however, geologic/hydrologic review of subsurface transfers is recommended to ensure that the Walker Branch Watershed 30-years hydrologic record is not compromised. A subsidiary issue which would impact the National Precipitation and Dry Deposition Monitoring Netword site on Walker Branch Watershed, at a minimum, would be the use of chemical biocides in cooling tower waters.

Environmental Regulatory Impacts

An ORNL regulatory monitoring station, which is a reference sampling station for NPDES surface water monitoring as well as radiological parameters, is located on White Oak Creek. The station is located at the headwaters, which are on the crest of Chestnut Ridge quite close to the proposed NSNS site. Data collected at the station provide background information at a "clean" site, against which other data is compared for evidence of contamination. Care would be required during construction on the ridge to protect the monitoring station and keep it "clean."

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Many other small streams that drain the ORR, including Chestnut Ridge, have recently been added as surface water sampling sites. These include Grassy Creek, Ish Creek, Northwest Tributary, and Raccoon Creek. It will be important to prevent soil erosion during construction on the ridge to protect all streams and creeks from compliance violations due to excessive suspended solids (i.e., sedimentation). In addition, these streams could be in violation of compliance limits subsequent to construction as a result of runoff from landscaped areas and roads and parking lots.

The preferred site is located in the Bear Creek watershed, and covered under the Y-12 NPDES Permit. Currently, only storm water type discharges are permitted in this area. Any process type discharges would have to be negotiated with state or local regulatory authorities. Several options are possible regarding the treatment/discharge of waste waters, some options could require a modification to the NPDES Permit.

Y-12's NPDES monitoring point S-24, rad monitoring point 304, and spring SS-5, could potentially be affected by the construction and operation of this 100 acre facility.

More information would be needed to fully assess other permitting needs, including air permitting, however, this need not be a problem.

Potential Impacts to Streams and Wetlands

No federal jurisdictional wetlands were identified in the site characterization area, consisting of the proposed boring locations and drill rig access paths, in a survey of the site conducted on March 11, 1997. Based on surveys in many areas of the ORR, ridge tops are considered to be highly unlikely locations for wetlands, with the possible exception of sinkholes and depression contours.

Adverse impacts to offsite wetlands and headwater tributaries of White Oak Creek immediately southeast of the site can occur unless effective erosion control measures are implemented prior to construction to prevent runoff and siltation of these important habitats. Care must also be taken to avoid erosion due to access path clearing and boring (e.g., escape of drilling muds) during any characterization activities.

A major spring just north of the site provides significant flow to Bear Creek, which has the Tennessee dace, a species listed as in need of management by the Tennessee Wildlife Resources Commission. Effective measures must be taken to prevent siltation of this headwater spring. Likewise, any long-term impact to the ecologically fragile seep-fed wetlands in the Bear Creek Spring Area at the base of Chestnut Ridge must be avoided.

A critical concern regarding the development of Chestnut Ridge is the long-term impact to the ecologically fragile seep-fed wetlands in NA52 (Bear Creek Spring Area) at the base of Chestnut Ridge. Adverse impacts which would over time destroy or degrade this sensitive habitat include: changes to the local hydrology and drainage patterns as a result of up-slope grading, construction and paving; increased erosion and siltation/sedimentation as a result of up-slope grading and construction; and chemical run-off from landscaped areas (fertilizers and pesticides) and roads (petrol-chemicals and salts).

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Potential Impacts to Ecologically Sensitive Areas

The NSNS site overlaps several environmentally sensitive areas, including a National Environmental Research Park Natural Area (NA52; Bear Creek Spring Area) and three Preliminary Conservation Sites recommended for protection by The Nature Conservancy (BSR2-10, BSR3 16, and Landscape Complex 1). Additionally, the oak-hickory forest area on the southeast facing slope of Chestnut Ridge drains toward ecologically sensitive streams and wetlands in NA55 (Chestnut Ridge Springs Area), ARA6 (Upper White Oak Creek), BSR3-22, and BSR4-3. This forest provides significant landscape connectivity between NA52 and NA55. Parts of this forest should be protected (due to drainage effects) for increased natural area viability. Potential adverse impacts to environmentally sensitive areas include (1) reduction in T&E species habitat quality; (2) introduction or spread of exotic species; and (3) forest fragmentation and reduced landscape connectivity between Natural Areas.

Potential Impacts to T&E Wildlife and Plant Species

Although no extensive surveys for T&E wildlife have been conducted in the Chestnut Ridge area, a reconnaissance was conducted recently and several state-listed birds could occur there. Also, the Chestnut Ridge area of the ORR exemplifies the unfragmented hardwood habitat that is so increasingly scarce in the region. Protection and enhancement of such habitat would help protect interior forest species, such as bats (e.g., Rafinesque's big-eared bat and the Indiana bat) and neotropical migrant songbirds (e.g., Cerulean warbler).

The following three Tennessee-listed vascular plant species and an additional species which is highly ranked by The Nature Conservancy were determined to be present in the surrounding area during previous surveys, and potential habitat for these species exists onsite:

- Pink lady-slipper (Cypripedium acaule) / TN-Endangered
- Golden seal (Hydrastis canadensis) / TN-Threatened
- Ginseng (Panax quinquefolius / TN-Threatened
- Whorled horsebalm (Collinsonia verticillata) / The Nature Conservancy global ranking-High

Potential Impacts to Borrow Area

The NSNS Site Selection dialogue indicates the need for a storage area for backfill material and for spoils material, and that the "now exhausted Chestnut Ridge borrow area" could serve in that capacity. This conflicts with recent information obtained by the Environmental Restoration organization, where surveys have shown a large amount of soil for closure activities and other borrow material needs. Since this borrow area (a.k.a. West Borrow Area) is the only active borrow area on the ORR, consideration should be given to 1) selecting another soil storage area, possibly adjacent to the NSNS Site or, 2) selecting a replacement area with suitable clay to serve the regular needs of the ORR for closure/borrow material.

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Potential Impacts to Cultural Resources

A preliminary cultural resource literature review indicates that there is at least one pre-1942 homestead near the west boundary of the Chestnut Ridge site. To comply with the National Historic Preservation Act, a Section 106 survey would be required for all of the 100 acres proposed for construction. No major archeological or historical sites are anticipated in this area however.

Other Considerations

There is great potential for erosion during construction as well as during operation of the facility. Both sides of the ridge are steep and may be very difficult to stabilize after clearing trees.

Soil data is available electronically (GIS) and should be useful in evaluating the site.

The site selection included karst rock formation, but excluded sinkhole areas. All karst areas have the potential for future sinkhole formation and underground caves. Sinkhole survey information is also available.

Part of the Aerial Survey program conducted by Environmental Restoration Program included the use of remote sensing magnetometers, etc. that might help identify more details associated with near surface caves, etc. (e.g., something less than solid rock). Richard Durfee's GIS group may have that data.

All environmental issues would be examined during the required NEPA review.

There do not appear to be any security consideration for this or any of the other potential sites. During the design phase, PSO needs to be involved to patrol guidance on elements such as barriers, property protection, access control, and Protective Force and Fire response.

From a radiological control perspective, there are no substantive comments on the identification of this or any of the other potential sites at the ORR. Obviously, the design of the facility will require consideration for shielding and dose control to workers, but that will occur later if project proceeds.

SOUTH OF HFIR AND EAST OF TSF (ALTERNATIVE #1)

Potential Impacts to Cultural Resources

This area includes the Gravel Hill Cemetery and several standing structures that made up the Gravel Hill Community, once supporting a school for that portion of Roane County. Recent surveys have shown that some of these sites are individually eligible for the National Register of Historic Places (NRHP), and collectively the area is eligible as a historic district. Additional surveys and considerable mitigation would be required to develop this area.

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Potential Impacts to T&E Species

The following TN state-listed species was determined to be present in the surrounding area and may be present within the site: Ginseng (Panax quinquefolius) / TN Threatened. This site encroaches on a Preliminary Conservation Site recommended for protection by The Nature Conservancy (Landscape Complex 2). Without more detailed mapping of this site, it is not possible to identify any other encroachments on Environmentally Sensitive Areas.

Other Potential Environmental Impacts

Measures must be taken to avoid impacts on the extensive Copper Ridge Cave Reference Area system.

EAST OF HPRR (ALTERNATIVE #2)

Potential Impacts to Cultural Resources

This area includes some old home sites that recent surveys have documented as not eligible for the NRHP. An additional survey and little or no mitigation is likely for developing this area.

Potential Impacts to T&E Species

The following TN state-listed species were determined to be present in the surrounding area and may be present within the site:

- Ginseng (Panax quinquefolius) / TN Threatened
- Lesser ladies-tresses (Spiranthes ovalis) / TN Special Concern
- Appalachian bugbane (Cimicifuga rubifolia) / Federal Special Concern (former C2 candidate), TN Threatened

The following TN state-listed species were determined to be present in the surrounding area and may be adversely impacted by offsite effects of development (such as changes in local hydrology and drainage patterns, and increased erosion and sedimentation):

- Spreading false-foxglove (Aureolaria patula) / Federal Special Concern (former C2 candidate), TN Threatened
- Carey saxifrage (Saxifraga careyana) / TN Special Concern.

Potential Impacts to Ecologically Sensitive Areas

The site encroaches on a Preliminary Conservation Site recommended for protection by The Nature Conservancy (Landscape Complex 2). Without more detailed mapping of this site, it is not possible to any identify other encroachments on Environmentally Sensitive Areas.

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The TN state-listed sharp shined hawk and yellow bellied sapsucker have been observed in the Park City Road area adjacent to the site. Also, this site is less desirable than the others because of the additional disturbance that would occur to meet road and other infrastructure requirements.

FREELS BEND AREA (ALTERNATIVE #3)

Potential Impacts to Cultural Resources

This area includes a valuable cultural resource, the Freels Cabin, listed on the National Register of Historic Places (NRHP). In addition, the site contains several archeological areas where Native American artifacts have been recovered. A considerable amount of investigation and evaluation, including consultation with the State Historic Preservation Officer, would be required for proposed projects in this area.

Potential Impacts to T&E Species

This site is the only site that has been surveyed for T&E wildlife. State listed in-need-of-management species on this site include: southeastern shrew, Sharp-shined and Cooper's hawks, great egret, northern harrier, yellow-bellied sapsucker, and grasshopper sparrow. The federally threatened bald eagle has been observed during the winter, and the state threatened osprey nests in the area. This is an excellent wildlife site, providing a mosaic of fields, hedgerows, woodlots, and water, an increasingly rare combination in the region. Development of this site would entail additional disturbance to wildlife habitat (compared to the preferred, TSF, or CRBR sites) for road improvement and other infrastructure development.

This site also encroaches on a Cooperative Management Area for T&E species (CMA 3), Lower Freels Bend Meadows. However, it is possible that the development of the NSNS at this site would be compatible with continued management of the surrounding area for T&E species.

Other Considerations

The mid-part of Freels Bend supports the Ecological and Physical Sciences Study Center, an important educational field resource for school children and teachers.

Hay grown on Freel's Bend is sampled and analyzed for radionuclides in compliance with the regulatory requirements in DOE Order 5400.1 to be incorporated into 10 CFR 834. The results are reported in the publicly available ORR Annual Site Environmental Report.

If you have any questions, please do not hesitate to contact me.

WWT:JRN:PDP:bsb

Attachments

EXHIBIT 3

RESERVATION MANAGEMENT ORGANIZATION RECOMMENDATION FOR SITING THE SNS FACILITY

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LOCKHEED MARTIN

Memorandum

Date: August 15, 1997

To: Richard K. Genung, Fred R. Mynatt

c: B. R. Appleton, K. K. Baksa, H. M. Braunstein. D. G. Lund (ETMC), T. R. Butz, J. E. Cleaves, R. Cox (ORISE), L. T. Cusick, S. G. Garland, R. P. Hosker, Jr. (NOAA/ATDD), D. T. Kendall, F. C. Kornegay. J. M. Loar, A. R. Medley, J. R. Newman, J. B. Overly, P. D. Parr, J. D. Peebles, R. C. Peters, J. G. Rogers, D. S. Shriner, W. K. Simon, W. W. Thompson, Jr., D. K. Wilfert

From: W. W. Teer, 1009COM, MS-8230 (576-0102)

Subject: **Reservation Management Organization Recommendation for Siting the National Spallation Neutron Source (NSNS) Facility**

Recommendation

The Reservation Management Organization (RMO) recommends the Chestnut Ridge Site on the southern slope of Chestnut Ridge immediately west of the Roane/Anderson County line and Chestnut Ridge Road as the preferred site for the National Spallation Neutron Source (NSNS). Issues of concern raised in the June review by the RMO (W. W. Teer, Jr. to F. R. Mynatt, June 25, 1997) have been adequately addressed. This site is shown as the "Primary Site" on the accompanying map. RMO approval of this does not preclude the need for National Environmental Policy Act (NEPA) documentation, Area Manager approvals, or other reviews as required.

Background

The NSNS project has developed requirements and criteria and has performed a selection process that identified Chestnut Ridge as the primary site. Several alternative sites have been identified. The RMO was informed of the NSNS project in November 1995, and the selection process was formally submitted to them on April 3, 1997.

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RMO representatives identified issues and provided comments and suggestions regarding the NSNS site selection. They were summarized in a memorandum from W. W. Teer, Jr. to F. R. Mynatt, dated June 25, 1997.

The Chestnut Ridge site is the best site for NSNS because:

a) It is the most cost effective site. It is near roads, utilities, and construction-borrow areas; it has the best situation for transport of waste and use of ORNL shops, security, and other facilities; and it has the most advantageous topological configuration for site excavation and construction of berm shielding.

b) It has the least potential impact on the environment and the public. The site avoids wetlands, blue line streams, historical sites, threatened and/or endangered species, and other environmental impacts as well or better than the alternative sites. It is also the most remote from public access areas.

c) It has the best location for supporting ORNL neutron sciences programs.

d) It will be located close to the site preferred for JINS, which will support neutron science programs at ORNL, High Flux Isotope Reactor (HFIR), and NSNS.

Issues and Resolutions

The major issues regarding the Chestnut Ridge site are that its karst topography could adversely impact construction, and the NSNS construction could adversely impact environmental science research at the Walker Branch Watershed (WBW) area located east of the site and the White Oak Creek headwaters south of the site.

Cognizant personnel from ORNL and the National Oceanic and Atmospheric Administrations (NOAA) were contacted to evaluate and resolve these issues. The issues addressed, and their corresponding resolutions, are described below.

Construction on Karst Topology

Present information about foundation stability requirements, preliminary foundation design work, shock test data from ORNL, and preliminary core borings indicate that construction on Chestnut Ridge will not be a problem if approached correctly. Further, construction on Karst topography is not uncommon in the Knoxville area and/or on the Oak Ridge Reservation.

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Further study of ORNL geological data from magnetometer measurements and much more core boring in FY 98 will be used to confirm the situation.

The NSNS project team will employ an integrated approach and/or plan that is generated with appropriate stakeholders and subject matter experts. A workshop with appropriate stakeholders and experts will define the issues and identify the technology available to measure, monitor, design, etc. Information from the workshop and existing ORNL data will be used to plan for core boring (including considering how bore holes might be used for monitoring wells and other items in the future), excavation, and lead into foundation design.

NOAA Research Issues

Dust from construction could affect the long-term monitoring of wet and dry deposition of key air pollutants. This potential impact will be of short duration (less than 1 1/2 years with most activity occurring in the first 7 to 8 months), and it is presently felt that this impact can be handled with normal dust control methods, possibly some additional measurements taken during construction, and other data protection means.

Carbon dioxide and nitrogen oxides from natural gas water heaters to generate building heat could affect studies of carbon dioxide uptake. This impact is not expected to be significant, and if it is, it can be handled by changes in the NSNS design (to provide heat a different way for example).

The heat and water vapor plume from the cooling tower could affect the measurement of air-surface exchange of momentum, heat, and water vapor. Modeling of the cooling tower will be performed in FY 98 to quantify the impact and examine the virtues of different cooling tower locations and arrangements to determine how best to mitigate the impact. This modeling will lead to an acceptable design. If not, a second research tower will be built at a suitable location far enough in advance of site excavation to calibrate it with respect to the existing tower and conditions.

White Oak Creek Impact

Construction on the Chestnut Ridge site could impact aquatic habitats and monitoring activities in the headwaters of White Oak Creek.

Technology to properly protect White Oak Creek from silt and other construction hazards is available. Proper planning and monitoring of construction activities will prevent adverse impacts.

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ORNL personnel will assist the NSNS team input requirements into conventional facilities requirements documents and the RFP for the Architect Engineer/Construction Manager contract. The NSNS project team will also conduct workshop(s) with experts in construction near sensitive areas to make sure that all the technology and tricks of the trade available are applied. This and plans, monitoring, and frequent meetings with the stakeholders during land survey, core boring, excavation, and other high activity times should provide acceptable results.

Construction Impact on Deep Subsurface Hydrology

NSNS site excavation could change the deep subsurface hydrology that very often exists with a karst topology to the degree that it causes an adverse impact on the WBW subsurface hydrology. This effect would occur primarily because the water table will be lowered when excavation occurs.

Well measurements during construction could be used to "recalibrate or adjust" the existing WBW data.

Assessment of potential impacts will be determined by performing drawdown and pump tests and examing magnetometer data. Based on drawdown and pump test results, tracer tests and, if warranted, modeling of the excavation design will be performed.

Consideration of Alternate Sites

The RMO suggested consideration of the Clinch River Breeder Reactor (CRBR) site (one of the alternative sites identified) and the Oak Ridge National Laboratory (ORNL) 0800 area across the Clinch River from Jones Island. The CRBR site is considered unacceptable because its location is too distant from other neutron sciences research facilities and the acceptable locations for the Joint Institute of Neutron Sciences (JINS) facility, and because it is owned by the Tennessee Valley Authority (TVA). Acquiring the site from TVA would likely cause an unacceptable cost and/or schedule impact to the NSNS project. The 0800 area is too small for NSNS construction and would cause adverse impacts to environmental sciences research in that area.

Summary

An NSNS project Design Team will have environmental components appropriately integrated (with representation, for example, from NOAA, Tennessee Wildlife Resources Agency, ORNL Environmental Sciences Division, National Environmental Research Park, etc.) This team will also pursue creative approaches for additional environmental research opportunities offered by the NSNS facility. Communication with RMO on implementation of these resolutions will be provided, and major changes in siting will be brought to the RMO for consideration.

Richard K. Genung, Fred R. Mynatt
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In conclusion, it is felt that Chestnut Ridge provides the most advantageous location for the facility, that solutions and fallback positions exist for the issues raised. Consequently, the RMO recommends that the Chestnut Ridge should be designated as the preferred site for NSNS construction.

If you have any questions or need additional information, please do not hesitate to contact m.

WWT:JRN:sgl

Attachment

Phone: (423) 576-0102
FAX (423) 241-3597
INTERNET: wwt@ornl.gov

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LOS ALAMOS NATIONAL LABORATORY
SITE SELECTION REPORT

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National Spallation Neutron Source
Los Alamos National Laboratory
Site Selection Report

Prepared for the
United States Department of Energy/
Oak Ridge Operations Office

Prepared by

The Planning Office of
Facilities Safeguards and Securities Six (FSS-6)
and Ecology Group (ESH-20)

Los Alamos National Laboratory
Los Alamos, New Mexico

March 28, 1997

NATIONAL SPALLATION NEUTRON SOURCE
LANL SITE SELECTION REPORT

Los Alamos National Laboratory
March 28, 1997

INTRODUCTION

This report evaluates four potential sites for construction of the National Spallation Neutron Source (NSNS) at Los Alamos National Laboratory (LANL) in Los Alamos, New Mexico. In 1995 the Department of Energy (DOE) determined that NSNS would require an Environmental Impact Statement (EIS). The DOE then developed a process to identify suitable alternatives to the DOE's "preferred alternative" at Oak Ridge National Laboratory (ORNL). The process evaluated 39 DOE sites, and LANL qualified as one of three alternative locations besides ORNL for the facility. The other two alternative locations were Argonne National Laboratory and Brookhaven National Laboratory. *(Draft National Spallation Neutron source Project, Alternate Site Selection Report; US Department of Energy, Office of Energy Research; prepared by Roy F. Weston, Inc., August 23, 1996)*

This report provides the NSNS program with a decision-making tool for selecting an alternative candidate site at Los Alamos National Laboratory for the NSNS facility. The site evaluation process uses the following steps for selecting a recommended site:

- List NSNS physical design parameters provided by the NSNS design team
- Inventory of candidate LANL sites
- Evaluation of each candidate site according to NSNS siting criteria
- Determination of the candidate site with the best attributes and least restrictions to accommodate the NSNS

Four candidate sites were identified from which the recommended site was determined to best meet the NSNS criteria: Technical Area* (TA-) 70, TA-33, TA-58 and TA-71. These areas and the project footprint are illustrated on the four maps presented at the end of this report.

NSNS SITE REQUIREMENTS

The NSNS site must accommodate several physical and environmental requirements. These requirements are categorized as functional, environmental, and programmatic and are listed below.

* LANL is divided into technical areas (TAs) that are used for building sites, experimental areas, waste disposal locations, roads, and utility rights-of-way. However, these uses account for only a small part of the total land area. Most land provides buffer areas for security and safety and is held in reserve for future uses.

Functional

- A site that accommodates a hammer-head shaped structure measuring 500 x 500 meters with a tail centered on the above square and measuring 100 x 500 meters
- A site that can be excavated to be level and founded on solid rock
- Additional space for support buildings and access roads requiring an additional 100,000 square meters
- Sufficient earth fill available on site or nearby to provide an average of 15 feet cover for shielding over the hammer-head shaped area
- Reasonable proximity to other facilities at LANL
- Reasonable access to a disposal area for rock and excess earth excavation
- Proximity to stockpile areas for earth excavation for covering and shielding the main structure
- Avoid significant overhead and underground utility relocation (e.g., power lines, water line mains and gas transmission lines, steam lines)
- Minimize runoff to, through and from the site
- Reasonable access to existing utility systems to include:
  - 40 MW electrical power
  - potable water
  - compressed air, natural gas, sanitary sewer, steam and chilled water (desirable, can be provided by on-site facilities)
  - availability of construction power within one mile
- Reasonable proximity to primary and/or secondary paved roads for users, researchers, materials, supplies; for target transport; for waste and irradiated material removal
- Buffer zone to avoid residential areas and large worker populations

Environmental

- Avoid construction in floodplain
- Avoid construction in or disturbance of wetlands
- Avoid locations with threatened or endangered plant or animal species
- Avoid Solid Waste Management Units (SWMUs) and Potential Release Sites (PRSs)
- Minimize impact on National Environmental Research Park (NERP)

Programmatic

- Conform with appropriate site development and land use plans
- Avoid existing recreation uses

INVENTORY OF CANDIDATE LANL SITES

Siting and construction of the NSNS facility is a major undertaking requiring a large site. While LANL covers 43 square miles, much of the terrain is rugged canyons separated by high mesas. Many sites are presently developed, and there are limited undeveloped sites of adequate size where the NSNS facility would have sufficient land. Of the total available sites some are too small in area or are isolated and/or geographically separated from major developed areas of the laboratory. Several sites are candidates for eventual transfer of ownership to Los Alamos County, nearby Pueblos or other entities.

There are only four sites that appear to meet the siting criteria and that are considered here for development of the NSNS facility. These sites are TA-70 (Alternative Site # 1); TA-33 (Alternative Site #2); TA-58 (Alternative Site #3) and TA-71 (Alternative Site #4). Each of these sites is evaluated according to the above siting criteria. Table 1 presents the summary evaluation of the four potential candidate sites according to the siting criteria for the NSNS facility.

Table 1. Analysis of Siting Criteria at Four Potential LANL Sites

Siting Criteria	TA-70, Alternative Site #1	TA-33, Alternative Site #2	TA-58, Alternative Site #3	TA-71, Alternative Site #4
FUNCTIONAL				
1. Physical accommodation of building footprint (500 m x 500 m with attached 100 m x 500 m addition) at same elevation and founded on sound rock	Adequate	Adequate	Too small	Adequate
2. Adequate earth backfill to provide an average of 15 feet cover for shielding	Adequate	Adequate	Adequate	Adequate
3. Close proximity to LANL support facilities and services	Remote from existing facilities/ services	Remote from existing facilities/ services	Adjacent to existing facilities/ services	Remote from existing facilities/ services
4. Reasonable access to disposal area for rock and excess earth excavation	Reasonable access	Reasonable access	Reasonable access	Reasonable access
5. Avoid relocating significant overhead/underground utilities	Avoids underground utilities but requires realignment of overhead electrical line	Avoids underground utilities but requires realignment of overhead electrical line	Relocation of multiple utilities	Avoids underground utilities but requires realignment of 2 overhead electrical lines
6. Proximity/access to existing utility systems (40 MW power, potable water, compressed air, natural gas, sanitary sewer, steam and chilled water [desirable but can be provided on-site], construction power within one mile	Remote from existing utility systems	Remote from existing utility systems	Close to existing utility systems	Remote from existing utility systems
7. Proximity to primary and/or secondary paved road access	Adequate	Adequate; possible relocation of road required	Adequate	Adequate
8. Adequate buffer zone	Adequate	Close proximity to Bandelier National Monument	Adjacent to highly populated TA	Close proximity to residential area

Table 1 (cont.). Analysis of Siting Criteria at Four Potential LANL Sites

Siting Criteria	TA-70, Alternative Site #1	TA-33, Alternative Site #2	TA-58, Alternative Site #3	TA-71, Alternative Site #4
ENVIRONMENTAL				
9. Avoid disturbance of floodplains and wetlands	No adverse floodplain or wetland impacts	No adverse floodplain or wetland impacts	No adverse floodplain impacts, possible wetland impact	No adverse floodplain or wetland impacts
10. Avoid locations with threatened or endangered plant or animal species (0.25 mile radius)	Bald eagle roosting habitat	Bald eagle roosting habitat	Northern goshawk foraging habitat; unoccupied Mexican spotted owl habitat	No impact
11. Avoid locations with threatened or endangered plant or animal species (1.0 mile radius)	Bald eagle roosting habitat	Bald eagle roosting habitat; Peregrine falcon nesting habitat	Northern goshawk foraging habitat; Spotted owl roosting habitat	Bald eagle roosting habitat
12. Avoid SWMUs and PRSs	No SWMUs or PRSs	No SWMUs or PRSs	No SWMUs or PRSs	No SWMUs or PRSs
13. Avoid locations with historic, cultural, or archaeological resources present	Not surveyed but known to have cultural resources present	56% surveyed, cultural resources present	49% surveyed, no cultural resources identified yet	24% surveyed, cultural resources present
14. Minimize impact on National Environmental Research Park (NERP)	All LANL is within NERP boundaries	All LANL is within NERP boundaries	All LANL is within NERP boundaries	All LANL is within NERP boundaries
PROGRAMMATIC				
15. Compatible with site development and land use plans	Consistent with 1990 Site Devel-opment Plan and annual updates	Consistent with 1990 Site Devel-opment Plan and annual updates	Consistent with 1990 Site Devel-opment Plan and annual updates	Consistent with 1990 Site Devel-opment Plan and annual updates
16. Avoid existing recreation uses	Existing trails	Visible to hikers in Bandelier	Existing trails	Existing trails

EVALUATION OF CANDIDATE SITES

TA-58 (Alternative Site #3), has appropriate gross acreage, but its narrow shape and topography do not permit a sufficiently level site for construction of the facility on one level. There is also insufficient area for an adequate buffer around the site. TA-3, the most developed and populated of LANL's technical areas, is within 100 meters of the boundary of the potential site. Also, a major, multiple-utility corridor traversing the site would require relocation. Therefore, this candidate site has been eliminated from consideration.

Three remaining sites are of sufficient size to accommodate the NSNS facility: TA-33, TA-70 and TA-71. There is sufficient earth back fill to cover the facility for shielding at any of the sites, and reasonable access to a disposal area for excess earth excavation materials exists. Runoff to, through and from each of the sites could be minimized by standard engineering techniques. All three of these sites have direct access to New Mexico State Route Four. None of the sites have SWMUs or PRSs. However, none of the three sites are completely free from constraints, as discussed in the next paragraphs.

TA-70 (Alternative Site #1) is a completely undeveloped mesa except for a major electric power line that traverses the site. There are several unpaved paths used for recreational hiking. The footprint of the NSNS facility would cover an area with grade changes of 140 feet. There are no significant underground utilities requiring relocation, however, an overhead electrical line will require realignment. Adequate electric power can be made available. Potable water will have to be brought to the site, and compressed air, natural gas, sanitary sewer, steam and chilled water will have to be provided by on-site facilities. This site is within 0.25 mile of bald eagle roosting habitat. The site has never been surveyed officially for cultural resources but four archaeological sites have been recorded in the area.

TA-33 (Alternative Site #2) has been the site of former tritium laboratories and an explosive test site. It is also immediately adjacent to Bandelier National Monument where preservation of archaeological ruins and the natural environment is a major goal. TA-33 can accommodate the facility, but will require relocation of the road leading to an existing radio telescope facility and to a former explosives test site. The footprint of the NSNS facility would cover an area with grade changes of 120 feet. There are no significant underground utilities requiring relocation, however, an overhead electrical line will require realignment. Adequate electric power can be made available. Potable water will have to be brought to the site, and compressed air, natural gas, sanitary sewer, steam and chilled water will have to be provided by on-site facilities. This site is within 0.25 mile of bald eagle roosting habitat and within one mile of peregrine falcon nesting habitat. Twelve cultural resources have been recorded in the surveyed area of this alternative site.

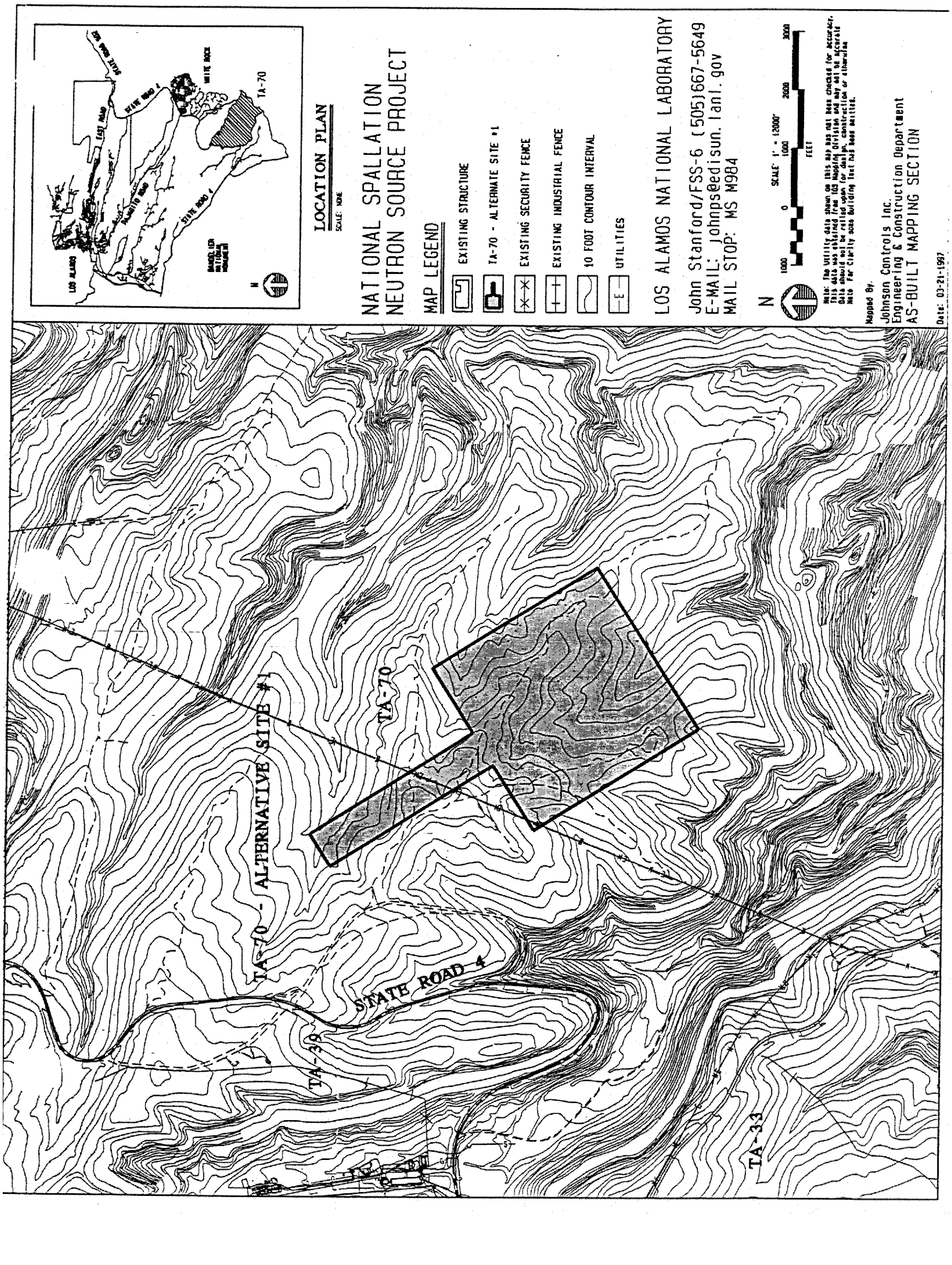
TA-71 (Alternative Site #4) is another undeveloped mesa and similar to TAs-70 and 33. The footprint of the NSNS facility would cover an area with grade changes of 110 feet. Both an existing power line and a second power/utility line will have to be relocated. This site is adjacent to the residential community of White Rock which is less than one mile to the east. This site is not within 0.25 mile of habitat for any threatened or endangered species. However, it is within one mile of bald eagle roosting habitat. Six cultural resources have been recorded in the surveyed area of this site.

RECOMMENDED SITE

Candidate sites at TAs 70, 33 or 71 could physically accommodate the NSNS facility. None of these three sites is located on the major fault lines shown in the 1990 Site Development Plan for LANL. However, there are similar constraints at each site:

- Construction on sites with grade changes ranging between 110 and 140 feet
- Utility corridors requiring realignment
- Cultural resources are either documented or expected at all alternative sites but mitigation of adverse effects on cultural resources could be achieved through data recovery
- Threatened or endangered species concerns
- Buffer encroachments - particularly at TA-33 (Bandelier National Monument) and TA-71 (the White Rock community)

A comparison of the sites was accomplished by assigning a score to each of the cells in Table 1, weighting each criteria and summing the scores. This analysis showed that TA-70 and TA-71 rank nearly the same and either one could be chosen as the recommended site. However, the fact that TA-70 has an adequate buffer zone and its utility corridor could be more easily realigned gives it a slight advantage over TA-71. Therefore, we recommend that TA-70 (Alternative Site #1) be designated as the LANL candidate site to accommodate the NSNS facility.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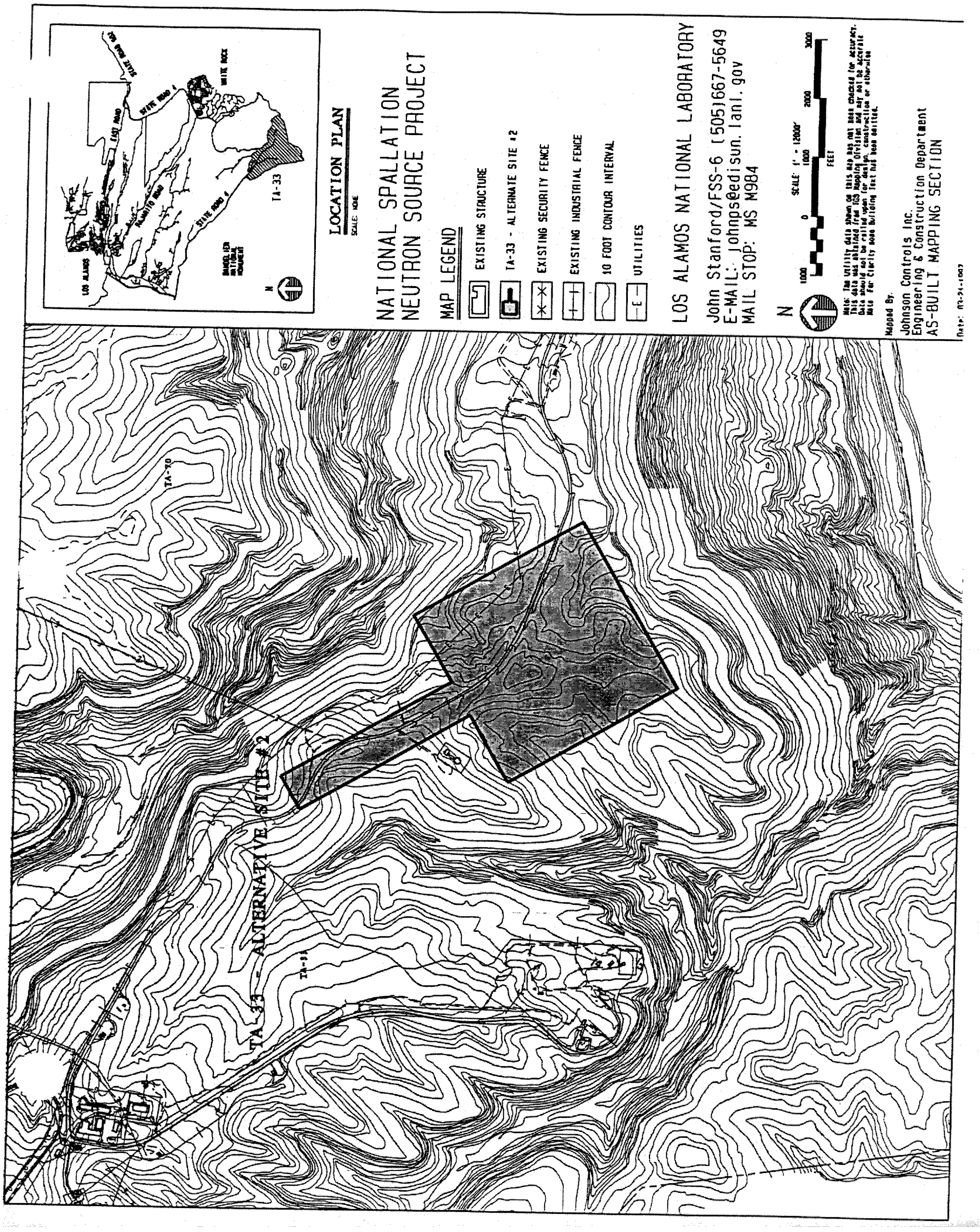
NATIONAL SPALLATION NEUTRON SOURCE PROJECT
MAP LEGEND
EXISTING STRUCTURE
TA-70 - ALTERNATE SITE #1
EXISTING SECURITY FENCE
EXISTING INDUSTRIAL FENCE
10 FOOT CONTOUR INTERVAL
UTILITIES
LOS ALAMOS NATIONAL LABORATORY
John Stanford/FSS-6 (505)667-5649
E-MAIL: johnps@edisun.lanl.gov
MAIL STOP: MS M984
N
FEET
Mapped By
Johnson Controls Inc.
Engineering & Construction Department
AS-BUILT MAPPING SECTION
Date: 03-21-1997
TA-70 - ALTERNATIVE SITE #1
TA-70
STATE ROAD 4
TA-39
TA-33


LOCATION PLAN
TA-33
NATIONAL SPALLATION
NEUTRON SOURCE PROJECT
MAP LEGEND
EXISTING STRUCTURE
TA-33 - ALTERNATE SITE #2
EXISTING SECURITY FENCE
EXISTING INDUSTRIAL FENCE
10 FOOT CONTOUR INTERVAL
UTILITIES
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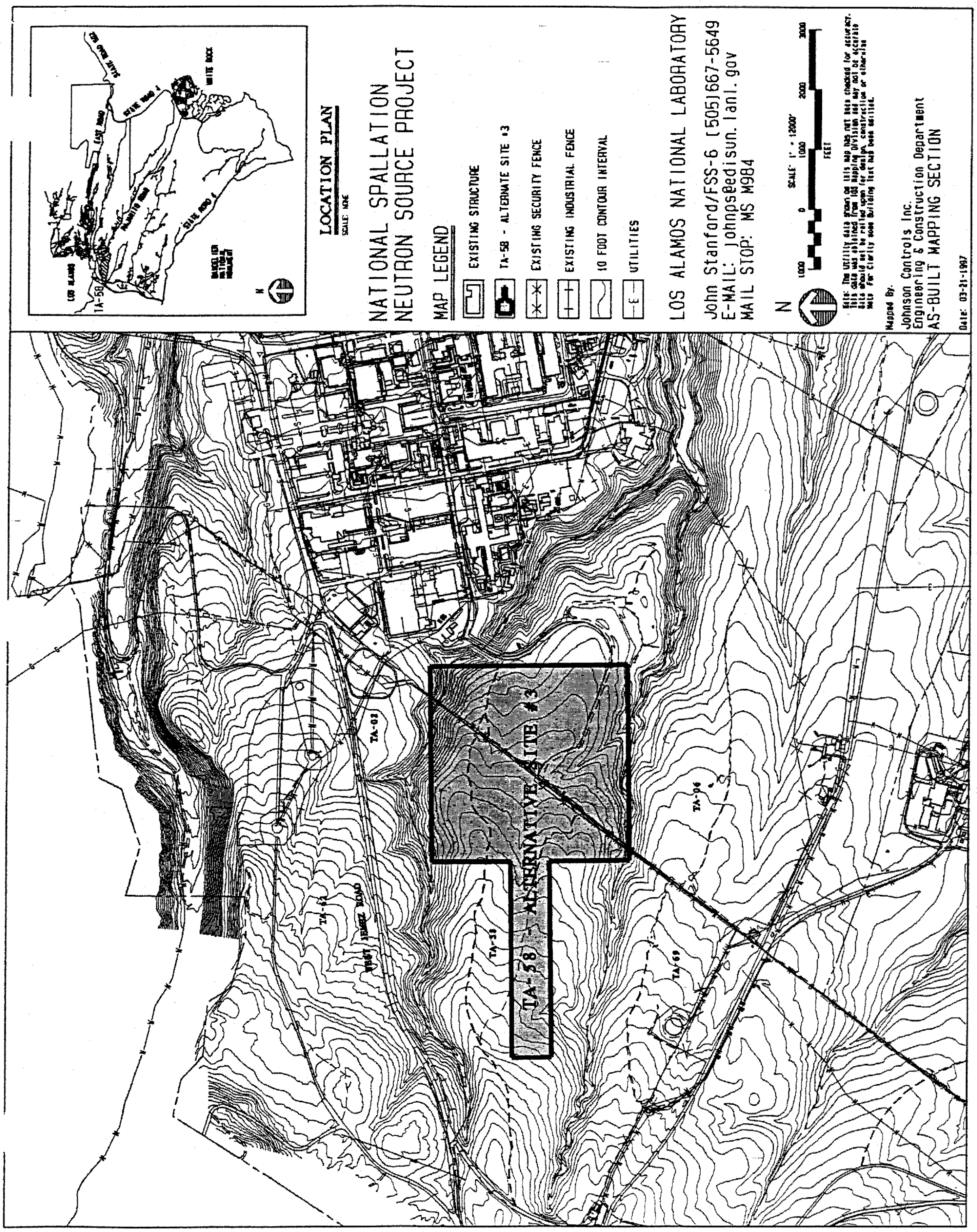
N
Mapped By:
Johnson Controls Inc.
Engineering & Construction Department
AS-BUILT MAPPING SECTION
TA-33 - ALTERNATIVE SITE #2
TA-70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NATIONAL SPALLATION
NEUTRON SOURCE PROJECT
MAP LEGEND
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EXISTING SECURITY FENCE
EXISTING INDUSTRIAL FENCE
10 FOOT CONTOUR INTERVAL
UTILITIES
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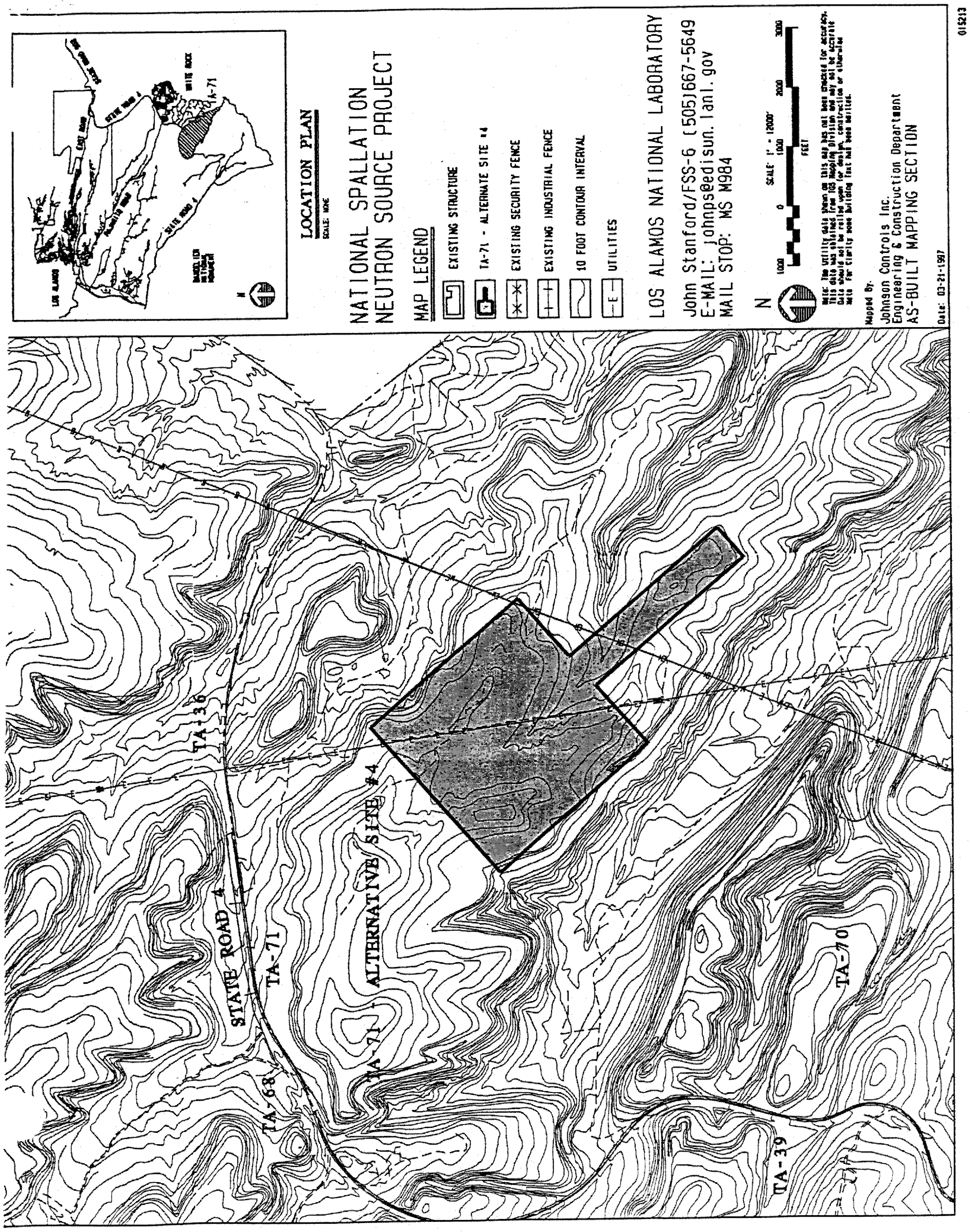
N
FEET
Mapped By:
Johnson Controls Inc.
Engineering & Construction Department
AS-BUILT MAPPING SECTION
Date: 03-21-1997
TA-58 - ALTERNATIVE SITE #3
TA-03
TA-62
TA-58
TA-69
TA-04
WHITE ROCK
LOS ALAMOS


LOCATION PLAN
SCALE: NONE
NATIONAL SPALLATION
NEUTRON SOURCE PROJECT
MAP LEGEND
EXISTING STRUCTURE
TA-71 - ALTERNATE SITE #4
EXISTING SECURITY FENCE
EXISTING INDUSTRIAL FENCE
10 FOOT CONTOUR INTERVAL
UTILITIES
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MAIL STOP: MS M984
N
Mapped By:
Johnson Controls Inc.
Engineering & Construction Department
AS-BUILT MAPPING SECTION
Date: 03-21-1997
015213
TA-36
STATE ROAD 4
TA-71
ALTERNATIVE SITE #4
TA-71
TA-68
TA-70
TA-39

ARGONNE NATIONAL LABORATORY SITE SELECTION REPORT

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Final Report

Selection of a Single Alternative Site at Argonne National Laboratory-East for the National Spallation Neutron Source

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Environmental Assessment Division
Argonne National Laboratory

May 1998

Background

This report describes the selection of a single alternative site at Argonne National Laboratory-East (ANL) for the National Spallation Neutron Source (NSNS). The purpose of selecting a site at ANL is to provide an alternative site for analysis in the NSNS EIS, which will be prepared according to the requirements of the National Environmental Policy Act of 1969. DOE has determined that ANL is a reasonable alternative site for this facility. Other alternative sites include the preferred site, Oak Ridge National Laboratory (ORNL) and Los Alamos National Laboratory (LANL).

This siting analysis is based on a draft report, entitled *Draft National Spallation Neutron Source Project Alternative Selection at Argonne National Laboratory-East*, prepared by W. S. White, Chicago Operations Office, on February 27, 1997. That report tentatively identified four potential sites (Figure 1), one each in the 400 Area in the southwestern corner of the site (Alternative 1), the 800 Area in the northwestern corner of the site (Alternative 2), the 600 Area in the central area of the site (Alternative 3), and the East Area (Alternative 4). These sites were selected by overlaying a representative 110-acre quadrant onto an Argonne National Laboratory-East site map. At the time that report was written, area was the only siting criteria available. Current requirements for site area are greater in extent than were used in the February 27, 1997 report, the site configuration is now known, and general siting criteria have been established. This siting report reflects the changes in site area requirements, site configuration, and siting requirements.

This siting analysis is based on certain assumptions about the description of the project. These assumptions were used at the request of the NSNS NEPA Document Manager in order to ensure that the ANL site analysis would be consistent with the alternatives at ORNL and LANL. It should be noted that certain organizations within ANL have proposed that an NSNS at ANL would be of a different configuration than that proposed for ORNL and should be located at a site not selected in this report based on the EIS siting assumptions. The EIS assumptions are:

- That the area of land required for the facility would be the same as used for siting at ORNL and Los Alamos National Laboratory. There would be no adaptation for preconceptual designs earlier proposed by ANL.

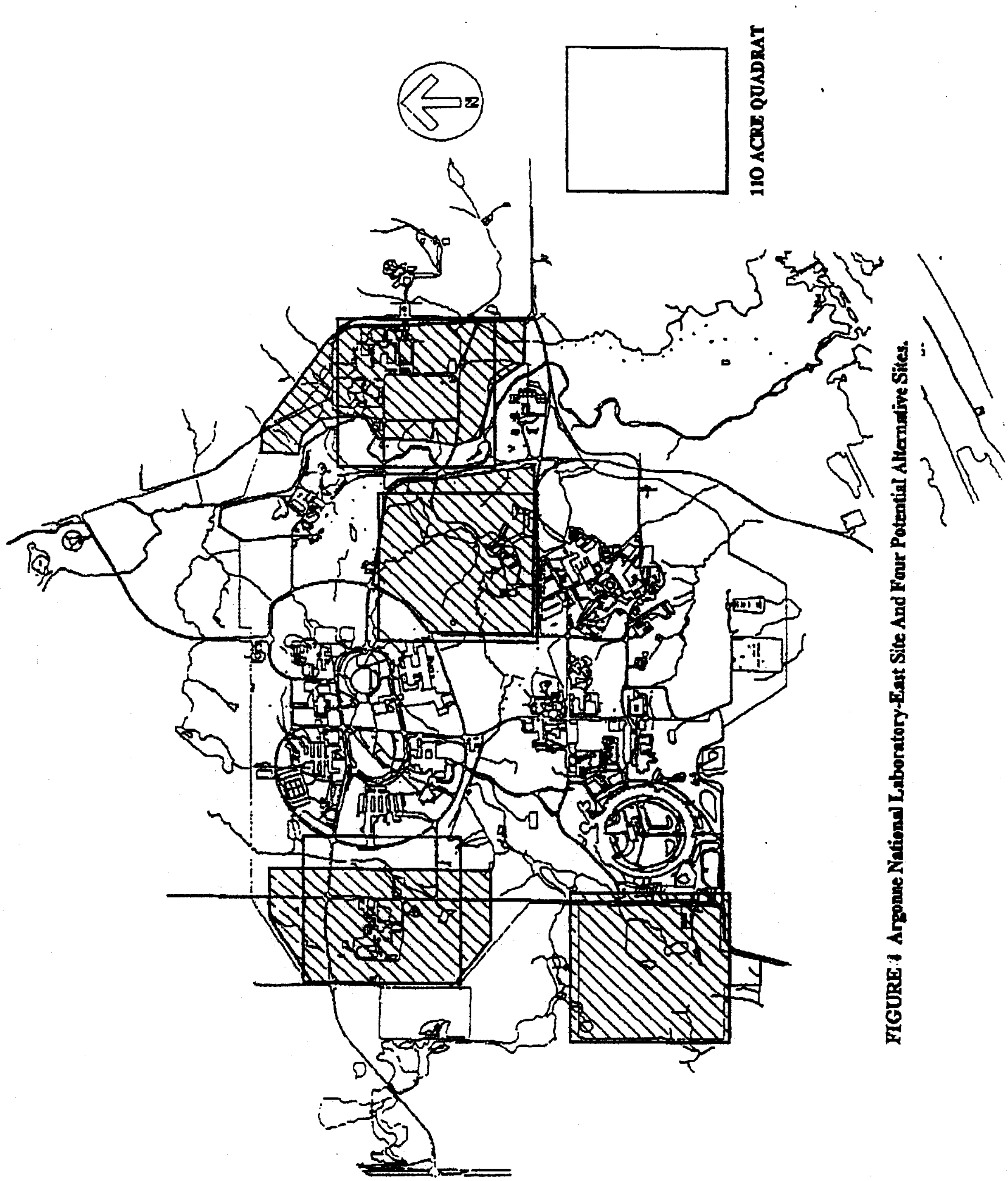

FIGURE 4 Argonne National Laboratory-East Site And Four Potential Alternative Sites.

- That the configuration and shape of the site would be the same at ANL as at ORNL or LANL. There would be no adaptation to ANL conditions or adaptations for preconceptual designs optimized for ANL site conditions.
- That the NSNS accelerator and support facilities would be of the same design assumed for ORNL or LANL; there would be no adaptation or optimization for conditions and existing facilities at ANL.
- That the same siting criteria developed for conditions at ORNL would be used for the ANL siting analysis, although several of these may not have much bearing on the development constraints present in the glacial till area in which ANL is located.

Siting Criteria

Since the initial DOE siting report was prepared for ANL, further siting criteria for the NSNS have been specified, including 1) functional criteria, based on construction and operational requirements of the facility; 2) environmental criteria, 3) criteria related to health and safety, and 4) programmatic criteria. These criteria have been developed for selecting a NSNS site at ORNL; and they have been applied for selection of an alternative site at LANL. The criteria are:

1. Functional Criteria

   - The main building site has a requirement of 500 m x 500 m with an adjoining 100 m x 500 m centered on the main area (T- or hammer-shaped); all on the same elevation after excavation and founded on bedrock. An adjacent area, measuring 100,000 m^2, is needed for support facilities, roads, buffer, etc., which can be on different elevations.
   - The main buildings must be constructed on solid rock foundation; however, karst formations are not to be eliminated as candidate sites.
   - Sufficient earth backfill must be available on site or nearby to provide an average of 15 ft cover for the main building.
   - The site must be in reasonable proximity to a disposal area for rock and excess earth excavation, such as a previously expended borrow area.
   - The site location minimizes excavation of contaminated soils.
   - The site should avoid the cost of relocating significant overhead and underground utilities (e.g. power lines, water line mains, and gas transmission lines).
   - The location should minimize runoff to or through the site.
   - The site should be in close proximity and access to existing utility systems, including 30-40 MW of electrical power. Other utility requirements include potable water, compressed air, natural gas, sanitary sewer, steam and chilled water (can be provided by onsite facilities), and construction power within one mile.
   - The site should be in close proximity to primary and/or secondary roads.

2. Environmental Criteria

- The site should avoid disturbance of wetlands and streams.
- The site should avoid locations with threatened or endangered plant or animal species.
- The site should avoid locations with historic, cultural, or archeological resources.
- The site should minimize impact on natural, reference, and research areas, including NERPs[1].

2. Health and Safety Criteria

- The site must be located above the 500-year floodplain elevation.
- The site must avoid geological faults prone to seismic movement.
- The site must provide a minimum 500 meter separation from existing occupied structures.

3. Programmatic Criteria:

- The site should consider appropriate site development and land use plans.

Method of Analysis

The characteristics of the four sites with respect to the siting criteria were determined by examining existing data sets contained in the ANL Sitewide Geographic Information System. The footprint of the proposed facility was overlaid on each of the four areas identified in the earlier siting report, and the footprints were rotated and moved so at to achieve the best possible fit with the siting criteria in or near each of the four areas (Figure 2). Because the footprint of the facility has a maximum dimension of 1000 meters, which is greater than the dimensions (691 m) of the 110-acre areas originally identified in the first siting report, none of the footprints fit exactly within the boundaries identified in the earlier report.

Each of the four sites were evaluated against each siting criterion, and a subjective opinion developed as to whether 1) the site easily met or exceeded the criterion [+], 2) could meet the criterion with a small degree of mitigation or site conditions were only mildly unfavorable [O], or 3) the site clearly failed the criterion or site conditions were clearly unfavorable [-]

Results

The results of the evaluation of potential sites against the siting criteria are presented in Table 1. On the basis of this evaluation, Alternative 1 (400 Area) met or exceeded five of the criteria and clearly failed ten, Alternative 2 (800 Area) met or exceeded seven of the

[1] National Environmental Research Parks (NERPs) are areas of DOE sites designated for environmental and ecological research.

criteria and clearly failed five, Alternative 3 (600 Area) met or exceeded six of the criteria and clearly failed eight, and Alternative 4 (East Area) met or exceeded six of the criteria and clearly failed eight.

All sites meet several of the siting criteria.

1. All sites have the necessary area available to accommodate the site footprint.
2. None of the locations are over known faults.
3. All areas are near or are crossed by paved roads.
4. Research and development use is consistent with the Site Development Plan.

All sites also do not meet several of the siting criteria.

1. At all sites the depth to bedrock is greater than 60 ft. It is assumed that an NSNS at ANL would not be founded on bedrock. Even so, construction and operation of accelerator facilities has been highly successful at ANL.
2. ANL does not have an onsite source of backfill; material from excavation would have to be used, unless fill were brought in from offsite.
3. ANL does not have an onsite disposal area for large volumes of excavated material; offsite disposal would be necessary
4. All sites contain wetland areas or streams.
5. All areas have historic, cultural, or archeological resources; one with an site that eligible for listing and the others with areas for which eligibility needs to be determined.
6. All locations are closer than 500 m to the nearest occupied structure.

Alternative 2 in the 800 Area at the northwest corner of ANL comes the closest to meeting the siting criteria (Table 1), and was determined to be the best siting location at ANL. The advantages of this location are: 1) differences in surface elevation are moderate (30 ft), 2) no state or federal threatened or endangered species are known to use the site, and 3) the area has little ecological research potential. Limited utilities are onsite, but are located nearby. Other disadvantages of the location include: 1) four contaminated areas which are currently under consideration for remediation, 2) an unused water pumping station and associated water mains might have to be removed, and 3) presence of a small drainage way on site.

As with all the other sites, fill for the 800 Area site would be obtained off the ANL site and rock and excess earth would be disposed of off the ANL site. One of the archeological sites would need a determination whether it is eligible for listing under the National Historic Preservation Act. The site is very close to other occupied structures; a guard house at 20 meters and an office/laboratory building at 110 meters. This site has one disadvantage which is not related to a site selection criteria; it overlays and blocks the Westgate Rd. entrance to the site. Westgate road and the entrance guard house would have to be relocated around the periphery of the facility.

Alternative 4 in the East Area was determined to be the second best location. The advantages of this location are: 1) differences in elevation are moderate (30 ft), 2) no known state of federal threatened or endangered species are known to use the site, and 3) the area has little ecological research potential. The disadvantages of this location are: 1) the foot print overlays the main gas line to the ANL site, possibly requiring removal and relocation; 2) the linac portion of the footprint would cross Sawmill Creek, a permanent stream, and the associated 100-yr and 500-yr floodplain and bordering wetlands. Other disadvantageous characteristics include: 1) four contaminated areas which are currently under consideration for remediation, and 2) partial utility availability onsite with others located nearby. Alternative 4 would be located in an area which houses storage areas, plant facilities services buildings, and shipping and receiving. Relocation of these facilities might be necessary.

Alternative 3 in the 600 Area is the third best of the alternatives. The advantages of this location include: 1) no known state of federal threatened or endangered species are known to use the site, and 2) the area has little ecological research potential. The disadvantages of this location are: 1) the foot print overlays the main steam and gas lines to the ANL site, possibly requiring removal and relocation; 2) the linac portion of the footprint would cross Freund Brook, a permanent stream, and the associated 100-yr and 500-yr floodplain and bordering wetlands, and 3) a pond on Freund Brook and associated wetlands are within the main portion of the footprint. Other disadvantageous characteristics include: 1) greater differences in elevation than the other sites (60 ft), 2) one known area of contamination which is under consideration for remediation, and 3) partial availability of utilities onsite with others located nearby. Construction of the NSNS at Alternative 3 might require removing the original Freund Lodge (which predates ANL), a motel-like facility, several cottages, the swimming pool, and the tennis courts. The lodging function of these facilities could be taken over by ANL's new hotel-like lodging facility near the Advanced Photon Source.

Alternative 1 in the 400 Area was judged to be the least favorable site. Advantageous characteristics include: 1) differences in surface elevation are moderate (30 ft) and 2) there are no identified areas of site contamination. Disadvantages of this location include: 1) the only possible orientation for the footprint overlays an interstate gas transmission line; 2) utility service to the site is very limited, although utilities are nearby, 3) state-listed birds, reptiles, and plants are present, 4) the site contains a remnant prairie, old oak woodlands, ponds and wetlands with good research potential, 5) and the site contains headwater ephemeral ponds and wetlands and the 500-yr and 100-yr floodplains of Upper Freund Brook.

One difficulty with this site is that the footprint alignment can not be reoriented to avoid the gas transmission line without either a land exchange to modify the boundaries of ANL or moving the facility further into Upper Freund Brook and associated wetlands. If some rounding of the corners of the site were allowed, the gas transmission line might be avoided. The site is very close to another accelerator facility, the Advanced Neutron Source, which constrains site rotation in the clockwise direction. If the site were rotated in the counter-clockwise direction, main area and the linac of the NSNS would further encroach on the floodplain and wetlands associated with Upper Freund Brook. These drainage features include the headwaters of Upper Freund Brook and a series of small ponds and marshes. State endangered species known from this location include the Black-crowned Night Heron (feeding habitat), the Great Egret (feeding habitat), Kirkland's Water Snake (resident), and a state-listed marsh plant. This site also contains eight archeological sites. A site near the tip of the linac is eligible for listing. Several of the other sites would need a determination whether they are eligible for listing. One corner of the site is within an area that is thought to be a prairie remnant, a habitat-type with significant regional cumulative impacts and potential value for research purposes.

Conclusion

The alternative location which most closely matches the siting criteria for the NSNS is Alternative 2 in the 800 Area at the northwest corner of the ANL site. This location has the least involvement with floodplains, wetlands, threatened and endangered species, research areas, important habitats, and unfavorable topography. This site has several disadvantages related to several small areas of contamination and proximity to occupied structures. In addition, the site overlays Westgate Road, the west entrance to ANL. Without further engineering design information for NSNS, it is uncertain whether the alignment of the footprint could be moved south enough to reroute Westgate Road around the perimeter of the facility. Moving the facility to the south would place the linac portion of the footprint near on Upper Freund Brook and impinge on wetlands and floodplains in that area.

Table 1. Evaluation of the Potential Sites for the National Spallation Neutron Source.

(+ = favorable or meets or exceeds criterion; 0 = could meet criterion with minor mitigation or mildly unfavorable;
- = clearly fails the criterion or conditions clearly unfavorable)

Siting Criteria	Alt. 1: 400 Area Suitability		Alt. 2: 800 Area Suitability		Alt. 3: 600 Area Suitability		Alt. 4: East Area Suitability	
FUNCTIONAL CRITERIA								
Main building site requirement of 500 m x 500 m with an adjoining 100 m x 500 m centered on the main area (T- or hammer-shaped); all on the same elevation after excavation and founded on bedrock. An adjacent area measuring 100,000 m2 for support facility	Area available. Surface elevation differences of about 30 ft. (see below for geology)	+	Area available. Surface elevation differences of about 30 ft. (see below for geology)	+	Area available. Surface elevation differences of about 60 ft. (see below for geology)	0	Area available. Surface elevation differences of about 30 ft. (see below for geology)	+
Main buildings must be constructed on solid rock foundation; however karst formations are not to be eliminated as candidate sites.	110-120 ft of material above bedrock.	-	110-130 ft of material above bedrock.	-	80-170 ft of material above bedrock.	-	60-70 ft of material above bedrock.	-
Sufficient earth backfill available on site or nearby to provide an average of 15 ft cover for the main building.	Material from excavation of site available for backfill, no other onsite source.	0	Material from excavation of site available for backfill, no other onsite source.	0	Material from excavation of site available for backfill, no other onsite source.	0	Material from excavation of site available for backfill, no other onsite source.	0
Reasonable proximity to disposal area for rock and excess earth excavation, such as previously expended borrow area.	No onsite disposal area.	-	No onsite disposal area.	-	No onsite disposal area.	-	No onsite disposal area.	-
Site minimizes excavation of contaminated soils.	no identified areas of contamination	+	4 known areas of contamination	0	1 known area of contamination	0	4 known areas of contamination	0

Siting Criteria	Alt. 1: 400 Area Suitability		Alt. 2: 800 Area Suitability		Alt. 3: 600 Area Suitability		Alt. 4: East Area Suitability	
Should avoid cost of relocating significant overhead and underground utilities (e.g. power lines, water line mains, and gas transmission lines).	Footprint overlays an interstate gas transmission line at the southern boundary of the ANL site, footprint placement constrained by wetlands.	-	Buildings in area needing utilities have been demolished or are slated for demolition. Water pumping station and associated water mains are not in use.	+	Footprint overlays main steam line and gas line to the interior of ANL.	-	Footprint overlays main gas line to the ANL site.	-
Minimize runoff to or through the site.	Some short-term runoff during storm events. Ponding in headwater wetlands to Upper Freund Brook.	-	Some short-term runoff during storm events.	0	Major receiving stream for stormwater runoff.	-	Major receiving stream and floodway for stormwater runoff.	-
Close proximity and access to existing utility systems, including 30-40 MW of electrical power. Other utility requirements include: potable water, compressed air natural gas, sanitary sewer, steam and chilled water, and construction power.	Limited utilities on site, utilities available nearby.	0	Limited utilities on site, utilities available nearby.	0	Good utility service adjacent to site.	+	Partial utility availability onsite.	0
Close proximity to primary and/or secondary roads.	Road access to area.	+	Road access to area.	+	Road access to area.	+	Road access to area.	+

Siting Criteria	Alt. 1: 400 Area Suitability		Alt. 2: 800 Area Suitability		Alt. 3: 600 Area Suitability		Alt. 4: East Area Suitability	
ENVIRONMENTAL CRITERIA								
Avoid disturbance of wetlands and streams	Small ponds and marshes on site, main area and linac contains the headwaters of Upper Freund Brook and its associated wetlands.	-	Main area contains a small drainage way with wetland vegetation and a remnants an abandoned beaver pond. Tip of linac reaches border of wetlands on Upper Freund Brook.	-	Main area and linac contains Freund Brook and a pond and associated wetlands.	-	Main area and linac contains Sawmill Creek and associated wetlands.	-
Avoid locations with threatened or endangered plant or animal species	State listed birds, reptiles, and plants.	-	No Involvement	+	No Involvement.	+	No Involvement.	+
Avoid locations with historic, cultural, or archeological resources present	Eight known sites, one eligible site at the tip of the linac, several sites need to have eligibility determined.	-	Two sites, one not eligible, one site needs eligibility determined.	-	One large area needs to have eligibility determined.	-	One large area needs to have eligibility determined.	-
Minimize impact on natural, reference, and research areas, including NERPs.	Remnant prairie present, old oak woodlands, ponds and wetlands with best research potential.	-	Small amount of old oak. Little research potential.	+	Some areas of woodland. Research potential low.	+	Research potential low.	+
HEALTH AND SAFETY CRITERIA								
The site must be located above the 500-year floodplain elevation.	Site contains 500 year floodplains, and is in the 100-year floodplain of Upper Freund Brook.	-	Site avoids 500-year floodplains, except for small drainage way at the north east edge of the site.	O	Linac portion of the footprint crosses Freund Brook and its 500-year and 100-year floodplains.	-	Linac portion of the footprint crosses Sawmill Creek and its 500-year and 100-year floodplains.	-

Siting Criteria	Alt. 1: 400 Area Suitability		Alt. 2: 800 Area Suitability		Alt. 3: 600 Area Suitability		Alt. 4: East Area Suitability	
The site must avoid geological faults prone to seismic movement.	No known faults.	+	No known faults.	+	No known faults.	+	No known faults.	+
The site must provide a minimum 500 meter separation from existing occupied structures.	Nearest occupied buildings are 65 m.	-	Nearest occupied buildings are 110 m. Guard post at site entrance is within 20 m, but would be moved.	-	Nearest occupied buildings are 160 m.	-	Nearest occupied buildings are130 m.	-
PROGRAMMATIC CRITERIA								
Site considers appropriate site development and land use plans.	Research and development use consistent with Site Development Plan	+	Research and development use consistent with Site Development Plan	+	Research and development use consistent with Site Development Plan	+	Research and development use consistent with Site Development Plan	+
Total Suitability	5 + 2 O 10 -		7 + 5 O 5 -		6 + 3 O 8 -		6 + 3 O 8 -	

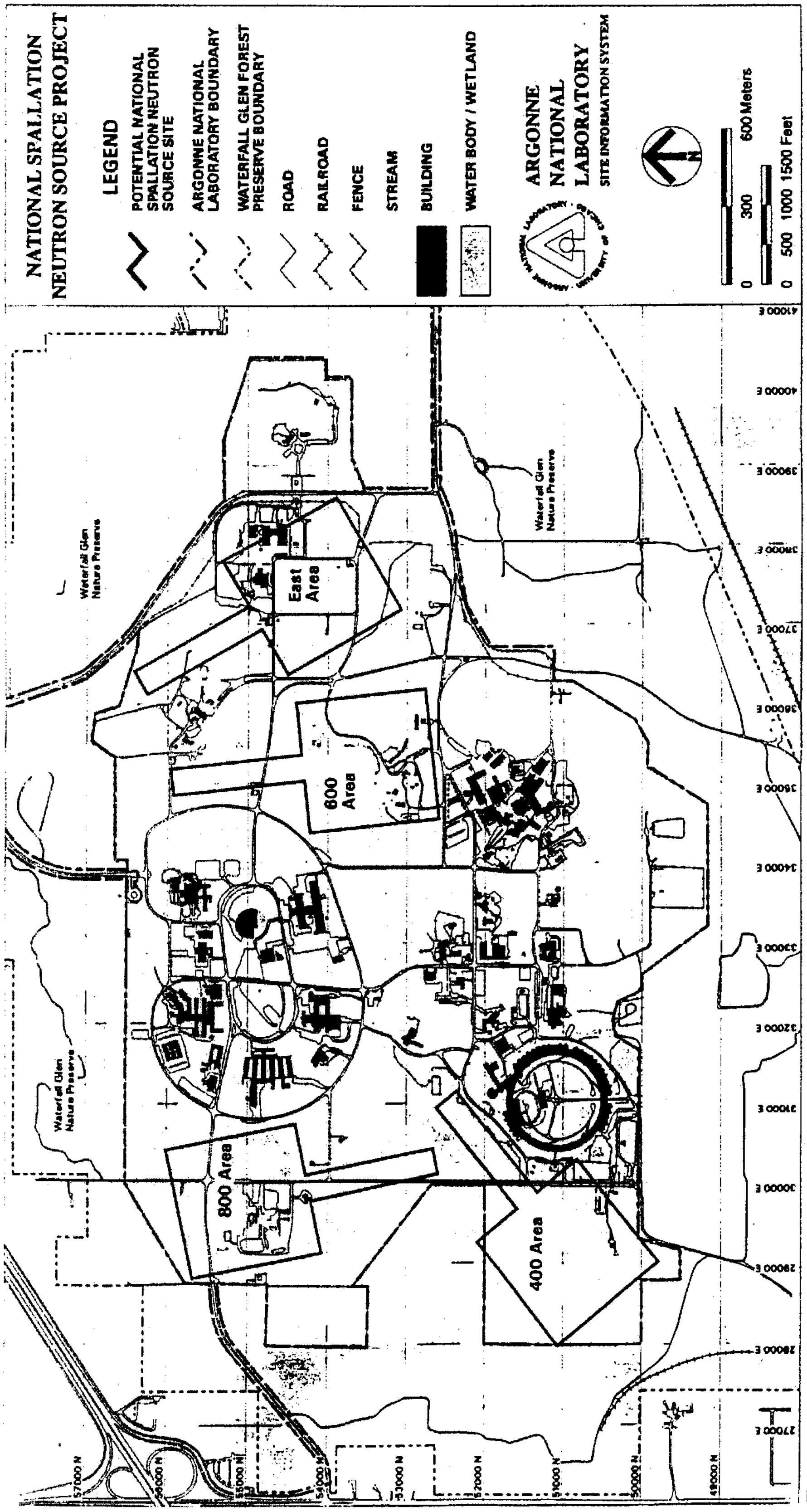

Figure 2. Argonne National Laboratory-East Site and Four Potential Alternative Sites

BROOKHAVEN NATIONAL LABORATORY SITE SELECTION REPORT

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NATIONAL SPALLATION NEUTRON SOURCE BNL SITE SELECTION REPORT

Brookhaven National Laboratory
September 16, 1997

INTRODUCTION

This report evaluates four potential sites for construction of the National Spallation Neutron Source (NSNS) at Brookhaven National Laboratory (BNL) in Upton, New York. In 1995 the Department of Energy (DOE) determined that NSNS would require an Environmental Impact Statement (EIS). The DOE then developed a process to identify suitable alternatives to the DOE's "preferred alternative" at Oak Ridge National Laboratory (ORNL). The process evaluated 39 DOE sites, and BNL qualified as one of three alternative locations besides ORNL for the facility. The other two alternative locations were Argonne National Laboratory and Los Alamos National Laboratory. *(Draft National Spallation Neutron Source Project, Alternate Site Selection Report: U.S. Department of Energy, Office of Energy Research; prepared by Roy F. Weston, Inc., August 23, 1996)*

This report provides the NSNS program with a decision-making tool for selecting an alternative candidate site at Brookhaven National Laboratory for the NSNS facility. The site evaluation process uses the following steps for selecting a recommended site:

- List NSNS physical design parameters provided by the NSNS design team
- Inventory of candidate BNL sites
- Evaluation of each candidate site according to NSNS siting criteria
- Determination of the candidate site with the best attributes and least restrictions to accommodate the NSNS

Four candidate sites were identified from which the recommended site was determined to best meet the NSNS criteria. These areas and the project footprint are illustrated on the four maps presented at the end of this report.

NSNS SITE REQUIREMENTS

The NSNS site must accommodate several physical and environmental requirements. These requirements are categorized as functional, environmental, and programmatic and are listed below.

Functional

- A site that accommodates a hammer-head shaped structure measuring 500 x 500 meters with a tail centered on the above square and measuring 100 x 500 meters
- A site that can be cut to provide proper fill for shielding of hammer-head shaped area.
- Additional space for support buildings and access roads requiring an additional 100,000 square meters
- Reasonable proximity to other facilities at BNL
- Avoid significant overhead and underground utility relocation (e.g., power lines, water line mains and gas transmission lines, steam lines)
- Minimize runoff to, through and from the site
- Reasonable access to existing utility systems to include:
  - 40 MW electrical power
  - potable water
  - compressed air, natural gas, sanitary sewer, steam and chilled water (desirable, can be provided by on-site facilities) availability of construction power within one mile
- Reasonable proximity to primary and/or secondary paved roads for users, researchers, materials, supplies; for target transport; for waste and irradiated material removal
- Buffer zone to avoid residential areas and large worker populations

Environmental

- Avoid construction in or disturbance of wetlands
- Avoid locations with threatened or endangered plant or animal species

Programmatic

- Conform with appropriate site development and land use plans
- Avoid existing recreation uses

INVENTORY OF CANDIDATE BNL SITES

Siting and construction of the NSNS facility is a major undertaking requiring a large site. While BNL covers 10 square miles, a significant portion of the undeveloped area is the head water region of the Peconic River. The four sites are presently undeveloped, and located adjacent to developed areas, and sized to accommodate the NSNS facility. In general terms, the four sites are Central, Northern, North Eastern, and Southern.

Siting Criteria	Central Site	Northern Site	North-Eastern Site	Southern Site
Functional				
1. Physical accommodation of building footprint (500m x 500m with attached 100m x 500m addition)	Adequate	Adequate	Adequate	Adequate
2. Adequate earth backfill to provide an average of 15 feet of cover for shielding	Adequate	Fill will be trucked in from on site	Fill will be trucked in from on site	Adequate
3. Close proximity to BNL support facilities and services	Adjacent to existing facilities / services	Remote from existing facilities / services	Remote from existing facilities / services	Remote from existing facilities / services
4. Avoid relocating significant overhead/ underground utilities	No major utilities in area	No utilities in area	No major utilities in area	No major utilities in area
5. Minimize runoff to, through, and from the site	Acceptable	Located near the head waters of the Peconic River	Located near the head waters of the Peconic River	Acceptable
6. Proximity/ access to existing utility systems (40MW power, potable water, compressed air, natural gas, sanitary sewer, steam, chilled water, construction power	All utilities are local except chilled water & natural gas	Only sanitary is local	Only sanitary is local	No utilities are local
7. Proximity to primary and/or secondary roads	Adequate	Roads will have to be installed	Roads will have to be installed	Adequate
8. Adequate buffer zone	Adequate	Close proximity to residential area	Close proximity to residential area	Close proximity to major public highway
ENVIRONMENTAL				
9. Avoid construction in wetlands	No adverse impact to wetlands	Possible impact to wetlands	Possible impact to wetlands	No adverse impact to wetlands
10. Avoid locations with threatened or endangered plant or animal species	No impact	No impact	No impact	Salamander
PROGRAMMATIC				
11. Compatible with site development and land use plans	Consistent with 1994 Site Development Plan	Encroaches into future RHIC experimental area	Encroaches into future RHIC experimental area	Encroaches into future linear accelerator area
12. Avoid existing recreation uses	Impacts shot gun range	None	None	None

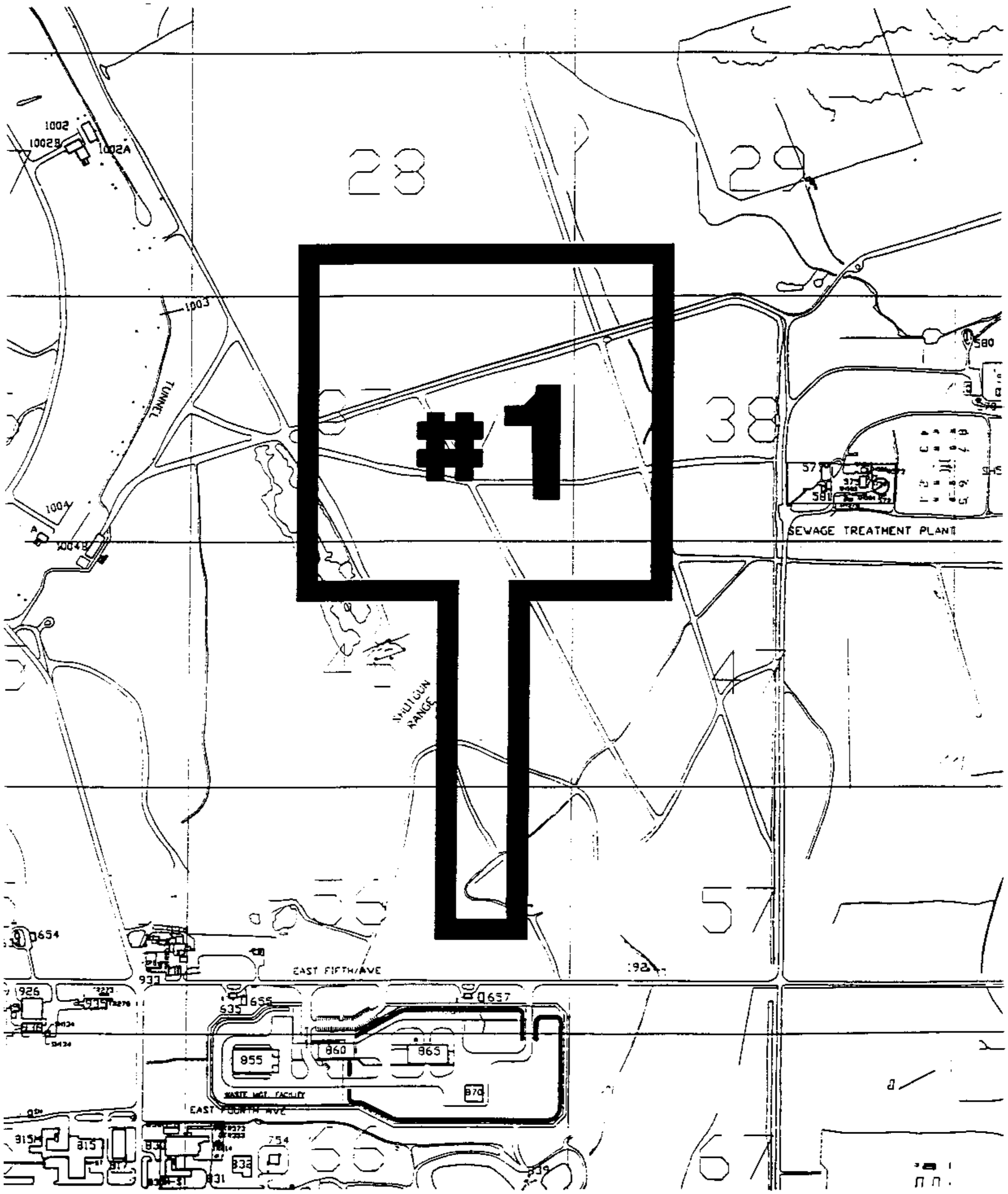
EVALUATION OF CANDIDATE SITES

The Central Site has the appropriate gross acreage, topography, proximity to the research community, utility support with the exception of a supply of chilled water and natural gas, roadways, and buffer zone. The site does not impact environmental concerns and can be accommodated into the site development plan.

The Northern Site has the appropriate gross acreage. However, the topography requires fill to be truck to the site for the necessary shielding. The site requires new roads and utilities to be constructed into the area. The site is near the head waters of the Peconic River and encroaches into future RHIC experimental areas.

The North-Eastern Site has the appropriate gross acreage. However, the topography requires fill to be truck to the site for the necessary shielding. The site requires new roads and utilities to be constructed into the area. The site is near the head waters of the Peconic River and encroaches into future RHIC experimental areas.

The Southern Site has the appropriate gross acreage, topography and access by major roads. The site requires utilities to be constructed into the area. The site encroaches into future Linear Accelerator Project.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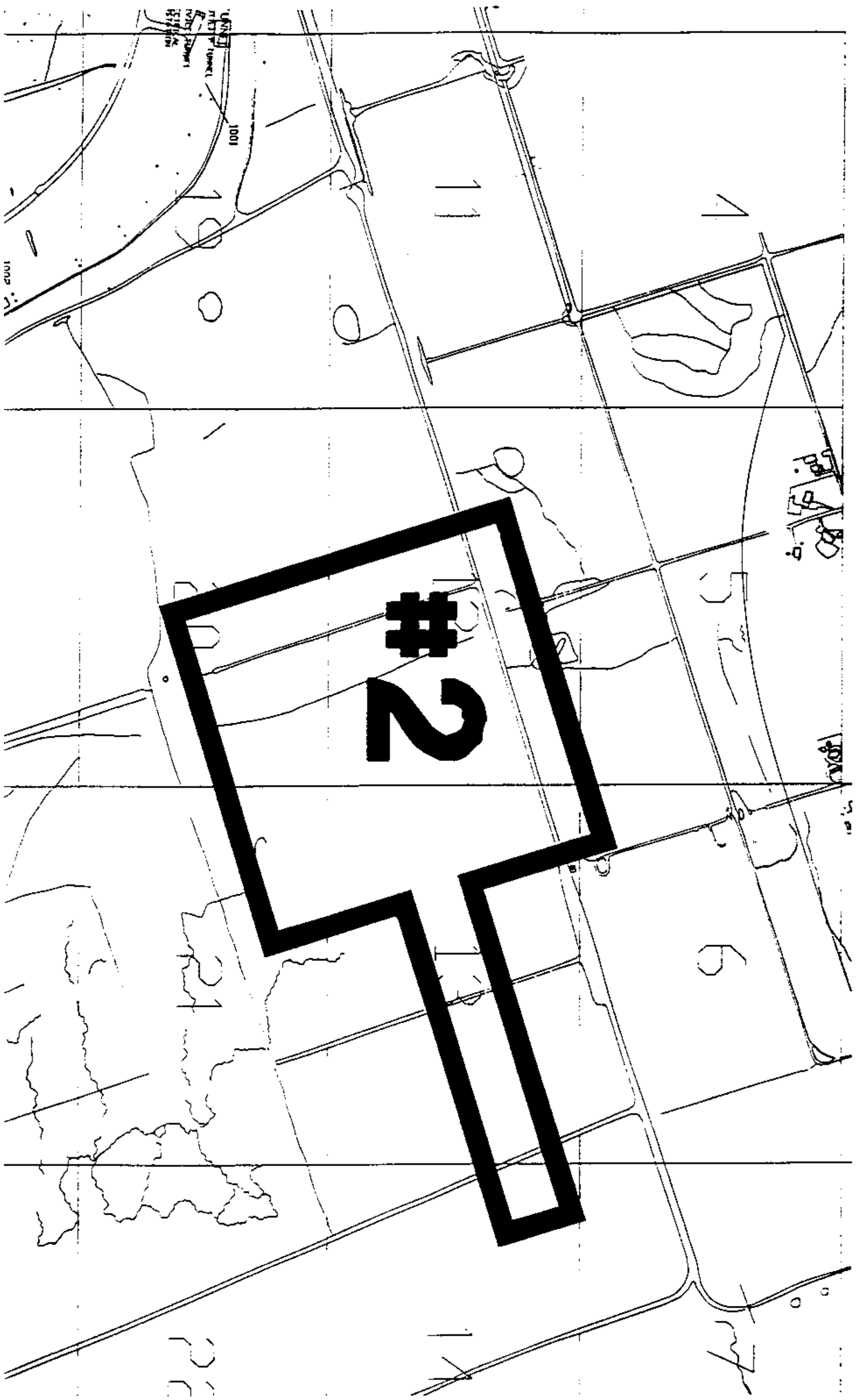
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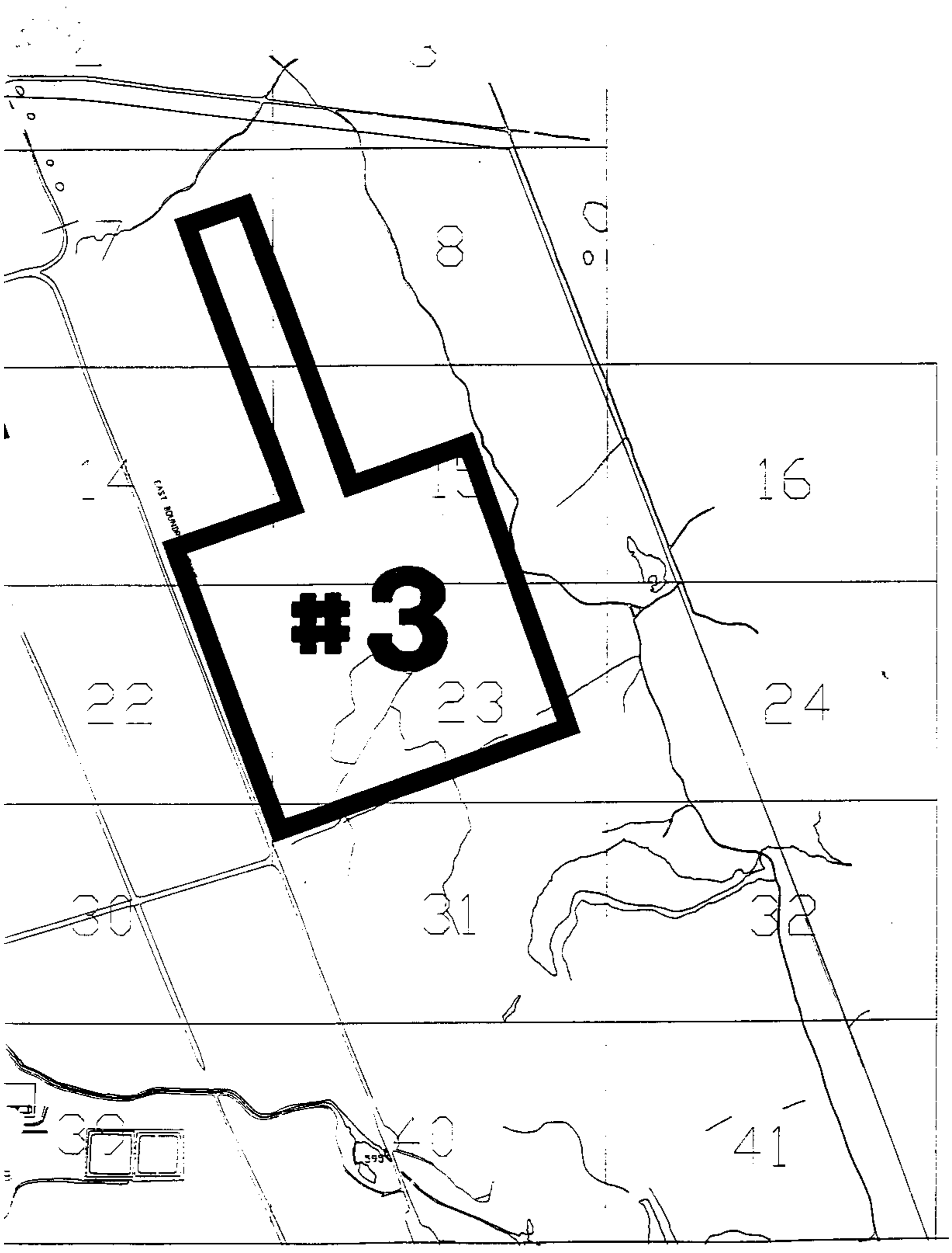
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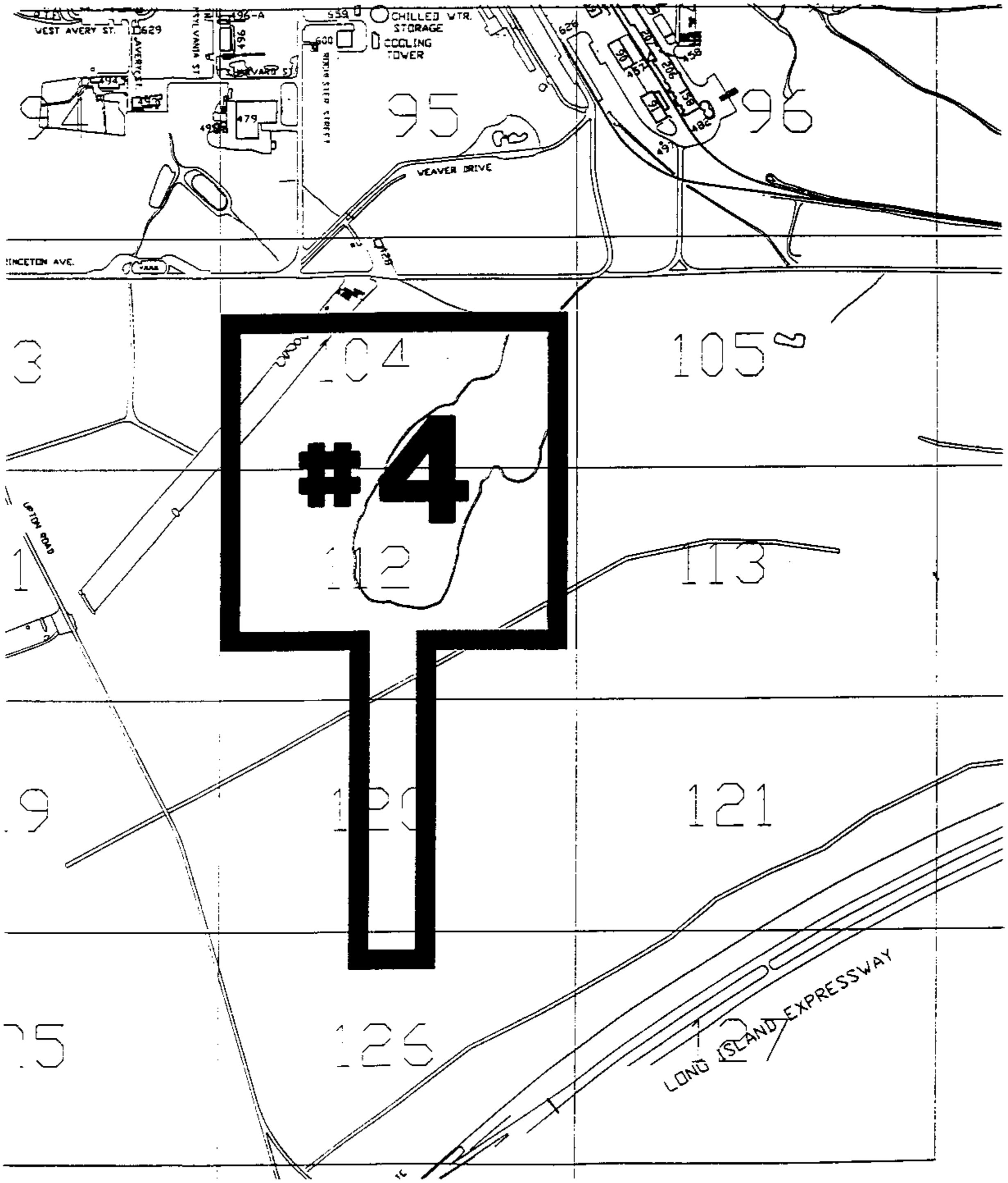
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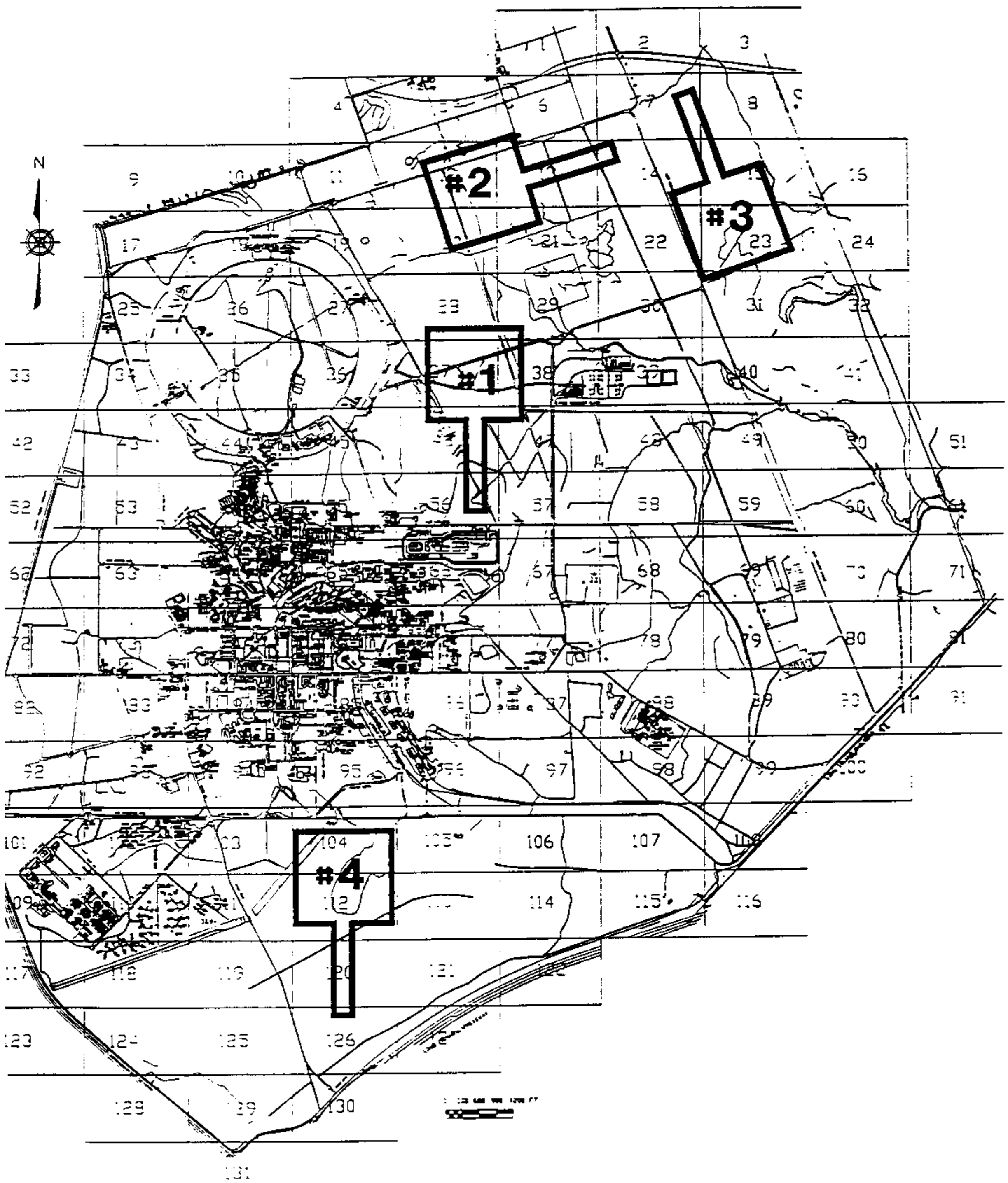
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APPENDIX C

LETTERS OF CONSULTATION ON PROTECTED SPECIES AND CULTURAL RESOURCES

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C. LETTERS OF CONSULTATION ON PROTECTED SPECIES AND CULTURAL RESOURCES

This appendix presents the letters of consultation concerning protected species and cultural resources for the four proposed SNS sites that were sent out by the Department of Energy (DOE), and the responses received from the agencies concerned. Agencies/individuals contacted include the affected States' Fish and Wildlife Services, Department of Environmental Conservation, and the U.S. Army Corps of Engineers (when applicable) concerning threatened and endangered species. Also contacted were the States' Historic Preservation Officers concerning cultural resources. The letters of consultation are presented in the following order:

Site	Letter Addressed To	Subject	Reply Addressed To
ORNL	James Widlak U.S. Fish and Wildlife Service	T&E Species	James L. Elmore U.S. Department of Energy
	Joseph Garrison TN Historical Commission	Cultural Resources	Ray T. Moore Department of Energy
	Reginald G. Reeves Department of Environment and Conservation	T&E Species	No Reply
	Lt. Col. Christopher Young U.S. Army Corps of Engineers	T&E Species	James L. Elmore U.S. Department of Energy
LANL	Jennifer Fowler-Propst U.S. Fish and Wildlife Service	T&E Species	G. Thomas Todd U.S. Department of Energy
	Lynne Sebastian Historic Preservation Division	Cultural Resources	No Reply
ANL	Benjamin Tuggle U.S. Fish and Wildlife Service	T&E Species	Michael Flannigan U.S. Department of Energy
	Anne E. Haaker Illinois Historic Preservation Agency	Cultural Resources	No Reply
BNL	Nancy Davis Ricci NYS Dept. of Environmental Conservation	T&E Species	K. Dean Helms U.S. Department of Energy
	Sherry Morgan U.S. Fish and Wildlife Service	T&E Species	K. Dean Helms U.S. Department of Energy
	Julian Adams NYS Office of Parks, Rec. & Historic Preservation	Cultural Resources	No Reply

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ORNL CONSULTATION LETTERS

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Department of Energy

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831—

September 18, 1997

Mr. James C. Widlak
Fish and Wildlife Service
United States Department of Interior
446 Neal Street
Cookeville, Tennessee 38501

Dear Mr. Widlak:

INFORMAL CONSULTATION UNDER SECTION 7 OF THE ENDANGERED SPECIES ACT FOR THE PROPOSED SITING, CONSTRUCTION, AND OPERATION OF THE NATIONAL SPALLATION NEUTRON SOURCE

The U.S. Department of Energy (DOE) proposes to site, construct, and operate the National Spallation Neutron Source (NSNS) and is currently preparing an environmental impact statement (EIS), pursuant to the National Environmental Policy Act (NEPA) on this Federal action. The proposed NSNS facility would consist of a proton accelerator system, a spallation target and appropriate experimental areas, laboratories, offices, and support facilities to allow ongoing and expanded programs of neutron research. The proposed site for the NSNS is the DOE-owned Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. The alternative sites under consideration include three other DOE-owned laboratories: Argonne National Laboratory, Argonne, Illinois; Brookhaven National Laboratory, Brookhaven, New York; and Los Alamos National Laboratory, Los Alamos, New Mexico.

The proposed NSNS would produce short pulses of neutrons for use in materials research. This would be accomplished through the "spallation" process wherein (1) subatomic particles, called protons, are accelerated to very high energies; (2) the high energy protons are "bunched" into a compact group; (3) the bunched, high energy protons are directed onto a target made of a high atomic number material, in this case mercury; and (4) the collision of the protons with the target produces a pulse of neutrons from the target material. Once the spallation process is completed and the neutron pulse is produced, the neutrons would be slowed to useful energy levels and guided onto samples of the materials being studied where the interactions of the neutrons and the specimens would be measured and analyzed, thus revealing information on the structure, properties, and behavior of the test material.

The proposed location of the NSNS at ORNL is on Chestnut Ridge, just west of Chestnut Ridge Road originating from the 7000 area of ORNL (see enclosed figure). The general terrain along

Mr. James C. Widlak -2- September 18, 1997

this ridge provides sufficient area for and burial of the linear accelerator portion of the NSNS. This site is close to utilities (electrical, water, and gas), is easily accessible via the existing road, lies close to a storage area for backfill material and spoils (the West Borrow Area), and is close to ORNL. The land cover is primarily oak-hickory forest.

Surveys for listed species, primarily associated with tributaries to Bear Creek, have been undertaken in the recent past and have identified several State of Tennessee listed species in Natural Area 52 and Habitat area 3, including *Collinsonia verticillata* (Whorled horse-balm) *Hydrastis canadensis* (Golden seal), *Panax quinquifolius* (Ginseng), and *Platanthera flava* var. *herbiola* (Tubercled rein-orchid). ORNL ecologists are surveying the proposed NSNS site for listed species to update previously collected data.

This letter is intended to serve as informal consultation under Section 7 of the Endangered Species Act. In this regard, DOE requests an updated list of protected species and habitat on and in the vicinity of the proposed NSNS site and solicits your recommendation and comments about the potential effects of this proposed action. Your input will be used in the preparation of the environmental impact statement . A reply by the end of October would be appreciated.

If you need further information on this request, please do not hesitate to call me at (423) 576-0938.

Sincerely,

James L. Elmore

James L. Elmore, Ph.D.
Alternate NEPA Compliance Officer

Enclosure

cc w/o enclosure:
D. Wilfert, ER-111, FEDC
D. Bean, EASI

United States Department of the Interior

FISH AND WILDLIFE SERVICE
446 Neal Street
Cookeville, Tennessee 38501

September 26, 1997

Dr. James L. Elmore
U.S. Department of Energy
P.O. Box 2001
Oak Ridge, Tennessee 37831

Re: National Spallation Neutron Source

Dear Dr. Elmore:

Thank you for your letter and enclosures of September 18, 1997, regarding the proposed project in Roane County, Tennessee. The Fish and Wildlife Service (Service) has reviewed the information submitted and offers the following comments.

According to our records, the following federally listed or proposed endangered or threatened species may occur in the project impact area:

Gray bat - Myotis grisescens (E)
Slender chub - Hybopsis cahni (T)
Yellowfin madtom - Noturus flavipinnis (T)
Red-cockaded woodpecker - Picoides borealis (E)
Spotfin chub - Hybopsis monacha (T)
American hart's tongue fern - Phyllitis scolopendrium var. americana (T)
Virginia spiraea - Spiraea virginiana (T)

The species records provided are based on the proposed location of your project. Freshwater mussel records have not been provided because your proposed project is not in the immediate vicinity of the Clinch River.

You should assess potential impacts and determine if the proposed project may affect the species. A finding of "may affect" could require initiation of formal consultation. We recommend that you submit a copy of your assessment and finding to this office for review and concurrence.

Information available to the Service does not indicate that wetlands exist in the vicinity of the proposed project. However, our wetland determination has been made in the absence of a field inspection and does not constitute a wetland delineation for the purposes of Section 404 of the Clean Water Act or the wetland conservation provisions of the Food Security Act. The Corps of Engineers or the Natural Resources Conservation Service should be contacted if other evidence, particularly that obtained during an on-site inspection, indicates the potential presence of wetlands. Our current assumption is that the proposed project will not be in the immediate vicinity of Bear Creek.

Thank you for the opportunity to comment on this action. If you have any questions, please contact Allen Robison of my staff at 615/528-6481.

Sincerely,

Lee A. Barclay, Ph.D.
Field Supervisor

Department of Energy

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831—

December 9, 1997

Mr. Joseph Garrison
Tennessee Historical Commission
Department of Environment and Conservation
701 Broadway
Nashville, Tennessee 37243-0442

Dear Mr. Garrison:

NATIONAL HISTORIC PRESERVATION ACT, SECTION 106 COMPLIANCE; SPALLATION NEUTRON SOURCE (SNS), ROANE AND ANDERSON COUNTIES TENNESSEE

Enclosed are a project summary, maps, and an archeological reconnaissance survey for the proposed project. The proposed project would be located along the southern slope of Chestnut Ridge within the Oak Ridge National Laboratories (ORNL), approximately midway between the Y-12 Plant and the main ORNL facilities in Roane and Anderson Counties, Tennessee. Based on the enclosed archeological reconnaissance survey prepared by DuVall and Associates, Department of Energy Oak Ridge Operations (DOE ORO) has determined that the proposed project would have no effect on historical, archeological, or cultural resources included or eligible for inclusion in the National Register of Historic Places. This determination is included with the Project Summary. With your concurrence in this determination, DOE ORO's responsibilities for compliance with Section 106 of the National Historic Preservation Act will be completed for this project. If you have questions or need additional information related to this proposed project please call me at (423) 576-9574.

Sincerely,

Ray T. Moore
DOE ORO Cultural Resources
Management Coordinator

Enclosure

cc w/enclosure:
EC Document Center K-25

cc w/o enclosure:
See Page 2

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TENNESSEE HISTORICAL COMMISSION
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
2941 LEBANON ROAD
NASHVILLE, TN 37243-0442
(615) 532-1550

December 29, 1997

Mr. Ray T. Moore
Department of Energy
Post Office Box 2001
Oak Ridge, Tennessee 37831

RE: DOE, ARCHAEOLOGICAL ASSESSMENT, SPALLATION NEUTRON SOURCE, OAK RIDGE, ROANE AND ANDERSON COUNTIES,

Dear Mr. Moore:

At your request, our office has reviewed the above-referenced archaeological survey report in accordance with regulations codified at 36 CFR 800 (51 FR 31115, September 2, 1986). Based on the information provided, we find that the project area contains no archaeological resources eligible for listing in the National Register of Historic Places.

Therefore, this office has no objection to the implementation of this project. If project plans are changed or archaeological remains are discovered during construction, please contact this office to determine what further action, if any, will be necessary to comply with Section 106 of the National Historic Preservation Act.

Your cooperation is appreciated.

Sincerely,

Herbert L. Harper
Executive Director and
Deputy State Historic
Preservation Officer

HLH/jmb

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Department of Energy

Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge, Tennessee 37831—

December 29, 1997

Mr. Reginald G. Reeves, Director
Division of Natural Heritage
State of Tennessee
Department of Environment and Conservation
401 Church Street
Nashville, Tennessee 37243-0443

Dear Mr. Reeves:

CONSULTATION CONCERNING STATE-LISTED SPECIES FOR THE PROPOSED SITING, CONSTRUCTION, AND OPERATION OF THE SPALLATION NEUTRON SOURCE

The U.S. Department of Energy (DOE) proposes to site, construct, and operate the Spallation Neutron Source (SNS) and is currently preparing an environmental impact statement (EIS), pursuant to the National Environmental Policy Act (NEPA), on this federal action. The proposed SNS facility would consist of a proton accelerator system, a spallation target and appropriate experimental areas, laboratories, offices, and support facilities to allow ongoing and expanded programs of neutron research. The proposed site for the SNS is the DOE-owned Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. The alternative sites under consideration include three other DOE-owned laboratories: Argonne National Laboratory, Argonne, Illinois; Brookhaven National Laboratory, Brookhaven, New York; and Los Alamos National Laboratory, Los Alamos, New Mexico.

The proposed SNS would produce short pulses of neutrons for use in materials research. This would be accomplished through the "spallation" process wherein (1) subatomic particles, called protons, are accelerated to very high energies; (2) the high energy protons are "bunched" into a compact group; (3) the bunched, high energy protons are directed onto a target made of a high atomic number material, in this case mercury; and (4) the collision of the protons with the target produces a pulse of neutrons from the target material. Once the spallation process is completed and the neutron pulse is produced, the neutrons would be slowed to useful energy levels and guided onto samples of the materials being studied where the interactions of the neutrons and the specimens would be measured and analyzed, thus revealing information on the structure, properties, and behavior of the test material.

Mr. Reginald G. Reeves
Page 2

The proposed location of the SNS at ORNL is on Chestnut Ridge, just west of Chestnut Ridge Road originating from the 7000 area of ORNL (see attached figure). The general terrain along this ridge provides sufficient area for and burial of the linear accelerator portion of the SNS. This site is close to utilities (electrical, water, and gas), is easily accessible via the existing road, lies close to a storage area for backfill material and spoils (the West Borrow Area), and is close to ORNL. The land cover is primarily oak-hickory forest.

Surveys for listed species, primarily associated with tributaries to Bear Creek, have been undertaken in the recent past and have identified several State of Tennessee listed species in Natural Area 52 and Habitat area 3, including *Collinsonia verticillata* (Whorled horse-balm) *Hydrastis canadensis* (Golden seal), *Panax quinquifolius* (Ginseng), and *Platanthera flava* var. *herbiola* (Tubercled rein-orchid). ORNL ecologists are surveying the proposed SNS site for listed species to update previously collected data.

This letter is intended to serve as a request for an updated list of state-protected species that may occur on and in the vicinity of the proposed SNS site and to solicit your recommendations and comments about the potential effects of this proposed action. Your input will be used in the preparation of the environmental impact statement . A reply by the end of January would be appreciated.

If you need further information on this request, please do not hesitate to call me at (423) 576-0938.

Sincerely,

James L. Elmore, Ph.D.
Alternate NEPA Compliance Officer

Enclosure

cc w/o enclosure:
D. Wilfert, ER-111, FEDC, Room 146
D. Bean, EASI, 663 Emory Valley Road, Oak Ridge, TN 37830
D. Arakawa, ER-112, ORNL Site Office, Bldg. 4500N, Room 0224

Department of Energy

Oak Ridge Operations
P.O. Box 2001
Oak Ridge, Tennessee 37831—

August 12, 1998

Lieutenant Colonel Christopher Young
Nashville District Engineer
U.S. Army Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202

Dear Colonel Young:

CONSULTATION UNDER SECTION 404 OF THE CLEAN WATER ACT FOR THE PROPOSED SITING, CONSTRUCTION, AND OPERATION OF THE SPALLATION NEUTRON SOURCE

The U.S. Department of Energy (DOE) proposes to site, construct, and operate the Spallation Neutron Source (SNS) facility, and is currently preparing an environmental impact statement (EIS), pursuant to the National Environmental Policy Act (NEPA) on this federal action. The proposed SNS facility would consist of a proton accelerator system, a spallation target, appropriate experimental areas, laboratories, offices, and support facilities for neutron research. The EIS will include discussion of potential impacts at four alternative locations for the SNS, all DOE-owned laboratories: Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee; Argonne National Laboratory (ANL), Argonne, Illinois; Los Alamos National Laboratory (LANL), Los Alamos, New Mexico; and Brookhaven National Laboratory (BNL), Upton, New York.

The proposed SNS would produce short pulses of neutrons for use in materials and biomedical research. This would be accomplished through the "spallation" process wherein (1) subatomic particles, called protons, are accelerated to very high energies; (2) the high energy protons are "bunched" into a compact group; (3) the bunched, high energy protons are directed onto a target made of a high atomic number material, in this case mercury; and (4) the collision of the protons with the target produces a pulse of neutrons from the target material. The neutrons would then be slowed to useful energy levels, and guided to samples of the materials being studied. The interactions of the neutrons and the specimens would be measured and analyzed, revealing information on the structure, properties, and behavior of the test material.

Construction of the SNS at ORNL would involve the taking of two small palustrine emergent wetlands on the Chestnut Ridge construction site (see Figures 4.1.2.1-1 and 4.1.5.2-1 from the preliminary draft EIS). These two wetlands have a combined area of 0.12 acres (0.05 ha). One of these small wetlands is an emergent wetland in an isolated depression (WOM14 on Figure 4.1.5.2-1). It is adjacent to another small wetland swale that lies immediately adjacent to

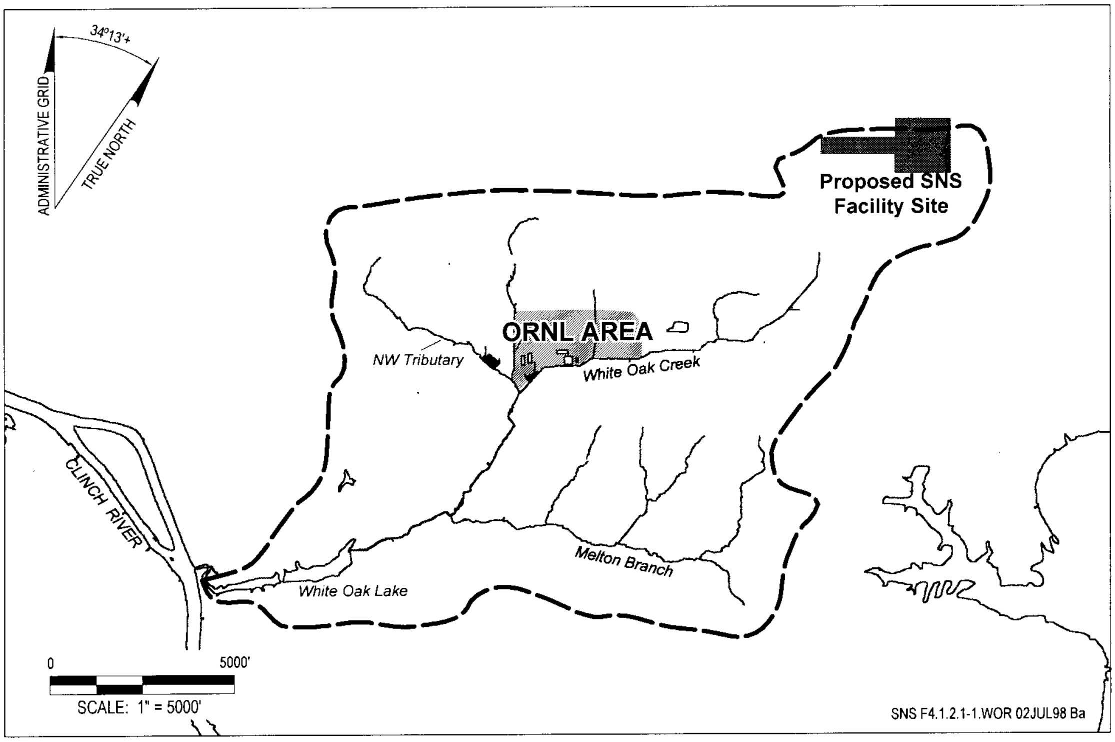

Figure 4.1.2.1-2. White Oak Creek drainage.

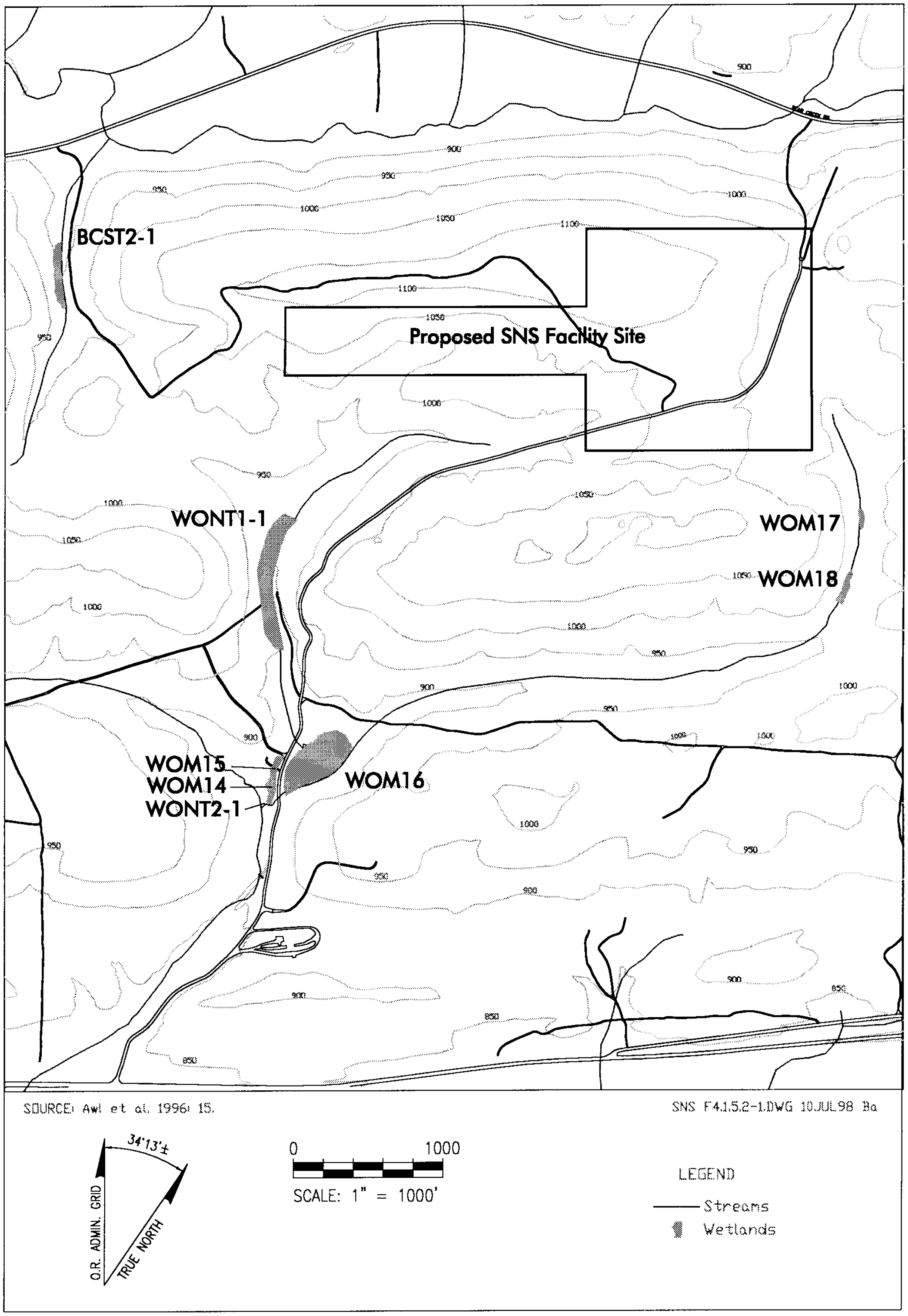

Figure 4.1.5.2-1. Wetland areas within and adjacent to the proposed SNS site.

Lieutenant Colonel Christopher Young 2

Chestnut Ridge Road near where it crosses White Oak Creek (WOM15). The depression does not appear to have a surface outlet to the swale or to nearby White Oak Creek. Upgrades needed to Chestnut Ridge Road and the laying of a gas pipeline would encroach on these areas and require the taking of the 0.12 acres of wetlands. A third wetland (WOM16) with an area of 1.6 acres (0.65 ha) could receive increased runoff and siltation during construction activities.

The purpose of this letter is to initiate consultation concerning permitting requirements under Section 404 of the Clean Water Act. It appears that these activities could be performed under nationwide permit number 26. Please advise as to whether this activity would be covered by a nationwide permit or if an individual permit would be needed. Also, include in your reply what types and extent of mitigation, if any, might be required. Any other comments on the Section 404 aspects of the project would be appreciated. I would be most grateful if you could reply by the end of August.

If you need further information on this request, please do not hesitate to call me at (423)576-0938.

Sincerely,

James L. Elmore, PhD
Alternate NEPA Compliance Officer

Enclosure

cc w/enclosure:
Dave Wilfert, ER-111
Dave Bean, EASI
Tim Joseph, SE-32
Clarence Hickey, ER-83

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1070
NASHVILLE, TENNESSEE 37202-1070

IN REPLY REFER TO

August 25, 1998

Regulatory Branch

Subject: Proposed Siting, Construction, and Operation of the Spallation Neutron Source Facility

James L. Elmore, PhD
Department of Energy
Oak Ridge Operations
P.O. Box 2001
Oak Ridge, Tennessee 37831

Dear Dr. Elmore:

We have received your letter requesting information concerning permit requirements for wetland impacts that may occur as a result of the subject work. Your letter states that upgrades to Chestnut Ridge Road and the placement of a gas pipeline would encroach upon approximately 0.12 acres of wetlands.

As we discussed on the phone today, the work would likely be covered under a nationwide permit (NWP). NWP 26 is scheduled to expire at the end of this year; however, there are NWP's that cover minor road crossings and utility line discharges.

Until detailed plans of the activities requiring a DA permit are received, we are not able to determine which NWP would apply or if an individual permit would be necessary. Also, mitigation requirements, if any, would have to be determined at that time.

If you have any question regarding this matter, please contact me at the above address, telephone(615)736-5183.

Sincerely,

Bradley N. Bishop
Project Manager
Construction-Operations Division

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LANL CONSULTATION LETTERS

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E. Withers

Department of Energy
Albuquerque Operations Office
Los Alamos Area Office
Los Alamos, New Mexico 87544

DEC 08 1997

Ms. Jennifer Fowler-Propst
State Supervisor
U. S. Fish and Wildlife Service
Ecological Services
2105 Osuna Road, NE
Albuquerque, NM 87113

Dear Ms. Fowler-Propst:

The Department of Energy (DOE) is preparing an Environmental Impact Statement (EIS) for the siting, construction, and operation of the Spallation Neutron Source (SNS) Facility. This proposed facility would consist of a proton accelerator system, a spallation target, and appropriate experimental areas, laboratories, offices, and support facilities for neutron research, including parking areas. The EIS will include discussion of potential impacts at four alternative locations for the SNS: Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee; Argonne National Laboratory, Argonne, Illinois; Brookhaven National Laboratory, Upton, New York; and Los Alamos National Laboratory (LANL), Los Alamos, New Mexico. At LANL, the site location identified as most suitable for this type of facility lies within Technical Area 70 along a mesa top about equidistant from Ancho Canyon to the southwest and an unnamed canyon to the northeast. The rims of both canyons would lie about one-quarter mile away from the facility site, with the Rio Grande being located to the east about 1.2 miles, and State Road 4 being located about one-quarter mile to the west. The vegetation in the proposed SNS site area is dominated by piñon-juniper woodlands with scattered juniper savannas.

Existing site information is being used for the analysis of alternatives presented in the Draft SNS EIS. If LANL is chosen as the preferred location for this facility, an in-depth analysis of the site would be performed, which would include the preparation of a Biological Assessment and consultation with the U. S. Fish and Wildlife Service (Service). In the initial stages of analysis, the species being considered for this Los Alamos County site and their current legal status are as follows:

- *Falco peregrinus anatum* (American peregrine falcon) - endangered
- *Strix occidentalis lucida* (Mexican spotted owl) - threatened
- *Empidonax traillii extimus* (Southwestern willow flycatcher) - endangered
- *Haliaeetus leucocephalus* (Bald eagle) - threatened
- *Falco peregrinus tundrius* (Arctic peregrine falcon) - threatened
- *Grus americana* (Whooping crane) - endangered
- *Mustela nigripes* (Black-footed ferret) - endangered

Jennifer Fowler-Propst 2 DEC 08 1997

The site includes foraging habitat for the American peregrine falcon and foraging and roosting habitat for the bald eagle. The nearest identified peregrine falcon nesting habitat is within White Rock Canyon about 1.2 miles from the site. Wintering bald eagles forage and roost within White Rock Canyon and its connecting canyons, including Ancho Canyon.

We request that the Service review this list for completeness of species considered and the accuracy of legal status in light of any changes in listing under the Endangered Species Act that may have taken place during the last year. Please either then concur with this list or supply us with an updated list.

We would like to thank the Service for its continued support and assistance in our LANL National Environmental Policy Act and Endangered Species Act compliance efforts. For your information and planning purposes, the current estimate for having a Draft LANL Sitewide EIS available for stakeholder review is the February 1998 time frame. It is expected that the Sitewide Biological Assessment will be delivered to your office before that time for your review and concurrence with our determination.

Sincerely,

G. Thomas Todd
G. Thomas Todd
Area Manager

LAAME:3EW-100

cc:
J. Elmore, ORNL
E. Withers, LAAME, LAAO
R. Enz, Scientech, LAAO
J. Huchton, ESH-20, LANL, MS-M887

United States Department of the Interior

FISH AND WILDLIFE SERVICE

New Mexico Ecological Services Field Office
2105 Osuna NE
Albuquerque, New Mexico 87113
Phone: (505) 761-4525 Fax: (505) 761-4542

January 7, 1998

Cons. #2-22-98-I-096

G. Thomas Todd, Area Manager
U.S. Department of Energy
Albuquerque Operations Office
Los Alamos Area Office
Los Alamos, NM 87544

Dear Mr. Todd:

This responds to your letter dated December 8, 1997, requesting a list of species federally listed or proposed to be listed as endangered or threatened. The Department of Energy (DOE) is preparing an Environmental Impact Statement for the siting, construction, and operation of the Spallation Neutron Source (SNS) Facility. The proposed facility would consist of a proton accelerator system, a spallation target, and appropriate experimental areas, laboratories, offices, and support facilities for neutron research. The proposed site location identified as most suitable for this type of facility lies within Technical Area 70 along a mesa top about equidistant from Ancho Canyon to the southwest and an unnamed canyon to the northeast. The rims of both canyons lie about one-quarter mile away from the facility site. The vegetation in the proposed SNS site area is dominated by pinon-juniper woodlands with scattered juniper savannas.

Due to staffing constraints, we are unable to develop site specific species lists for your action. However, we have enclosed a list of Federally endangered, threatened, and candidate species, and species of concern potentially occurring in Los Alamos County, New Mexico. Note that the Arctic peregrine falcon (Falco peregrinus tundrius) is listed as endangered, not threatened as indicated in your letter. Under the Endangered Species Act (Act), it is the responsibility of the Federal action agency or its designated representative to determine whether the proposed action "may affect" any listed or proposed species.

Candidates are those species for which the U.S. Fish and Wildlife Service (Service) has sufficient information on their biological status and threats to propose them as endangered or threatened, but for which issuance of a proposed rule is precluded by work on higher priority species. Species of concern include those for which further biological research and field study are needed to resolve their conservation status. Candidate species and species of concern have no legal protection under the Act and are included in this document for planning purposes only. However, the Service is

G. Thomas Todd, Area Manager 2

concerned and would appreciate receiving any status information that is available or gathered on these species.

Wetlands, riparian vegetation, and the above listed species' sensitive habitat(s) should also be protected. If adverse impacts cannot be avoided, we would appreciate discussing your project in more detail.

We suggest you contact the New Mexico Department of Game and Fish and the New Mexico Energy, Minerals and Natural Resources Department for information concerning fish, wildlife, and plants of State concern.

For further communication on this project, please refer to consultation #2-22-98-I-096. If we can be of further assistance, please contact Yvette Truitt of my staff at (505) 761-4525 ext. 120.

Sincerely,

Jennifer Fowler-Propst
Field Supervisor

Enclosure

cc: (wo/enc)
Director, New Mexico Department of Game and Fish, Santa Fe, New Mexico
Director, New Mexico Energy, Minerals and Natural Resources Department, Forestry and Resources Conservation Division, Santa Fe, New Mexico

Species List
Los Alamos County
January 7, 1998

Los Alamos

Big free-tailed bat, Nyctinomops macrotis (=Tadarida m., T. molossa), SC
Black-footed ferret, Mustela nigripes, E
Goat Peak pika, Ochotona princeps nigrescens, SC
Long-legged myotis, Myotis volans, SC
New Mexican meadow jumping mouse, Zapus hudsonius luteus, SC
Occult little brown bat, Myotis lucifugus occultus, SC
Spotted bat, Euderma maculatum, SC
American peregrine falcon, Falco peregrinus anatum, E
Arctic peregrine falcon, Falco peregrinus tundrius, E (S/A)
Bald eagle, Haliaeetus leucocephalus, T
Ferruginous hawk, Buteo regalis, SC
Mexican spotted owl, Strix occidentalis lucida, T
Loggerhead shrike, Lanius ludovicianus, SC
Northern goshawk, Accipiter gentilis, SC
Southwestern willow flycatcher, Empidonax traillii extimus, E
White-faced ibis, Plegadis chihi, SC
Whooping crane, Grus americana, XN
Flathead chub, Platygobio (=Hybopsis) gracilis, SC
Jemez Mountains salamander, Plethodon neomexicanus, SC

Index

E	=	Endangered
PE	=	Proposed Endangered
PE w/CH	=	Proposed Endangered with critical habitat
T	=	Threatened
PT	=	Proposed Threatened
PT w/CH	=	Proposed Threatened with critical habitat
PCH	=	Proposed critical habitat
C	=	Candidate Species
SC	=	Species of Concern
S/A	=	Similarity of Appearance
*	=	Introduced population
XN	=	Nonessential experimental

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Protected and sensitive species found on the LANL, as reported in the site-wide EIS for LANL.

SPECIES	FEDERAL STATUS/ SPECIES OF CONCERN	STATE STATUS	HABITAT NEEDS	COMMENTS
		ANIMAL SPECIES		
American Peregrine Falcon (*Falco peregrinus anatum*)	Endangered	Threatened	• Uses the juniper savannah, pinyon-juniper woodland, ponderosa pine forest, and mixed-conifer forest vegetation zones • Requires cliffs for nesting	• Forages on LANL. Nests and forages on adjacent lands.
Whooping Crane (*Grus americana)*	Endangered	Endangered	• Requires rivers and marshes • Roosts on sand bars	• Migratory visitor along the Rio Grande and Cochiti Lake
Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	Endangered	Endangered	• Requires riparian areas and vegetation • Requires dense riparian vegetation	• Potential presence on LANL and White Rock Canyon • Potential nesting area on LANL • Present in Jemez Mountains • Present in riparian zone near Española
Bald Eagle (*Haliaeetus leucocephalus)*	Threatened	Threatened	• Rivers and lakes	• Observed as a migratory and winter resident along the Rio Grande and on adjacent LANL lands
Mexican Spotted Owl (*Strix occidentalis lucida*)	Threatened	Sensitive (informal)	• Mixed conifer, ponderosa pine • Prefers tall, old-growth forest in canyons and moist areas for breeding • Forages in forests, woodlands, and rocky areas	• Breeding resident on LANL, LAC, BNM, and SFNF lands • Critical habitat designated on SFNF lands
Jemez Mountain Salamander (*Plethodon neomexicanus)*	Species of Concern	Threatened	• Uses the mixed-conifer forest vegetation zone • Requires north-facing, moist slopes	• Permanent resident on LANL, LAC, BNM, and SFNF lands

Protected and sensitive species found on the LANL, as reported in the site-wide EIS for LANL (continued).

SPECIES	FEDERAL STATUS/ SPECIES OF CONCERN	STATE STATUS	HABITAT NEEDS	COMMENTS
Baird's Sparrow (*Ammodramus bairdii*)	Species of Concern	Threatened	• Uses the pinyon-juniper woodland, ponderosa pine forest and mixed-conifer forest vegetation zones	• Observed on SFNF lands
Spotted Bat (*Euderma maculatum*)	Species of Concern	Threatened	• Uses the pinyon-juniper woodland, ponderosa pine forest, and spruce-fir forest vegetation zones • Requires riparian areas • Roosts in cliffs near water	• Permanent resident on BNM and SFNF lands • Seasonal resident on LANL
New Mexico Jumping Mouse (*Zapus hudsonius luteus*)	Species of Concern	Threatened	• Uses the mixed-conifer and spruce-fir forest vegetation zones • Requires riparian areas • Requires water nearby	• Permanent resident on LAC and SFNF lands • Overwinters by hibernating
Flathead Chub (*Platygobio gracilis*)	Species of Concern	Unlisted	• Requires access to perennial rivers	• Permanent resident of the Rio Grande between Española and the Cochiti Reservoir
Ferruginous Hawk (*Buteo regalis*)	Species of Concern	Unlisted	• Uses the juniper savannah and pinyon-juniper woodlands vegetation zone	• Observed as a breeding resident on LAC, LANL, BNM, and SFNF lands
Northern Goshawk (*Accipiter gentilis*)	Species of Concern	Sensitive (informal)	• Uses the mixed-conifer, ponderosa pine, spruce-fir forest vegetation zones	• Observed as a breeding resident on LAC, LANL, BNM, and SFNF lands
White-Faced Ibis (*Plegadis chihi*)	Species of Concern	Unlisted	• Requires perennial rivers and marshes	• Summer resident and migratory visitor on the Rio Grande and SFNF lands

Protected and sensitive species found on the LANL, as reported in the site-wide EIS for LANL (continued).

SPECIES	FEDERAL STATUS/ SPECIES OF CONCERN	STATE STATUS	HABITAT NEEDS	COMMENTS
Loggerhead Shrike (*Lanius ludovicianus*)	Species of Concern	Unlisted	• Uses the juniper savannah, pinyon-juniper woodland, ponderosa pine forest, and mixed-conifer forest vegetation zones	• Observed on LAC, BNM, and SFNF lands
Big Free (Tailed Bat (*Nyctinomops macrotis)*	Species of Concern	Sensitive (informal)	• Uses the juniper savannah, pinyon-juniper woodland, and ponderosa pine forest, and mixed conifer forest vegetation zones • Roosts on cliffs	• Migratory visitor on LAC, BNM, and SFNF lands
Fringed Myotis (*Myotis thysanodes)*	Species of Concern	Sensitive (informal)	• Uses the juniper savannah, pinyon juniper woodland, ponderosa pine forest vegetation zones • Roosts in caves and buildings	• Observed on LANL, BNM, and SFNF lands
Long-Eared Myotis (*Myotis evotis)*	Species of Concern	Sensitive (informal)	• Uses the ponderosa pine forest, mixed-0conifer, and spruce-fir forests vegetation zones • Roosts in dead ponderosa pine trees	• Summer resident on LANL, LAC, BNM, and SFNF lands
Long-Legged Myotis (*Myotis volans*)	Species of Concern	Sensitive (informal)	• Uses the pinyon-juniper woodland, ponderosa pine forest, and mixed-conifer forest vegetation zones • Roosts in dead conifer trees	• Summer resident on LANL, LAC, BNM, and SFNF lands
Small-Footed Myotis (*Myotis ciliolabrum*)	Species of Concern	Sensitive (informal)	• Uses the juniper savannah, pinyon-juniper woodland, ponderosa pine forest, and mixed-conifer forest vegetation zones • Roosts in cliffs and caves	• Observed on LANL, BNM, and SFNF lands • Overwinters by hibernating
Yuma Myotis (*Myotis yumanensis*)	Species of Concern	Sensitive (informal)	• Uses the juniper savannah and pinyon-juniper woodland forest vegetation zones • Roosts in cliffs and caves near water	• Summer resident on LANL, LAC, and SFNF lands

Protected and sensitive species found on the LANL, as reported in the site-wide EIS for LANL (continued).

SPECIES	FEDERAL STATUS/ SPECIES OF CONCERN	STATE STATUS	HABITAT NEEDS	COMMENTS
Occult Little Brown Bat (*Myotis lucifugas occultus*)	Species of Concern	Sensitive (informal)	• Uses the pinyon-juniper woodland and ponderosa pine forest vegetation zones • Requires riparian areas • Forages over water	• Observed on SFNF lands
Pale Townsend's Big-eared Bat (*Plecotus townsendii pallescens*)	Species of Concern	Sensitive (informal)	• Uses the pinyon-juniper woodland, ponderosa pine forest, and mixed-conifer forest vegetation zones • Roosts in caves	• Observed on LANL and BNM lands • Overwinters by hibernating
Goat Peak Pika (*Ochotona princeps nigrescens*)	Species of Concern	Sensitive (informal)	• Uses the mixed-conifer and spruce-fir forests vegetation zones • Requires boulder piles and rockslides	• Observed on LAC and BNM lands
Gray Vireo (*Vireo vicinior*)	Unlisted	Threatened	• Uses riparian area in the juniper savannah and pinyon-juniper forests vegetation zones	• Observed on LAC, BNM, and SFNF lands
PLANT SPECIES				
Wood Lily (*Lilium philadelphicum L.* var. *andium* (Nutt. Ker)	Unlisted	Endangered	• Grows in the ponderosa pine forest, mixed-conifer, and spruce-fir forests vegetation zones • Requires moist soil	• Observed on LAC, BNM, and SFNF lands
Yellow Lady's Slipper Orchid (*Cyprepedium calceolus L.* var. *Pubescens* (Willd.) Correll)	Unlisted	Endangered	• Requires riparian areas • Grows in the mixed-conifer forest vegetation zones • Requires moist soil	• Observed on BNM lands
Helleborine Orchid (*Epipactis gigantea* Dougl.)	Unlisted	Rare and sensitive	• Requires riparian areas • Grows in the juniper savannah and pinyon-juniper woodland forests vegetation zones • Requires springs, seeps, or other wet areas	• Observed on LAC lands

Note: This listing was developed with information and guidance provided by biologists from LANL; the FWS; the USFS; the NPS; the National Biological Service; the NMDGF; the New Mexico Energy, Minerals, and Natural Resources Department; and the New Mexico natural Heritage Program, as well as consultations with independent consultants and reviews of the technical literature.

Department of Energy
Albuquerque Operations Office
Los Alamos Area Office
Los Alamos, New Mexico 87544

JUN 2 5 1998

Dr. Lynne Sebastian
State Historic Preservation Officer
Historic Preservation Division
228 East Palace Avenue, 3rd Floor
Santa Fe, NM 87503

Dear Dr. Sebastian:

The U.S. Department of Energy (DOE) is proposing to site, construct, and operate the Spallation Neutron Source (SNS) facility and is currently preparing a Draft Environmental Impact Statement (EIS) for this proposal pursuant to the National Environmental Policy Act (NEPA). This letter is to inform you of DOE's engagement in this decision-making process, which could potentially affect Los Alamos National Laboratory (LANL). The proposed SNS facility would consist of the construction and operation of a proton accelerator system, a spallation target, and appropriate experimental areas, laboratories, offices, and support facilities for neutron research. The Draft EIS will include discussion of potential impacts for siting the SNS facility at four alternative DOE laboratory locations: Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee (the contemplated Preferred Alternative); Argonne National Laboratory (ANL), Argonne, Illinois; Brookhaven National Laboratory (BNL), Upton, New York; and LANL, Los Alamos, New Mexico.

The proposed location of the SNS at LANL is within Technical Area 70 (TA-70). The site is located on a mesa flanked by Ancho Canyon 0.27 mi (0.47 km) to the southwest and a small unnamed canyon an equal distance to the northeast. The Rio Grande is located about 1.2 mi (1.9 km) to the east of the site and State Road 4 is about 0.22 mi (0.35 km) to its west. Elevations range from 6,410 feet (1,954 m) to 6,490 feet (1,978 m). The total Area of Potential Effect is estimated to be about 110 acres and includes a 100-foot buffer around the construction site. To date, about 65 percent of the proposed SNS site area has been surveyed for historical, archeological, and cultural resources using linear pedestrian transects spaced 16-33 feet (5-10 m) apart. Five archeological sites have been identified that are deemed to be eligible for inclusion in the National Register of Historic Places under Criterion D. These sites are either single- or double-room field houses, or two- to eight-room pueblos from either the Coalition, Early Coalition, or Classic time periods.

Dr. Lynne Sebastian 2 JUN 2 5 1998

If DOE decides to select LANL as the preferred site for the SNS, rather than ORNL as is now currently contemplated, a comprehensive survey for cultural resources will be completed for the TA-70 LANL site. We will then engage in full and complete consultation with your office under Section 106 of the National Historic Preservation Act.

If you have any questions regarding this project, please call Dean Triebel at (505) 665-6353 or Elizabeth Withers at (505) 667-8690.

Sincerely,

CS Przybylek

C. S. Przybylek
Acting Area Manager

LAAME:3EW-109

cc:
Dave Wilfert
Oak Ridge National Laboratory
Bethel Valley Road
Oak Ridge, TN 37831
Dean Triebel, LAAME, LAAO
Tony Ladino, ESH-20, LANL, MS-M887

ANL CONSULTATION LETTERS

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Department of Energy
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439

DEC 11 1997

Mr. Benjamin Tuggle
Field Supervisor
U.S. Fish and Wildlife Service
Chicago Illinois Field Office
1000 Hart Road-Suite 180
Barrington, Illinois 60010

Dear Mr. Tuggle:

SUBJECT: INFORMAL CONSULTATION UNDER SECTION 7 OF THE ENDANGERED SPECIES ACT FOR THE PROPOSED SITING, CONSTRUCTION, AND OPERATION OF THE SPALLATION NEUTRON SOURCE

The U.S. Department of Energy (DOE) proposes to site, construct, and operate Spallation Neutron Source (SNS) and is currently preparing an Environmental Impact Statement (EIS), pursuant to the National Environmental Policy Act on this Federal action. The proposed SNS Facility would consist of a proton accelerator system, a spallation target and appropriate experimental areas, laboratories, offices, and support facilities for neutron research. The EIS will include discussion of potential impacts at four alternative locations for the SNS, all DOE-owned laboratories: Oak Ridge National Laboratory, Oak Ridge, Tennessee; Argonne National Laboratory (ANL), Argonne, Illinois; Los Alamos National Laboratory, Los Alamos, New Mexico; and Brookhaven National Laboratory, Upton, New York. This letter pertains to the potential site located at ANL.

The proposed SNS would produce short pulses of neutrons for use in materials and biomedical research. This would be accomplished through the "spallation" process wherein (1) subatomic particles, called protons, are accelerated to very high energies; (2) the high energy protons are "bunched" into a compact group; (3) the bunched, high energy protons are directed onto a target made of a high atomic number material, in this case mercury; and (4) the collision of the protons with the target produces a pulse of neutrons from the target material. The neutrons would be slowed to useful energy levels, and guided to samples of the materials being studied. The interactions of the neutrons and the specimens would be measured and analyzed, revealing information on the structure, properties, and behavior of the test material.

DEC 1 1 1997

Mr. Benjamin Tuggle - 2 -

The proposed location of the SNS at ANL is in the 800 Area in the northwest corner of the Laboratory (see enclosed figure). There are several areas of wetlands and floodplains that may be affected by construction of the SNS, however, impacts could probably be mitigated. According to our information, there would be no involvement of habitat for State or Federally-listed threatened or endangered species. I have enclosed a description of the ecological resources based on a recent biological survey of the site performed by ANL.

This letter serves as informal consultation under Section 7 of the Endangered Species Act. In this regard, DOE requests an updated list of protected species and habitat on and in the vicinity of the proposed SNS site and solicits your recommendation and comments about any potential effects this proposed action may have. Your input will be used in the preparation of the EIS. Reply at your earliest convenience would be appreciated.

If you need further information on this request, please do not hesitate to call W. S. White, of my staff, at (630) 252-2101.

Sincerely,

Michael J. Flannigan, Director
Safety and Technical Services

Enclosure:
As Stated

cc: D. Wilfert, OR, w/o encl.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Chicago Illinois Field Office
1000 Hart Road – Suite 180
Barrington, Illinois 60010
708/381-2253

IN REPLY REFER TO:
FWS/AES-CIFO

December 23, 1997

Michael Flannigan
U.S. Department of Energy
Chicago Operations Office
9600 South Cass Avenue
Argonne, IL 60439

Dear Mr. Flannigan:

This is in response to your letter dated December 11, 1997 requesting information on endangered or threatened species and Informal Consultation in accordance with Section 7 of the Endangered Species Act of 1973, as amended. The request was pertaining to the proposed siting, construction, and operation of a spallation neutron source at Argonne National Laboratory (ANL). Three other alternative sites in other parts of the country are also being investigated.

We have reviewed the information included with your letter. It is not clear if all of the resources described therein are within the "800 Area" or if they are throughout the ANL site. Of the habitats described, the wetlands and mature oak woodlands would have the most ecological value and thus potential impacts to these communities would be of the greatest concern to this Office. The only federally listed species that may be affected by the project is the Hine's emerald dragonfly (*Somatochlora hineana*). As you noted, this species does not occur within the project site but is in the vicinity. Further specifics of the project would be needed before a determination could be made as to the likelihood of adverse impacts to this species from the project. As with other recent consultations regarding projects at Argonne, the primary concern would relate to potential groundwater impacts. As more information becomes available through the development of an Environmental Impact Statement we would be happy to review it to make a definitive determination.

Thank you for the opportunity for input and consultation early in your evaluation and planning process. If you have any questions, please contact Mr. Jeff Mengler at 847/381-2253, ext. 226.

Sincerely,

for John D. Rogner
Acting Field Supervisor

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Department of Energy
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439

DEC 12 1997

Ms. Anne E. Haaker
Deputy State Historic Preservation Officer
Illinois Historic Preservation Agency
Old State Capitol
Springfield, Illinois 62701

Dear Ms. Haaker:

SUBJECT: CONSULTATION UNDER SECTION 106 OF THE NATIONAL HISTORIC PRESERVATION ACT FOR THE PROPOSED SITING, CONSTRUCTION, AND OPERATION OF THE SPALLATION NEUTRON SOURCE

The U.S. Department of Energy (DOE) proposes to site, construct, and operate Spallation Neutron Source (SNS) and is currently preparing an Environmental Impact Statement (EIS), pursuant to the National Environmental Policy Act on this Federal action. The proposed SNS Facility would consist of a proton accelerator system, a spallation target and appropriate experimental areas, laboratories, offices, and support facilities for neutron research. The EIS will include discussion of potential impacts at four alternative locations for the SNS, all DOE-owned laboratories: Oak Ridge National Laboratory, Oak Ridge, Tennessee; Argonne National Laboratory (ANL), Argonne, Illinois; Los Alamos National Laboratory, Los Alamos, New Mexico; and Brookhaven National Laboratory, Upton, New York. This letter pertains to the potential site located at ANL.

The proposed SNS would produce short pulses of neutrons for use in materials and biomedical research. This would be accomplished through the "spallation" process wherein (1) subatomic particles, called protons, are accelerated to very high energies; (2) the high energy protons are "bunched" into a compact group; (3) the bunched, high energy protons are directed onto a target made of a high atomic number material, in this case mercury; and (4) the collision of the protons with the target produces a pulse of neutrons from the target material. The neutrons would be slowed to useful energy levels, and guided to samples of the materials being studied. The interactions of the neutrons and the specimens would be measured and analyzed, revealing information on the structure, properties, and behavior of the test material.

DEC 12 1997

Ms. Anne Haaker - 2 -

The proposed location of the SNS at ANL is in the 800 Area in the northwest corner of the Laboratory (see enclosed material). Within the general vicinity of this site, nine archaeological sites have been recorded. One site (11-Du-203) is eligible for listing on the *National Register of Historic Places*, four sites (11-Du-208, 11-Du-295, 11-Du-296, and 11-Du-297) have been determined not eligible, and four sites (11-Du-201, 11-Du-207, 11-299, and 11-Du-300) remain to be evaluated for their eligibility status. None of the nine sites are directly within the footprint of the proposed facility but will be considered in the EIS due to their proximity to the preferred site. It is likely that, at a minimum, the site nearest the footprint (11-Du-207) would require an eligibility determination.

This letter serves as consultation under Section 106 of the National Historic Preservation Act. Your input will be used in the preparation of the EIS. Please reply at your earliest convenience.

If you need further information on this request, please do not hesitate to call W. S. White, of my staff, at (630) 252-2101.

Sincerely,

Michael J. Flannigan, Director
Safety and Technical Services

Enclosure:
As Stated

cc: D. Wilfert, OR, w/o encl.

BNL CONSULTATION LETTERS

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Department of Energy
Brookhaven Group
Building 464
P.O. Box 5000
Upton, New York 11973

JUN - 1 1998

Ms. Nancy Davis Ricci
Information Services
New York Natural Heritage Program
New York State Department of Environmental Conservation
700 Troy-Schenectady Road
Latham, NY 12110-2400

Dear Ms. Ricci:

SUBJECT: REQUEST FOR CONSULTATION UNDER SECTION 106 OF THE NATIONAL HISTORIC PRESERVATION ACT FOR THE PROPOSED SITING, CONSTRUCTION, AND OPERATION OF THE SPALLATION NEUTRON SOURCE

This letter is intended to serve as our request for informal consultation under Section 7 of the Endangered Species Act.

The U.S. Department of Energy (DOE) proposes to site, construct, and operate the Spallation Neutron Source (SNS) and is currently preparing an Environmental Impact Statement (EIS), pursuant to the National Environmental Policy Act (NEPA) on this federal action. The proposed SNS facility would consist of a proton accelerator system, a spallation target and appropriate experimental areas, laboratories, offices, and support facilities for neutron research. The EIS will include discussion of potential impacts at four alternative locations for the SNS, all DOE-owned laboratories: Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee; Argonne National Laboratory (ANL), Argonne, Illinois; Los Alamos National Laboratory (LANL), Los Alamos, New Mexico; and Brookhaven National Laboratory (BNL). Upton, New York.

The proposed SNS would produce short pulses of neutrons for use in materials and biomedical research. This would be accomplished through the "spallation" process wherein (1) subatomic particles, called protons, are accelerated to very high energies; (2) the high energy protons are "bunched" into a compact group; (3) the bunched, high energy protons are directed onto a target made of a high atomic number material. in this case mercury; and (4) the collision of the protons with the target produces a pulse of neutrons from the target material. The neutrons would then be slowed to useful energy levels, and guided to samples of the materials being studied. The interactions of the neutrons and the specimens would be measured and analyzed, revealing information on the structure, properties, and behavior of the test material.

Ms. N. Ricci -2- JUN - 1 1998

With regards to Brookhaven National Laboratory, the proposed location of the SNS at BNL is the central portion of the site, adjacent to the Relativistic Heavy Ion Collider (RHIC), (Site #1 on the enclosed site selection report). DOE requests an updated list of protected species and habitat on and in the vicinity of the proposed SNS site at BNL and solicits your recommendation and comments about the potential effects of this proposed action. Your input will be used in the preparation of the final environmental impact statement.

If you need further information on this request, please do not hesitate to call Jerry Granzen of my staff at (516) 344-4089.

Sincerely,

K. Dean Helms
Executive Manager

Enclosure:
As stated

cc: D. Bean, EAS, w/encl.
D. Wilfert, OR, w/encl.
M. Butler, BHG, w/encl.
K. Brog, BNL, w/encl.
M. Bebon, BNL, w/encl.
M. Schaffer, BNL, w/encl.
T. Sperry, BNL, w/encl.

New York State Department of Environmental Conservation
Division of Fish, Wildlife & Marine Resources
Wildlife Resources Center – New York Natural Heritage Program
700 Troy-Schenectady Road, Latham, New York 12110-2400
Phone: (518) 783-3932 FAX: (518) 783-3916

John P. Cahill
Commissioner

June 12, 1998

K. Dean Helms
U.S. Dept. Of Energy
Brookhaven Group
Bldg, 464, PO Box 5000
Upton, NY 11973

Dear Mr. Helms:

We have reviewed the New York Natural Heritage Program files with respect to your recent request for biological information concerning the Environmental Impact Statement for the proposed construction of the Spallation Neutron Source facility, four areas as indicated on your enclosed maps, located in the Town of Brookhaven, Suffolk County.

Enclosed is a computer printout covering the area you requested to be reviewed by our staff. The information contained in this report is considered sensitive and may not be released to the public without permission from the New York Natural Heritage Program.

Our files are continually growing as new habitats and occurrences of rare species and communities are discovered. In most cases, site-specific or comprehensive surveys for plant and animal occurrences have not been conducted. For these reasons, we can only provide data which have been assembled from our files. We cannot provide a definitive statement on the presence or absence of species, habitats or natural communities. This information should not be substituted for on-site surveys that may be required for environmental assessment.

This response applies only to known occurrences of rare animals and/or significant wildlife habitats. Please contact the appropriate NYS DEC Regional Office, Division of Environmental Permits, at the address enclosed for information regarding any regulated areas or permits that may be required (e.g., regulated wetlands) under State Law.

If this proposed project is still active one year from now we recommend that you contact us again so that we may update this response. Kindly address your requests to the above address,

Sincerely,

Carole L. Flood

Carole L. Flood Information Services
NY Natural Heritage Program

Encs
cc: Reg. 1, Wildlife Mgr.
Reg. 1, Fisheries Mgr.
Peter Nye, ESU, Delmar

NATURAL HERITAGE REPORT on RARE SPECIES and ECOLOGICAL COMMUNITIES

Prepared 10 JUN 1998 by NY Natural Heritage Program, NYS DEC, Latham, New York.

Records with a PRECISION value of "S" are known to be in a location which may be impacted by the proposed action.
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page 1

REFER TO THE USERS GUIDE FOR EXPLANTIONS OF CODES, RANKS, AND FIELDS.

* LOCATION SCIENTIFIC NAME & Common Name	NY LEGAL STATUS & HERITAGE RANK	FEDERAL STATUS	PRECISION & ACRES	EORANK & LAST SEEN	GENERAL HABITAT AND QUALITY	TOWN(S) & DETAILED LOCATION	USGS TOPO QUAD LAT & LONG	OFFICE USE
* KENTS POND								
RHYNCHOSPORA INUNDATA Drowned horned rush VASCULAR PLANT	ENDANGERED G4 S1		M	F 1922	GROWING IN WATER AWAY FROM SHORE.	RIVERHEAD. KENT POND BARRENS.	WADING RIVER 40 53 10 N 72 50 28 W	4007287 272
* RIDGE								
IRIS PRISMATICA Slender blue flag VASCULAR PLANT	UNPROTECTED G4G5 S2		M	H 1871	RICH MEADOWS.	BROOKHAVEN. RIDGE, RICH MEADOWS.	MIDDLE ISLAND 40 53 08 N 72 53 30 W	4007288 19
* UPTON								
ERYNNIS MARTIALIS Mottled dusky wing BUTTERFLY or SKIPPER	UNPROTECTED G4 S1S3		M	H 1965	MEADOW.	BROOKHAVEN. BROOKHAVEN NATIONAL LABORATORY. MEADOW.	MORICHES 40 51 50 N 72 52 04 W	4007277 40
ERYNNIS PERSIUS PERSIUS Persius dusky wing BUTTERFLY or SKIPPER	UNPROTECTED G4T2 SH		M	H 1966	PINE OAK FOREST.	BROOKHAVEN. BROOKHAVEN NATIONAL LABORATORY. TAKEN IN PINE OAK FOREST.	MORICHES 40 51 50 N 72 52 04 W	4007277 40

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PHYSALIS VIRGINIANA Virginia ground-cherry VASCULAR PLANT	UNPROTECTED G5 SH		M	H 1929	DRY FIELD.	BROOKHAVEN. DRY FIELD, CAMP UPTON, LONG ISLAND (UPTON).	MORICHES 40 51 50 N 72 52 04 W	4007277 40

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* BROOKHAVEN NATIONAL LABORATORY								
PLATANTHERA CRISTATA Crested fringed orchis VASCULAR PLANT	THREATENED G5 S1		S 1	E? 1984	WET PINE BARRENS.	BROOKHAVEN. FROM NW CORNER OF FILTRATION PLANT AT BROOKHAVEN NATIONAL LAB, GO 0.55 MI NNW.	WADING RIVER 40 53 07 N 72 51 32 W	4007287 280
* CRESCENT BOW DRIVE POND								
AMBYSTOMA TIGRINUM Tiger salamander AMPHIBIAN	ENDANGERED G5 S3		S 1	C 1994	A SMALL, NATURAL POND WITH WATER DEPTH OF 3 FEET, BOTTOM SEDIMENT OF SILTY MUD ON TOP OF SAND, AND PH 4.3-4.8. ASSOCIATED SPECIES: PSEUDACRIS CRUCIFER. BASED ON GLOBAL SPECS OF JANUARY 1993.	BROOKHAVEN. ON BROOKHAVEN NATIONAL LABORATORY PROPERTY AT THE SOUTH END OF CRESCENT BOW DRIVE AND LOCATED BETWEEN CRESCENT BOW DRIVE AND PLEASANT VIEW DRIVE.	WADING RIVER 40 53 27 N 72 51 51 W	4007287 47 ESU
* KENTS POND								
RHYNCHOSPORA INUNDATA Drowned horned rush VASCULAR PLANT	ENDANGERED G4 S1		M	F 1922	GROWING IN WATER AWAY FROM SHORE.	RIVERHEAD. KENT POND BARRENS.	WADING RIVER 40 53 10 N 72 50 28 W	4007287 272

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* PECONIC RIVER PONDS BROOKHAVEN								
AMBYSTOMA TIGRINUM Tiger salamander AMPHIBIAN	ENDANGERED G5 S3		S	CD 1994	A SMALL, NATURAL POND ALONG THE PECONIC RIVER WITH WATER DEPTH OF 1-1.5 FEET, HARD MUD BOTTOM SUBSTRATE WITH EMERGENT SEDGE VEGETATION AND PH 4.5. ASSOCIATED SPECIES: RANA SYLVATICA, PSEUDACRIS CRUCIFER, BUFO WOODHOUSII FOWLERI. BASED ON GLOBAL SPECS OF JANUARY 1993.	BROOKHAVEN. ON BROOKHAVEN NATIONAL LABORATORY PROPERTYY, SMALL POND ALONG THE PECONIC RIVER ON THE W SIDE OF A SERVICE ROAD S OF CRESCENT BOW DRIVE.	WADING RIVER 40 53 09 N 72 51 46 W	4007281 50 ESU
* PLEASANT VIEW DRIVE POND								
AMBYSTOMA TIGRINUM Tiger salamander AMPHIBIAN	ENDANGERED G5 S3		S	CD 1994	A SMALL, NATURAL POND WITH WATER DEPTH OF 3+ FEET, BOTTOM SEDIMENT OF SILT/MUCK AND PH 4.4. SMALL MATS OF FLOATING ALGAE. ASSOCIATED SPECIES: RANA SYLVATICA, CLEMMYS GUTTATA. BASED ON GLOBAL SPECS OF JANUARY 1993.	BROOKHAVEN. ON BROOKHAVEN NATIONAL LABORATORY PROPERTY JUST S OF THE SOUTH END OF PLEASANT VIEW DRIVE.	WADING RIVER 40 53 21 N 72 52 02 W	4007287 49 ESU
* UPTON								

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ERYNNIS PERSIUS PERSIUS Persius dusky wing BUTTERFLY or SKIPPER	UNPROTECTED G4T2 SH		M	H 1966	PINE OAK FOREST.	BROOKHAVEN. BROOKHAVEN NATIONAL LABORATORY. TAKEN IN PINE OAK FOREST.	MORICHES 40 51 50 N 72 52 04 W	4007277 40
PHYSALIS VIRGINIANA Virginia ground-cherry VASCULAR PLANT	UNPROTECTED G5 SH		M	H 1929	DRY FIELD.	BROOKHAVEN. DRY FIELD, CAMP UPTON, LONG ISLAND [UPTON].	MORICHES 40 51 50 N 72 52 04 W	4007277 40

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* CRESCENT BOW DRIVE POND								
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* KENTS POND								
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* UPTON								

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ERYNNIS PERSIUS PERSIUS Persius dusky wing BUTTERFLY or SKIPPER	UNPROTECTED G4T2 SH		M	H 1966	PINE OAK FOREST.	BROOKHAVEN. BROOKHAVEN NATIONAL LABORATORY. TAKEN IN PINE OAK FOREST.	MORICHES 40 51 50 N 72 52 04 W	4007277 40
PHYSALIS VIRGINIANA Virginia ground-cherry VASCULAR PLANT	UNPROTECTED G5 SH		M	H 1929	DRY FIELD.	BROOKHAVEN. DRY FIELD, CAMP UPTON, LONG ISLAND [UPTON].	MORICHES 40 51 50 N 72 52 04 W	4007277 40

8 Records Processed

Site #4

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SCIENTIFIC NAME & Common Name	NY LEGAL STATUS & HERITAGE RANK	FEDERAL STATUS	PRECISION & ACRES	EORANK & LAST SEEN	GENERAL HABITAT AND QUALITY	TOWN(S) & DETAILED LOCATION	USGS TOPO QUAD LAT & LONG	OFFICE USE
* LOCATION								
* BROOKHAVEN BARRENS ROADSIDE								
DESMODIUM CILIARE Little-leaf tick-trefoil VASCULAR PLANT	THREATENED G5 S2S3		M	E 1985	DRY PINE BARRENS ROADSIDE. ASSOC. SPECIES: AGALINIS SETACEA, EUPATORIUM ALHUM AND LESPEDEZA REPENS. NEED MORE INFORMATION TO ASSIGN A-D RANK.	BROOKHAVEN. FROM THE JUNCTION OF MIDDLE ISLAND MORICHES, MORICHES-YAPHANK, AND MANORVILLE ROADS, THE SITE EXTENDS E AND N AND IS DEFINED BY MANORVILLE ROAD. PLANTS OCCUR ALONG ROADSIDE AT EDGE OF PINE BARRENS.	MORICHES 40 50 25 N 72 51 50 W	4007277 51
LESPEDEZA STUEVEI Velvety lespedeza VASCULAR PLANT	RARE G4? S2		M	E 1985	DRY PINE BARRENS ROADSIDE. ASSOC. SPECIES: AGALINIS SETACEA, EUPATORIUM ALHUM AND LESPEDEZA REPENS. NEED MORE INFORMATION TO ASSIGN A-D RANK.	BROOKHAVEN. FROM THE JUNCTION OF MIDDLE ISLAND MORICHES, MORICHES-YAPHANK, AND MANORVILLE ROADS, THE SITE EXTENDS E AND N AND IS DEFINED BY MANORVILLE ROAD. PLANTS OCCUR ALONG ROADSIDE AT EDGE OF PINE BARRENS.	MORICHES 40 50 25 N 72 51 50 W	4007277 51
* UPTON								
ERYNNIS MARTIALIS Mottled dusky wing BUTTERFLY or SKIPPER	UNPROTECTED G4 S1S3		M	H 1965	MEADOW.	BROOKHAVEN. BROOKHAVEN NATIONAL LABORATORY. MEADOW.	MORICHES 40 51 50 N 72 52 04 W	4007277 40

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SIGNIFICANT HABITATS

DATE : 06/10/98

REPORT ID#	NAME OF AREA	TYPE OF AREA	COUNTY	TOWN OR CITY	QUADRANGLE	LATITUDE (DEG MIN SEC)	LONGITUDE (DEG MIN SEC)
SW 52-562	Peconic River and Drainage	Freshwater River	Suffolk	Brookhaven	Moriches	40 54 08	72 48 13
SW 52-576	Smith Estate Ponds	Tiger Salamander Ponds	Suffolk	Brookhaven	Bellport	40 51 42	72 54 25
SW 52-578	Water Tank Pond	Tiger Salamander Pond	Suffolk	Brookhaven	Moriches	40 51 07	72 51 44

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF ENVIRONMENTAL PERMITS REGIONAL OFFICES

REGION	COUNTIES	NAME	ADDRESS AND PHONE NO.
Region 1	Nassau Suffolk	Robert Greene Permit Administrator	Loop Road, Bldg. 40 SUNY Stony Brook, NY 11790-2356 (516) 444-0365
Region 2	New York City	George Danskin Permit Administrator	Hunters Point Plaza 4740 21st Street Long Island City, NY 11101-5407 (718) 482-4997
Region 3	Dutchess Orange Putnam Rockland, Sullivan Ulster, Westchester	Margaret Duke Permit Administrator	21 South Putt Corners Road New Paltz, NY 12561-1696 (914) 256-3059
Region 4	Albany Columbia Delaware Greene, Montgomery, Otsego Rensselaer, Schenectady, Schoharie	William J. Clarke Permit Administrator	1150 N. Westcott Road Schenectady, NY 12306-2014 (518) 357-2234
Region 5	Clinton Essex Franklin Fulton, Hamilton Saratoga, Warren, Washington	Richard Wild Permit Administrator	Route 86 Ray Brook, NY 12977 (518) 897-1234
Region 6	Herkimer Jefferson Lewis Oneida, St. Lawrence	Randy Vaas Permit Administrator	State Office Building 317 Washington Street Watertown, NY 13601 (315) 785-2246
Region 7	Broome Cayuga Chenango Cortland, Madison, Onondaga Oswego, Tioga, Tompkins	Ralph Manna, Jr. Permit Administrator	615 Erie Blvd. West Syracuse, NY 13204-2400 (315) 426-7439
Region 8	Chemung Genesee Livingston Monroe, Ontario, Orleans Schuyler, Seneca, Steuben Wayne, Yates	Albert Butkas Permit Administrator	6274 East Avon-Lima Road Avon, NY 14414 (716) 226-2466
Region 9	Allegany Cattaraugus Chautauqua Erie, Niagara, Wyoming	Steven Doleski Permit Administrator	270 Michigan Avenue Buffalo, NY 14203-2999 (716) 851-7165

USERS GUIDE TO NY NATURAL HERITAGE DATA

New York Natural Heritage Program, 700 Troy-Schenectady Road, Latham NY 12110-2400 phone: (518) 783-3932

NATURAL HERITAGE PROGRAM: The Natural Heritage Program is an ongoing, systematic, scientific inventory whose goal is to compile and maintain on the rare plants and animals native to New York State, and significant ecological communities. The data provided in the report facilitate sound plann conservation, and natural resource management and help to conserve the plants, animals and ecological communities that represent New York's natural herit.

DATA SENSITIVITY: The data provided in the report are ecologically sensitive and should be treated in a sensitive manner. The report is for your in-ho use and should not be released, distributed or incorporated in a public document without prior permission from the Natural Heritage Program.

NATURAL HERITAGE REPORTS (may contain any of the following types of data):

COUNTY NAME: County where the occurrence of a rare species or significant ecological community is located.
TOWN NAME: Town where the occurrence of a rare species or significant ecological community is located.
USGS 7 ½' TOPOGRAPHIC MAP: Name of 7.5 minute US Geological Survey (USGS) quadrangle map (scale 1:24,000).
LAT: Centrum latitude coordinate of the location of the occurrence. Caution: latitude & longitude must be used with PRECISION (e.g. the location of occurrence with M (minute) precision is not precisely known & is thought to occur within a 1.5 mile radius of the latitude/longitude coordinates).
LONG: Centrum longitude coordinate of the location of the occurrence. See also LAT above.
PRECISION: S - seconds: location known precisely. (within a 300' or 1-second radius of the latitude and longitude given.
M - minutes: location known only to within a 1.5 mile (1 minute) radius of the latitude and longitude given.
G - general: location known to within a 5 mile radius of the latitude and longitude given.
SIZE (acres): Approximate acres occupied by the rare species or significant ecological community at this location.
SCIENTIFIC NAME: Scientific name of the occurrence of a rare species or significant ecological community..
COMMON NAME: Common name of the occurrence of a rare species or significant ecological community.
ELEMENT TYPE: Type of element (i.e. plant, animal, significant ecological community, other, etc.)
LAST SEEN: Year rare species or significant ecological community last observed extant at this location.
EO RANK: Comparative evaluation summarizing the quality, condition, viability and defensibility of this occurrence. Use with LAST SEEN and PRECISION
A-E = Extant: A=excellent, B=good, C=marginal, D=poor, E=extant but with insufficient data to assign a rank of A - D.
F = Failed to find. Did not locate species, but habitat is still there and further field work is justified.
H = Historical. Historical occurrence without any recent field information.
X = Extirpated. Field/other data indicates element/habitat is destroyed and the element no longer exists at this location.
? = Unknown.
Blank = Not assigned.

NEW YORK STATE STATUS (animals): Categories of Endangered and Threatened species are defined in New York State Environmental Conservation Law section 11-0535. Endangered, Threatened, and Special Concern species are listed in regulation 6NYCRR 182.5.

E = Endangered Species: any species which meet one of the following criteria:
1) Any native species in imminent danger of extirpation or extinction in New York.
2) Any species listed as endangered by the United States Department of the Interior, as enumerated in the Code of Federal Regulations 50 CFR 17.11.

T = Threatened Species: any species which meet one of the following criteria:
1) Any native species likely to become an endangered species within the foreseeable future in NY.
2) Any species listed as threatened by the U.S. Department of the Interior, as enumerated in the Code of the Federal Regulations 50 CFR 17.11.

SC = Special Concern Species: those species which are not yet recognized as endangered or threatened, but for which documented concern exists for their continued welfare in New York. Unlike the first two categories, species of special concern receive no additional legal protection under Environmental Conservation Law section 11-0535 (Endangered and Threatened Species).

P = Protected Wildlife (defined in Environmental Conservation Law section 11-0103): wild game, protected wild birds, and endangered species of wildlife.

U = Unprotected (defined in Environmental Conservation Law section 11-0103): the species may be taken at any time without limit; however a license to take may be required.

G = Game (defined in Environmental Conservation Law section 11-0103): any of a variety of big game or small game species as stated in the Environmental Conservation Law; many normally have an open season for at least part of the year, and are protected at other times.

NEW YORK STATE STATUS (plants): The following categories are defined in regulation 6NYCRR part 193.3 and apply to NYS Environmental Conservation Law section 9-1503.

(blank) = no state status

E = Endangered Species: listed species are those with:
1) 5 or fewer extant sites, or
2) fewer than 1,000 individuals, or
3) restricted to fewer than 4 U.S.G.S. 7 ½ minute topographical maps, or
4) species listed as endangered by U.S. Department of Interior, as enumerated in Code of Federal Regulations 50 CFR 17.11.

T = Threatened: listed species are those with:
1) 6 to fewer than 20 extant sites, or
2) 1,000 to fewer than 3,000 individuals, or
3) restricted to not less than 4 or more than 7 U.S.G.S. 7 and ½ minute topographical maps, or
4) listed as threatened by U.S. Department of Interior, as enumerated in Code of Federal Regulations 50 CFR 17.11.

R = Rare: listed species have:
1) 20 to 35 extant sites, or
2) 3,000 to 5,000 individuals statewide.

U = Unprotected

V = Exploitably vulnerable: listed species are likely to become threatened in the near future throughout all or a significant portion of their range within the state if causal factors continue unchecked.

NEW YORK STATE STATUS (communities): At this time there are no categories defined for communities.

continued on next page

Department of Energy
Brookhaven Group
Building 464
P.O. Box 5000
Upton, New York 11973

JUN - 1 1998

Ms. Sherry Morgan, Field Supervisor
U.S. Fish and Wildlife Service
3817 Luker Highway
Cortland, NY 13045

Dear Ms. Morgan:

SUBJECT: REQUEST FOR CONSULTATION UNDER SECTION 106 OF THE NATIONAL HISTORIC PRESERVATION ACT FOR THE PROPOSED SITING, CONSTRUCTION, AND OPERATION OF THE SPALLATION NEUTRON SOURCE

This letter is intended to serve as our request for informal consultation under Section 7 of the Endangered Species Act.

The U.S. Department of Energy (DOE) proposes to site, construct, and operate the Spallation Neutron Source (SNS) and is currently preparing an Environmental Impact Statement (EIS), pursuant to the National Environmental Policy Act (NEPA) on this federal action. The proposed SNS facility would consist of a proton accelerator system, a spallation target and appropriate experimental areas, laboratories, offices, and support facilities for neutron research. The EIS will include discussion of potential impacts at four alternative locations for the SNS, all DOE-owned laboratories: Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee; Argonne National Laboratory (ANL), Argonne, Illinois; Los Alamos National Laboratory (LANL), Los Alamos, New Mexico; and Brookhaven National Laboratory (BNL), Upton, New York.

The proposed SNS would produce short pulses of neutrons for use in materials and biomedical research. This would be accomplished through the "spallation" process wherein (1) subatomic particles, called protons, are accelerated to very high energies; (2) the high energy protons are "bunched" into a compact group; (3) the bunched, high energy protons are directed onto a target made of a high atomic number material, in this case mercury; and (4) the collision of the protons with the target produces a pulse of neutrons from the target material. The neutrons would then be slowed to useful energy levels, and guided to samples of the materials being studied. The interactions of the neutrons and the specimens would be measured and analyzed, revealing information on the structure, properties, and behavior of the test material.

Ms. S. Morgan - 2 - JUN - 1 1998

With regards to Brookhaven National Laboratory, the proposed location of the SNS at BNL is the central portion of the site, adjacent to the Relativistic Heavy Ion Collider (RHIC), (Site #1 on the enclosed site selection report). DOE requests an updated list of protected species and habitat on and in the vicinity of the proposed SNS site at BNL and solicits your recommendation and comments about the potential effects of this proposed action. Your input will be used in the preparation of the final environmental impact statement.

If you need further information on this request, please do not hesitate to call Jerry Granzen of my staff at (516) 344-4089.

Sincerely,

for

K. Dean Helms
Executive Manager

Enclosure:
As stated

cc: D. Bean, EAS, w/encl.
D. Wilfert, OR, w/encl.
M. Butler, BHG, w/encl.
K. Brog, BNL, w/encl.
M. Bebon, BNL, w/encl.
M. Schaffer, BNL, w/encl.
T. Sperry, BNL, w/encl.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
3817 LUKER ROAD
CORTLAND, NY 13045

June 15, 1998

Mr. K. Dean Helms
Executive Manager
Department of Energy
Brookhaven Group
Building 464, P.O. Box 5000
Upton, NY 11973

Attention: Mr. Jerry Granzen

Dear Mr. Helms:

This responds to your letter of June 1, 1998, requesting information on the presence of endangered or threatened species in the vicinity of the proposed Spallation Neutron Source at the Brookhaven National Laboratory in the Town of Brookhaven, Suffolk County, New York. The information will be used in the preparation of an environmental impact statement.

Except for occasional transient individuals, no Federally listed or proposed endangered or threatened species under our jurisdiction are known to exist in the project impact area. Therefore, no Biological Assessment or further Section 7 consultation under the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.) is required with the U.S. Fish and Wildlife Service (Service). Should project plans change, or if additional information on listed or proposed species becomes available, this determination may be reconsidered. A compilation of Federally listed and proposed endangered and threatened species in New York is enclosed for your information.

The above comments pertaining to endangered species under our jurisdiction are provided pursuant to the Endangered Species Act. This response does not preclude additional Service comments under the Fish and Wildlife Coordination Act or other legislation.

For additional information on fish and wildlife resources or State-listed species, we suggest you contact:

New York State Department
of Environmental Conservation
Region 1
Building 40, SUNY
Stony Brook, NY 11794
(516) 444-0200

New York State Department
of Environmental Conservation
Wildlife Resources Center - Information Serv.
New York Natural Heritage Program
700 Troy-Schenectady Road
Latham, NY 12110-2400
(518) 783-3932

National Wetlands Inventory (NWI) maps may or may not be available for the project area. However, while the NWI maps are reasonably accurate, they should not be used in lieu of field surveys for determining the presence of wetlands or delineating wetland boundaries for Federal regulatory purposes. Copies of specific NWI maps can be obtained from:

Cornell Institute for Resource Information Systems
302 Rice Hall
Cornell University
Ithaca, NY 14853
Telephone: (607) 255-4864

Work in certain waters and wetlands of the United States may require a permit from the U.S. Army Corps of Engineers (Corps). If a permit is required, in reviewing the application pursuant to the Fish and Wildlife Coordination Act, the Service may concur, with or without stipulations, or recommend denial of the permit depending upon the potential adverse impacts on fish and wildlife resources associated with project implementation. The need for a Corps permit may be determined by contacting Mr. Joseph Seebode, Chief, Regulatory Branch, U.S. Army Corps of Engineers, 26 Federal Plaza, New York, NY 10278 (telephone: [212] 264-3996).

If you require additional information please contact Michael Stoll at (607) 753-9334.

Sincerely,

Mark W. Clough
ACTING FOR

Sherry W. Morgan
Field Supervisor

Enclosure

cc: NYSDEC, Stony Brook, NY (Environmental Permits)
NYSDEC, Latham, NY
COE, New York, NY

2

FEDERALLY LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES IN NEW YORK

Common Name	Scientific Name	Status	Distribution
FISHES			
Sturgeon, shortnose*	*Acipenser brevirostrum*	E	Hudson River & other Atlantic coastal rivers
REPTILES			
Turtle, bog	*Clemmys muhlenbergii*	T	Albany, Columbia, Dutchess, Genesee, Orange, Oswego, Putnam, Seneca, Ulster, Wayne, and Westchester Counties
Turtle, green*	*Chelonia mydas*	T	Oceanic summer visitor coastal waters
Turtle, hawksbill*	*Eretmochelys imbricata*	E	Oceanic summer visitor coastal waters
Turtle, leatherback*	*Dermochelys coriacea*	E	Oceanic summer resident coastal waters
Turtle, loggerhead*	*Caretta caretta*	T	Oceanic summer resident coastal waters
Turtle, Atlantic ridley*	*Lepidochelys kempii*	E	Oceanic summer resident coastal waters
BIRDS			
Eagle, bald	*Haliaeetus leucocephalus*	T	Entire state
Falcon, peregrine	*Falco peregrinus*	E	Entire state - re-establishment to former breeding range in progress
Plover, piping	*Charadrius melodus*	E	Great Lakes Watershed
		T	Remainder of coastal New York
Tern, roseate	*Sterna dougallii dougallii*	E	Southeastern coastal portions of state
MAMMALS			
Bat, Indiana	*Myotis sodalis*	E	Entire state
Cougar, eastern	*Felis concolor couguar*	E	Entire state - probably extinct
Whale, blue*	*Balaenoptera musculus*	E	Oceanic
Whale, finback*	*Balaenoptera physalus*	E	Oceanic
Whale, humpback*	*Megaptera novaeangliae*	E	Oceanic
Whale, right*	*Eubalaena glacialis*	E	Oceanic
Whale, sei*	*Balaenoptera borealis*	E	Oceanic
Whale, sperm*	*Physeter catodon*	E	Oceanic
MOLLUSKS			
Snail, Chittenango ovate amber	*Succinea chittenangoensis*	T	Madison County
Mussel, dwarf wedge	*Alasmidonta heterodon*	E	Orange County - lower Neversink River

* Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service.

1 Region 5 - 11/04/97 - 2 pp.

FEDERALLY LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES IN NEW YORK (Cont'd)

Common Name	Scientific Name	Status	Distribution
BUTTERFLIES			
Butterfly, Karner blue	*Lycaeides melissa samuelis*	E	Albany, Saratoga, Warren, and Schenectady Counties
PLANTS			
Monkshood, northern wild	*Aconitum noveboracense*	T	Ulster, Sullivan, and Delaware Counties
Pogonia, small whorled	*Isotria medeoloides*	T	Entire state
Swamp pink	*Helonias bullata*	T	Staten Island - presumed extirpated
Gerardia, sandplain	*Agalinis acuta*	E	Nassau and Suffolk Counties
Fern, American hart's-tongue	*Asplenium scolopendrium* var. *americana*	T	Onondaga and Madison Counties
Orchid, eastern prairie fringed	*Platanthera leucophea*	T	Not relocated in New York
Bulrush, northeastern	*Scirpus ancistrochaetus*	E	Not relocated in New York
Roseroot, Leedy's	*Sedum integrifolium* ssp. *Leedyi*	T	West shore of Seneca Lake
Amaranth, seabeach	*Amaranthus pumilus*	T	Atlantic coastal plain beaches
Goldenrod, Houghton's	*Solidago houghtonii*	T	Genesee County

E=endangered T=threatened P=proposed

2 Region 5 - 11/04/97 - 2 pp.

Department of Energy
Brookhaven Group
Building 464
P.O. Box 5000
Upton, New York 11973

JUN - 1 1998

Mr. Julian Adams, Program Analyst
New York State Office of Parks, Recreation, and
Historic Preservation
Field Service Bureau
Peebles Island, P.O. Box 189
Waterford, New York 12188-0189

Dear Mr. Adams:

SUBJECT: REQUEST FOR CONSULTATION UNDER SECTION 106 OF THE NATIONAL HISTORIC PRESERVATION ACT FOR THE PROPOSED SITING, CONSTRUCTION, AND OPERATION OF THE SPALLATION NEUTRON SOURCE

This letter is intended to serve as our request for consultation under Section 106 of the National Historic Preservation Act (NHPA).

The U.S. Department of Energy (DOE) proposes to site, construct, and operate the Spallation Neutron Source (SNS) and is currently preparing an Environmental Impact Statement (EIS), pursuant to the National Environmental Policy Act (NEPA) on this federal action. The proposed SNS facility would consist of a proton accelerator system, a spallation target and appropriate experimental areas, laboratories, offices, and support facilities for neutron research. The EIS will include discussion of potential impacts at four alternative locations for the SNS, all DOE-owned laboratories: Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee; Argonne National Laboratory (ANL), Argonne, Illinois; Los Alamos National Laboratory (LANL), Los Alamos, New Mexico; and Brookhaven National Laboratory (BNL), Upton, New York.

The proposed SNS would produce short pulses of neutrons for use in materials and biomedical research. This would be accomplished through the "spallation" process wherein (1) subatomic particles, called protons, are accelerated to very high energies; (2) the high energy protons are "bunched" into a compact group; (3) the bunched, high energy protons are directed onto a target made of a high atomic number material, in this case mercury; and (4) the collision of the protons with the target produces a pulse of neutrons from the target material. The neutrons would then be slowed to useful energy levels, and guided to samples of the materials being studied. The interactions of the neutrons and the specimens would be measured and analyzed, revealing

JUN 1 1998

Mr. J. Adams - 2 -

information on the structure, properties, and behavior of the test material.

With regards to Brookhaven National Laboratory, the proposed location of the SNS at BNL is the central portion of the site, adjacent to the Relativistic Heavy Ion Collider (RHIC), (Site #1 on the enclosed site selection report).

We request that your office provide a determination of potential impacts to historic resources for the potential siting of SNS at Brookhaven National Laboratory. If you need further information on this request, please do not hesitate to call Jerry Granzen of my staff at (516) 344-4089.

Sincerely,

for

K. Dean Helms
Executive Manager

Enclosure:
As stated

cc: D. Bean, EAS, w/encl.
D. Wilfert, OR, w/encl.
M. Butler, BHG, w/encl.
K. Brog, BNL, w/encl.
M. Bebon, BNL, w/encl.
M. Schaffer, BNL, w/encl.
T. Sperry, BNL, w/encl.

APPENDIX D

ECOLOGICAL RESOURCE SURVEY

REPORTS AND SUMMARIES

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D. ECOLOGICAL RESOURCE SURVEY REPORTS AND SUMMARIES

The reports contained in this appendix provide additional details on the existing environment at the proposed sites for the SNS at Oak Ridge National Laboratory, Los Alamos National Laboratory, and Brookhaven National Laboratory. The preparers of this EIS sent a detailed request for information to each of the sites. As part of this request, each site was directed to conduct a surveillance level survey for federal- and state-protected species, wetlands, and cultural resources at the proposed SNS site. The results of these surveys, as well as information specific to each of the proposed sites, are presented in these reports.

No report from Argonne National Laboratory is included in this appendix. The information received from this laboratory was not in a format that could easily be included in the appendix. All of the pertinent information has been included in Chapter 4 of the DEIS.

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ECOLOGICAL RESOURCE SURVEYS FOR THE PROPOSED NATIONAL SPALLATION NEUTRON SOURCE SITE ON THE OAK RIDGE RESERVATION:

1. POTENTIAL HABITAT FOR FEDERAL AND STATE LISTED ANIMAL AND PLANT SPECIES
2. JURISDICTIONAL WETLANDS

22 April 1997

Prepared for:
Enterprise Advisory Services, Inc.

Prepared by:
JAYCOR
B. Rosensteel
D. Awl
J. Mitchell
L. Pounds

In Response to:
Contract No. PO 01-00110

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1.0 INTRODUCTION

Ecological resource surveys were conducted on and adjacent to the proposed site of the National Spallation Neutron Source (NSNS) on the Oak Ridge Reservation (ORR), Oak Ridge, Tennessee, by the staff of JAYCOR Environmental in March, August, and September, 1997. The ORR is managed by Lockheed Martin Energy Systems, Inc. for the U.S. Department of Energy (DOE). The site includes approximately 290 acres (117 ha) along Chestnut Ridge and is located in Roane and Anderson Counties in the Ridge and Valley Province of Tennessee.

The ecological surveys performed were:

1. Reconnaissance surveys for potential habitat of state- and/or federally-listed plant and animal species, and;

2. A survey for jurisdictional wetlands.

2.0 THREATENED AND ENDANGERED SPECIES

2.1 INTRODUCTION

The objectives of the plant and animal surveys were to determine the vegetation communities and types of habitat that exist on the proposed site for the NSNS and adjacent land, and to report potential habitat for state and federally protected terrestrial and aquatic species.

The federal Endangered Species Act of 1973 (ESA) requires that DOE consider the impacts of its actions on plant and animal species which are listed by the U.S. Fish and Wildlife Service (FWS) as threatened or endangered and on areas designated or proposed for designation as critical habitat. The FWS recommends that federal agencies also consider species that are candidates for listing during environmental planning since candidate species may eventually be listed. The National Environmental Policy Act also requires that federally-funded projects avoid or mitigate impacts to listed species.

Plant species listed by the Tennessee Department of Environment and Conservation are also provided limited protection by the Tennessee Rare Plant Protection and Conservation Act of 1985. This act protects listed plant species from removal or destruction without the consent of the landowner. DOE supports the protection of state-listed species on the ORR.

The Tennessee Wildlife Resources Agency lists fish and wildlife species which are threatened, endangered or in need-of-management in Tennessee. These species are protected by state laws and the knowing destruction of these animals and their habitat are prohibited.

For many protected species, the presence or absence of potential habitat can be easily determined. Other protected species, however, may not have overly strict or narrow habitat requirements or may use more than one habitat type and these species present a more challenging task when trying to identify potential habitat. In addition to this uncertainty is the fact that species do not always occur where there is suitable habitat. Thus, even though we have listed those species for which there appears to be suitable habitat on the site, the actual presence or absence of these species should be verified through systematic surveys prior to site development activities. Surveys for threatened and endangered species should be conducted during the proper sampling season to increase the probability of documenting species present.

2.2 T&E FISH AND WILDLIFE HABITAT EVALUATION METHODOLOGY

Existing data, aerial photos, forestry compartment maps and other information were reviewed to identify areas of potential habitat for state and federally protected (T&E) species. Field surveys were conducted during early September to identify habitats present and to consider areas as potential habitat for protected species. Surveys included the areas to be developed, access roads, corridors, streams, and property adjacent to the site.

After reviewing information on the site and conducting field surveys, potential habitat for state and federal species was delineated. Species considered were those with previous records on the ORR (Mitchell et al. 1996) and those species with distribution ranges that include the ORR. Habitats were divided into categories and species known to occur in these habitats were considered as potentially occurring on the site.

2.3 T&E FISH AND WILDLIFE RESULTS

The major habitat types on the site are upland forest and pine forest. Upland forest encompasses those areas with mixed deciduous trees located on well-drained sites. It has at least three strataX canopy, and understory or shrub layer, and ground cover. Canopy trees include tulip poplar (*Liriodendron tulipifera*), chestnut oak (*Quercus prinus*), white oak (*Quercus alba*), northern red oak (*Quercus rubra*), hickories (*Carya* spp.), and American beech (*Fagus grandifolia*) in varying combinations depending on slope and aspect. The understory and shrub layer contains sapling and pole sized trees of the canopy species, and flowering dogwood (*Cornus florida*). The ground cover consists of seedlings of canopy and understory species, ferns, and various herbaceous plants.

The pine forest habitat is composed of almost pure pine stands. The most predominant stands are those of planted loblolly pines (*Pinus taeda*). The trees are in rows, the canopy is closed, the substrate consists almost entirely of a thick mat of pine needles, and there is scarce understory, shrub layer, or ground cover vegetation. Small stands of white pine (*Pinus strobus*), shortleaf pine (*Pinus echinata*), and virginia pine (*Pinus virginiana*) were found on the site.

Other important habitat types exist on the area but represent a relatively small percentage of the total site area. These habitats include utility corridors, riparian forest, and wetland.

Important water resources were found on the site. Tributaries forming on the south side of the ridge and flowing into White Oak Creek may provide habitat for several species including the southeastern shrew, mole salamander and four-toed salamander. Seasonal pools and sinkholes have been documented on the site during current and previous surveys. Pools and sinkholes should be inventoried during late winter and early spring to verify presence or absence of T&E species.

Surveys were conducted for habitat of T&E fish. There appears to be no habitat suitable for those species which have been previously documented on the ORR or for other T&E fish known to occur in the region.
No suitable habitat was identified on or adjacent to the site for any federally listed T&E species. Suitable habitat was found for species listed as threatened or in-need-of-management by the State of Tennessee, or as federal species of concern. While in-need-of-management species are protected by state law, federal species of concern are not given formal protection by the Endangered Species Act. Nonetheless, it is wise to consider these species

during planning because they could be upgraded to threatened or endangered status in the future. If these species are eventually listed, it is important to consult with the FWS to determine impacts on these species. Systematic surveys of these potential habitat areas during the appropriate verification time-frames would be necessary to confirm the presence or absence of T&E species at specific locations on site.

Previous studies have provided some indication of which protected species may occur on the site (Mitchell et al. 1996). Table 2-1 provides a list of species which potentially occur on the site, their preferred habitat, and status. Suitable habitat was located for nine species listed by the State of Tennessee as in-need-of-management, one species listed as State Threatened, and one federally listed species of concern. Figure 2-1 illustrates the locations of potential habitat for each of these T&E species. Each T&E species with the potential to occur on the site is discussed below.

2.3.1 Sharp-shinned Hawk

The sharp-shinned hawk is considered an uncommon permanent resident on the ORR. This species may nest in woods bordered by open country and has been seen during the nesting season on the ORR (Mitchell et. al 1996). Powerline corridors on the site provide potential nesting habitat for this hawk. Summer records on the ORR were reported by Krumholz (1954) , Howell (1958), Hardy (1991), and Mitchell et al. (1996).

2.3.2 Cooper=s Hawk

The Cooper=s Hawk is also an uncommon permanent resident of the ORR. This species prefers mixed woodlands bordered by open country and has been observed during the nesting season in nearby areas. Powerline corridors on the site may provide suitable nesting habitat for this bird. Summer records were reported by Krumholz (1954) and Mitchell et al. (1996).

2.3.3 Cerulean Warbler

Although this bird is rare in the Ridge and Valley Province, it should be considered a possible nester in the area. There are no recent nesting records on the ORR. This bird prefers mature hardwood forests as is represented by some of the hardwood stands on Chestnut Ridge. Summer records were reported by Anderson and Shugart (1974) and Howell (1958). Mitchell et al. (1996) has reported spring and fall records for this species.

2.3.4 Grasshopper Sparrow

This species is an uncommon summer resident in the Ridge and Valley Province. This bird prefers areas of grassy fields and farmlands. Some areas along the powerline corridors within the NSNS boundary may provide suitable nesting habitat for this bird. Summer records have been reported on the ORR by Howell (1958) , Kroodsma (1987), and Mitchell et al. (1996).

Table 2-1. Protected vertebrate species with potential habitat on the NSNS site, their preferred habitats, and federal or state protection status.

Species	Habitat on NSNS and Status	Preferred Habitat
Sharp-shinned hawk country (*Accipter striatus*)	Power line corridors In Need-of-Management	Mixture of woods and open
Cooper=s hawk (*Accipiter cooperii*)	Powerline corridors In Need-of-Management	Mixed woods with openings
Cerulean Warbler (*Dendroica cerulea*)	Mature hardwood forest on ridgetop Federal Species of Concern	Mature hardwood forests
Grasshopper Sparrow (*Ammodramus savannarum*)	Powerline corridors In Need-of-Management	Grassy fields and farmlands
Yellow-bellied sapsucker (*Sphyrapicus varius*)	Possible in most areas except pine stands In Need-of-Management	Open deciduous woods
Rafinesque=s big-eared bat (*Plecotus rafinesquii*)	Abandoned building along C-17 Road In Need-of-Management	Unoccupied man-made structures and caves
Southeastern shrew (*Sorex longirostris*)	Pine plantations and tributaries In Need-of-Management	Pine woods and stream banks
Northern Pine Snake (*Pituophis m. melanoleucus*)	Ridgetops and powerline corridors State Threatened	Pine woods, dry ridges, and old fields
Eastern Slender Glass Lizard (*Ophisaurus attenuatus longicaudus*)	Ridgetops and powerline corridors In Need-of-Management	Dry upland areas, brushy cut-over woodlands
Mole salamander (*Ambystoma talpoideum*)	Depression with temporary pools In Need-of-Management	Moist low-lying woodland areas with ponds
Four-toed salamander (*Hemidactylium scutatum*)	Tributaries of White Oak Creek In Need-of-Management	Hardwood forest wetlands

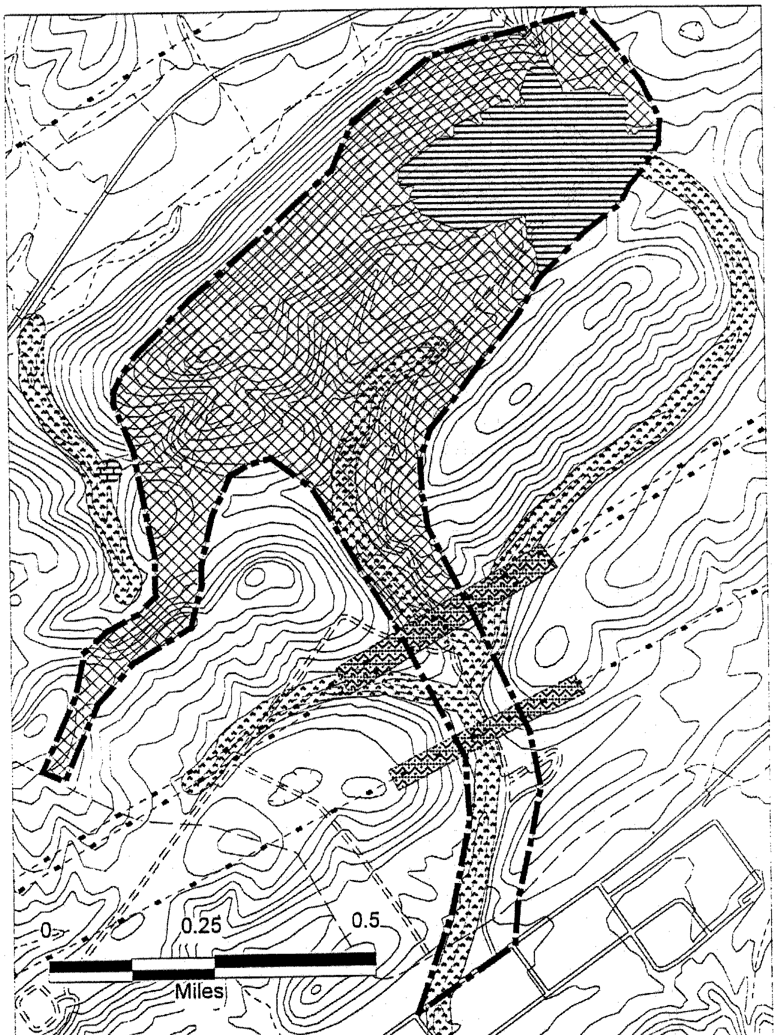

Fig.2-1. Potential habitat areas for T&E animal species within the proposed NSNS site.

Base Data:
ORNL Shared Data Initiative (SDI)

Map Composition:
September, 1997
D.Awl
JAYCOR Environmental

LEGEND

- ABANDONED HOUSE [Rafinesque's Big-eared Bat]
- DECIDUOUS WOODS/MIXED PINE HARDWOOD [Northern Pine Snake, Eastern Slender Gl
- PINES [Southeastern Shrew, Northern Pine Snake]
- POWERLINE RIGHT-OF-WAYS [Eastern Slender Glass Lizard, Northern Pine Snake, Shar
- WATER RESOURCES [Southeastern Shrew, Mole Salamander, Four-toed Salamander]
- NSNS Site Boundary

2.3.5 Yellow-bellied Sapsucker

This bird prefers open deciduous woods and is a common winter resident on the ORR. Suitable habitat for this species can be found throughout the site with the exception of pine woods. This species has been reported on the ORR previously by Krumholz (1954), Hardy (1991), and Mitchell et al. (1996).

2.3.6 Rafinesque=s Big-eared Bat

There are no current records for the big-eared bat on the ORR, however, the Reservation has not been thoroughly surveyed for bats. This bat prefers unoccupied man-made structures and caves for roosting. A old homesite is located on the C-17 road along the western boundary of the site. Although the building is not structurally intact, it does provide potential habitat for bats.

2.3.7 Southeastern Shrew

The southeastern shrew was found in many locations across the ORR by Mitchell et al. (1996). This shrew has been found in a variety of habitat types and may occur along spring branches or tributaries and along White Oak Creek on the site. Previous records for this species on the ORR were documented by Dunaway and Kaye (1961), Howell and Dunaway (1958), Smith (1976) and Mitchell et al. (1996).

2.3.8 Northern Pine Snake

The pine snake prefers sandy pine woods, dry mountain ridges and old field habitats. This species has not been documented on the ORR in recent years. However, records are difficult to obtain because of the burrowing nature of this animal. The Chestnut Ridge area along the ridge top and powerline right-of-way may provide suitable habitat for this species. This snake was documented on the ORR by Krumholz (1954).

2.3.9 Eastern Slender Glass Lizard

Currently their are no documented records for this species on the ORR. This species prefers dry upland areas and brushy cut-over woodland. The distribution range for this species includes the NSNS site and there may be suitable habitat for this species along the ridges and powerline corridors.

2.3.10 Mole Salamander

The mole salamander prefers areas of moist low-lying woodlands or wetland habitats. This species may occur on the NSNS site if the sinkhole and low-lying areas form semi-permanent pools in the winter months. This salamander has not been previously documented on the ORR.

2.3.11 Four-toed Salamander

This salamander prefers areas of hardwood forest wetland associated with sphagnum moss. However, this amphibian has been documented on the ORR in wet areas where sphagnum moss was not present (Mitchell et al.1996). This species may occur near tributary streams and along White Oak Creek.

2.4 T&E PLANT HABITAT EVALUATION METHODOLOGY

Most of the proposed NSNS site had not previously been surveyed for T&E plants, defined here as vascular plant species listed for protection by the Federal or the Tennessee State Government (Awl et al. 1996). On-site exploratory level surveys for potential T&E plant habitat at the proposed NSNS site were conducted March 11, 1997, by Deborah Awl, and August 28 and September 11 and 15, 1997, by Larry Pounds.

2.5 T&E PLANT RESULTS

The proposed NSNS site contains the following vegetation types and landscape elements associated with the occurrence of T&E plants on the ORR: deciduous forests, mixed deciduous and pine forests, over-mature/successional pine plantations, wetlands and stream bottoms, limestone outcrops, springs and seeps. The site encroaches on an Environmental Research Park designated Natural Area (NA52, Bear Creek Spring Area; Awl et al, 1996), and three TNC Preliminary Conservation Sites* (BSR2-10, BSR3-16, and Landscape Complex 1; TNC, 1995). Additionally, the forest area on the south-east facing slope of Chestnut Ridge drains toward ecologically sensitive streams and wetlands in NA55 (Chestnut Ridge Springs Area), ARA6 (Upper White Oak Creek), BSR3-22, and BSR4-3. This forest provides significant landscape connectivity between NA52 and NA55. Parts of this forest may be incorporated into NA55 due to its hydrologic relationship and the recently verified presence of T&E plants.

Ten T&E plant species were recognized as potentially occurring within the proposed NSNS site (Table 2-2). Two T&E plant speciesXPink ladys-slipper [*Cypripedium acaule*] and American ginseng [*Panax quinquifolius*]Xwere verified in three locations on site during this survey (fig.2-2). An additional species verified on site during previous surveys, *Carex howei*, was removed from protection status by the State of Tennessee in 1997. Of the remaining species potentially occurring on the site, two are classified as having high potential for occurrence, while the remaining six are classified as having low potential for occurrence. Systematic surveys of these potential habitat areas during the specified verification time-frames would be necessary to confirm the presence or absence of T&E species at specific locations on site.

Table 2-2. T&E Plant Species Potentially Occurring Within the Proposed NSNS Site.

Species	Common name	Habitat on ORR	Status*	Verification Time Frame	Potential for Occurrence Within the Proposed NSNS Site
Cypripedium acaule	Pink lady's-slipper	Dry to rich woods	E-CE	Apr.-July	Verified on site
Delphinum exaltatum	Tall larkspur	Barrens and woods	(C2), E	Aug.-Sept.	High
Fothergilla major	Mountain witchalder	Woods	T	Apr.-May	Low
Hydrastis canadensis	Golden seal	Rich woods	S-CE	April-July	Low
Juglans cinerea	Butternut	Slope near stream	(C2), T	no time frame	Low
Lilium canadense	Canada lily	Moist woods	T	June-July	High
Liparis loeselii	Fen orchis	Forested wetland	E	May-July	Low
Panax quinquifolius	Ginseng	Rich woods	S-CE	May-Oct.	Verified on site
Platanthera flava var. herbiola	Tuberculed rein-orchid	Forested wetland	T	May-Aug.	Low
Platanthera peramoena	Purple fringeless orchid	Wet meadow	T	July-Aug.	Low

*Status based on 1997 TN State List:

(C2) Special Concern, was listed under the formely used C2 candidate designation. More information needed to determine status.
E Endangered in Tennessee.
T Threatened in Tennessee.
S Special Concern in Tennessee.
-CE Status due to commercial exploitation

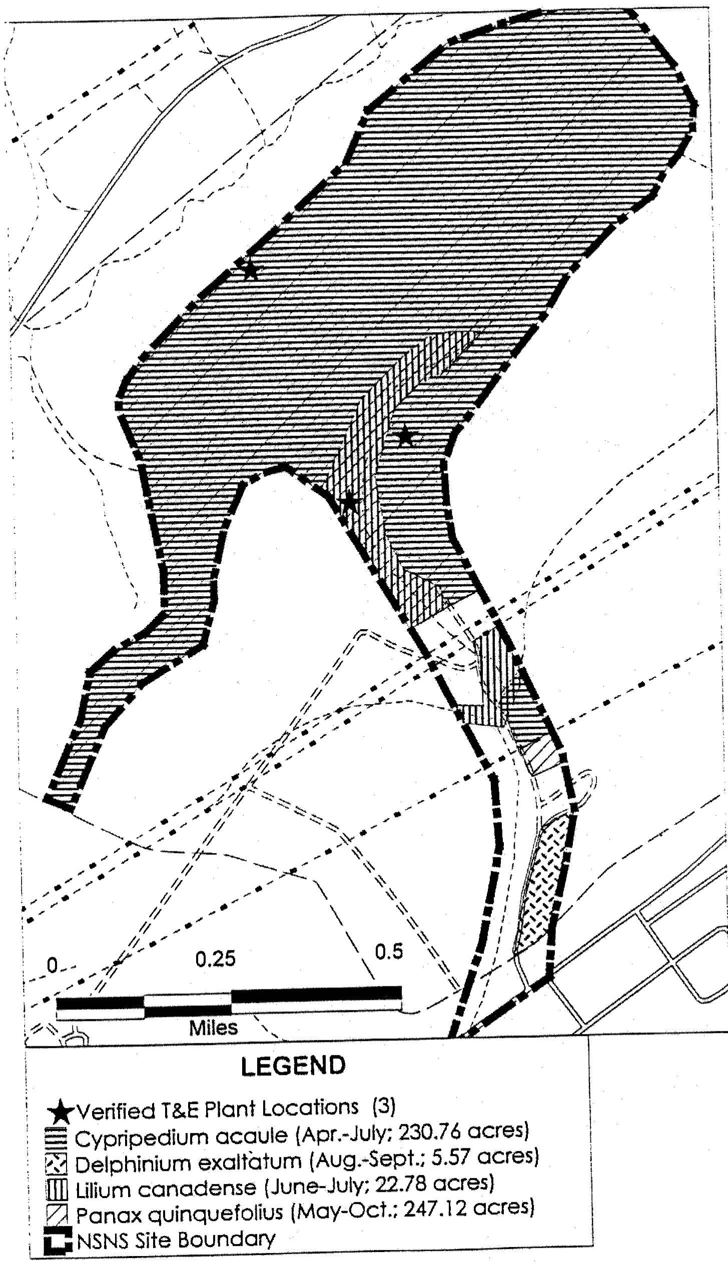

Fig. 2-2. T&E Plant locations and potential habitat areas within the proposed NSNS site.

Base Data:
ORNL Shared Data Initiative (SDI)

Map Composition:
September, 1997
D.Awl
JAYCOR Environmental

3.0 WETLAND SURVEY

Executive Order 11990, Protection of Wetlands dated May 24, 1977 requires federal agencies to avoid, to the extent possible, adverse impacts associated with the destruction and modification of wetlands and to avoid direct and indirect support of wetlands development wherever there is a practicable alternative. In accordance with U. S. Department of Energy (DOE) Regulations for Compliance with Floodplains/Wetlands Environmental Review Requirements (Subpart B, 10 CFR 1022.11), a survey was conducted in September 1997 to identify wetlands on the proposed site for the National Spallation Neutron Source (NSNS) on the Oak Ridge Reservation, Oak Ridge, Tennessee.

3.1 WETLAND IDENTIFICATION METHODOLOGY

3.1.1 The U. S. Army Corps of Engineers Wetland Delineation Methodology

As required by the Energy and Water Development Appropriations Act of 1992, wetlands are identified using the criteria and methods set forth in the Wetlands Delineation Manual [U.S. Army Corps of Engineers (USACE) 1987]. USACE defines wetlands as: "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."

The USACE lists three characteristics that are diagnostic of wetlands: (1.) The vegetation is characterized by a prevalence of macrophytes typically adapted to wetland soil and hydrological conditions; (2) the substrate is undrained hydric soil; and (3) the area is inundated either permanently or periodically at depths less than 2 m (6.6 ft.), or the soil is saturated to the surface at some time during the growing season of the prevalent vegetation.

3.1.1.1 Hydrophytic vegetation

USACE (1987) defines hydrophytic vegetation as "the sum total of macrophytic plant life that occurs in areas where the frequency and duration of inundation or soil saturation produce permanently or periodically saturated soils of sufficient duration to exert a controlling influence on the plant species present." The U.S. Fish and Wildlife Service (Reed 1988) has developed a classification system that assigns species to wetland indicator classes according to the frequency with which a species occurs in a wetland (Table 3-1). If more than 50% of the vegetation in each strata (i.e., canopy, sapling/shrub, vines, herbaceous) have an indicator status of obligate (OBL), facultative wetland (FACW), and/or facultative (FAC), the vegetation is classified as hydrophytic. A positive (+) or negative (-) sign following any of the facultative indicator categories indicates, respectively, a frequency toward the higher end of the category (more frequently found in wetlands) or the lower end of the category (less frequently found in wetlands).

Table 3-1. Plant indicator classifications and frequency of occurrence in wetlands

Classification	Occurrence in Wetlands(%)
Obligate Wetland	> 99
Facultative Wetland	67B99
Facultative	34B66
Facultative Upland	1B33
Upland	< 1

Source: P. B. Reed. 1988. National List of Plant Species That Occur in Wetlands: Tennessee. USFWS Biological Report NERC-88/18.42. U.S. Fish and Wildlife Service, Washington, D.C.

3.1.1.2 Hydric soils

Hydric soils are soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in a major part of the root zone. The following indicators are used to determine whether a given nonsandy soil meets the definition and criteria for hydric soils: The presence of organic soils, sulfidic material, aquic or peraquic moisture regime, iron and manganese concretions, and/or gleyed soil or a soil with a low chroma color and mottles.

Munsell Soil Color Charts (Kollmorgen Instrument Corp. 1992) are used to determine soil colors. The Munsell notation for color consists of separate notations for hue, value, and chroma. The hues are R (red), YR (yellow-red), and Y (yellow) and refer to the soil color in relation to the primary colors (red, yellow, and blue). The hues are further defined by the numbers 2.5, 5.0, 7.5, and 10 preceding the hue designation. The numbers indicate the gradation from red through yellow within each hue, with 2.5 being more red and 10 being more yellow. The value notation refers to the lightness of the hue, and ranges from 0 (absolute black) to 10 (absolute white). Chroma refers to the strength, or saturation, of the color, and ranges from 0 (neutral gray) to 8. In writing Munsell color notations, the sequence is always hue, value, and chroma. For instance, 10YR 5/2 indicates a soil on the yellow end of the yellow-red hue, with a value of 5 (mid-range) and a chroma of 2. Each Munsell notation corresponds to a color. For example, 10YR 5/2 is grayish-brown. Mineral hydric soils have one of the following features in the horizon immediately below the A-horizon, or between 0 and 25.6 cm (10 in.), whichever is shallower: 1) a matrix chroma of 2 or less in mottled soils or 2) a matrix chroma of 1 or less in unmottled soils.

3.1.1.3 Wetland hydrology

Of the three technical criteria, wetland hydrology is generally the least exact. Field indicators are useful for confirming wetland presence but are unreliable for delineating precise wetland boundaries. Indicators of wetland hydrology include recorded data (e.g., aerial photographs, soil surveys, floodplain delineations) and field evidence such as drainage patterns (surface scouring, absence of leaf litter, eroded soil, and drift lines), sediment deposition, watermarks, visual observation of either inundation or saturated soils or both, and oxidized rhizospheres.

3.2 WETLAND CLASSIFICATION

The wetlands identified in this survey were classified according to the system developed by Cowardin et al. (1979) for wetland and deepwater habitats of the United States. This hierarchical system describes wetlands and deepwater habitats by system, class, and subclass. Additional modifers are added for water regime, chemistry, soil, and disturbances. The systems are marine, estuarine, riverine, lacustrine, and palustrine. The marine and estuarine systems are oceanic and coastal and thus do not occur on ORR. The lacustrine and riverine systems encompass freshwater lakes and rivers/streams respectively. The palustrine system includes nontidal wetlands dominated by trees, shrubs, persistent emergents, and/or emergent mosses or lichens and includes vegetated wetlands traditionally called by such names as marsh, swamp, bog, fen, and pond.

The palustrine system includes five classes which are vegetated, and are thus considered as wetlands under the USACE definition (1987): (1) aquatic bed (dominated by submerged or floating plants), (2) mossBlichen, (3) emergent (dominated by herbaceous plants that rise above the water surface), (4) scrubBshrub (dominated by shrubs and saplings), and (5) forested. Subclasses of the vegetated classes indicate differences in vegetative form, such as broad-leaved or needle-leaved, deciduous or evergreen, and persistent (species that normally remain standing at least until the beginning of the next growing season) or nonpersistent (plants that fall to the surface of the substrate or below the surface of the water at the end of the growing season). Water regime modifiers include temporarily flooded (A); saturated (B); seasonally flooded (C); semi-permanently flooded (F), and permanently flooded (H).

3.3 FIELD SURVEY

Existing maps, reports, and other information sources were consulted to determine potential and known wetland locations (i.e., stream bottoms, floodplains, topographic depressions, other surface water features). The potential and known wetland locations were field surveyed on between September 5 and 18, 1997 by Barbara Rosensteel. The survey areas were:

1.) White Oak Creek bottomland from Bethel Valley Road to the head of the stream;
2.) White Oak Creek north tributary 2 (WONT2) from White Oak Creek to the site boundary;
3.) White Oak Creek north tributary 1 (WONT1): The entire stream bottom and subdrainages;
4.) Bear Creek south tributary 2 (BCST2): The stream bottom from Bear Creek Road to the head of the stream.

The wetland boundaries identified during this survey were not physically marked (i.e., with flagging or stakes) in the field and were not located by engineering (e.g., civil) survey or other ground location method (i.e., Global Positioning System). Therefore, the wetland boundaries are approximate and the areal sizes are estimates. The accuracy of the size estimates is limited by the large scale and 20-foot elevation contours of the site map available for wetland mapping.

3.4 FINDINGS AND DISCUSSION

3.4.1 Wetland Survey Findings

Eight wetland areas were identified in and near the boundary of the proposed NSNS site (Table 3-2). Five of the wetlands are in the White Oak Creek watershed and are fully or partially within the site boundary. Two wetland areas were identified in the upper reach of White Oak Creek upstream of the powerline ROW, which is outside of the site boundary. One wetland area is in the riparian zone of Bear Creek south tributary 4 which is downslope of the site boundary. The wetlands are shown in Figure 3-1. Data sheets which include vegetation, soils, and hydrology data for each of the wetlands are in Appendix 1.

Table 3-2. Jurisdictional wetlands identified on and adjacent to the proposed NSNS site

Wetland	Watershed	Estimated Area (acres)	Wetland Class	Within the proposed site boundary
WOM14	White Oak Creek	0.03	PEM1	YES
WOM15	White Oak Creek	0.09	PEM1F	YES
WOM16	White Oak Creek	1.60	PFO1C	YES
WOM17	White Oak Creek	0.15	PFO1C	NO
WOM18	White Oak Creek	<0.03	PEM1C	NO
WONT1-1	White Oak Creek	2.7	PFO1C	YES
WONT2-1	White Oak Creek	<0.01	PEM1	YES
BCST2-1	Bear Creek	0.35	PFO1C/PEM1C	NO

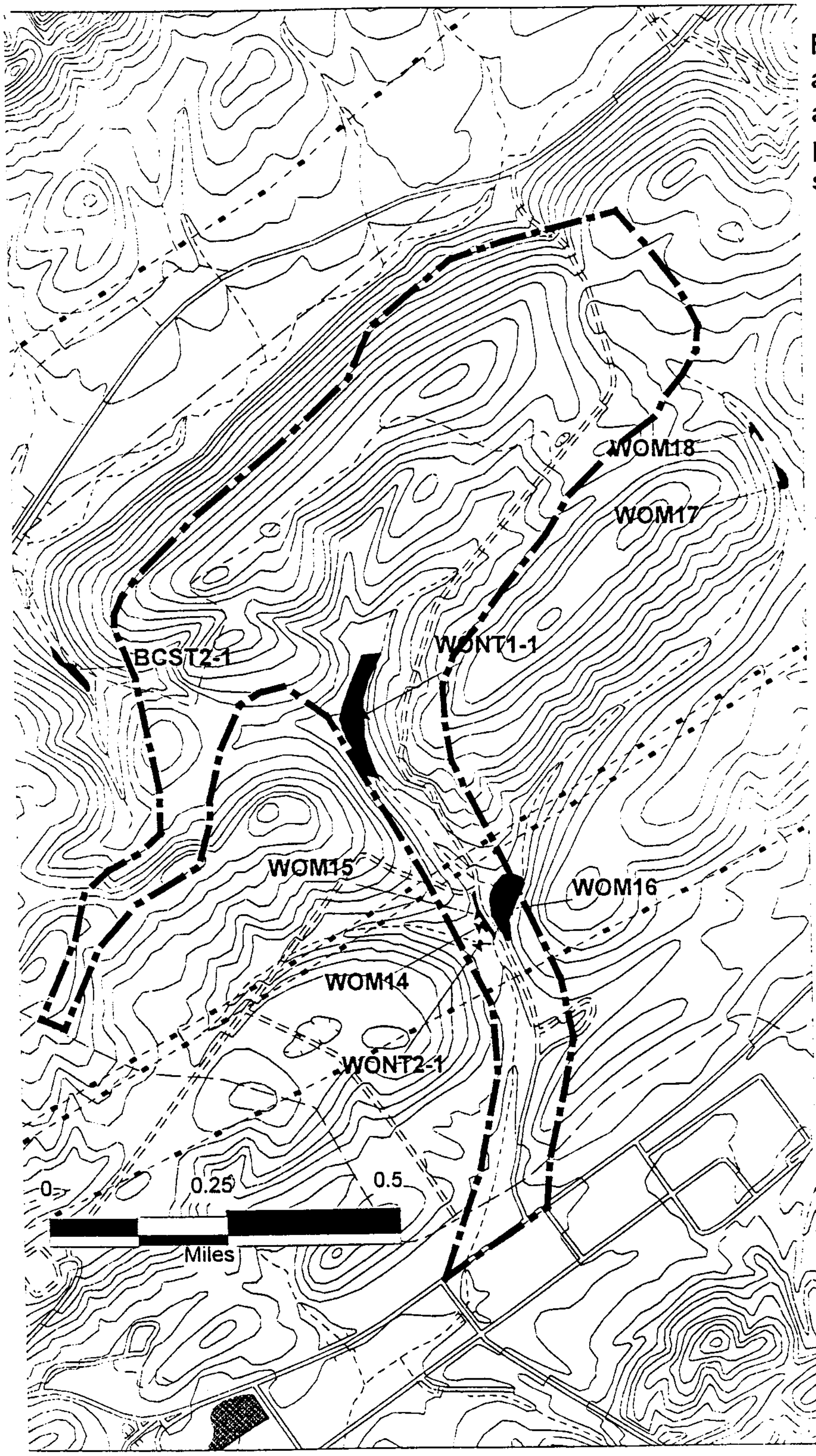

Fig.3-1. Wetland areas within and adjacent to the proposed NSNS site.

LEGEND

- Wetlands
- NSNS Site Boundary

Base Data:
ORNL Shared Data Initiative (SDI)

Map Composition:
September, 1997
D.Awl
JAYCOR Environmental

A small emergent wetland (WONT2-1) was identified along White Oak Creek north tributary 2. An old road, currently unused and overgrown, crosses the tributary near it=s confluence with White Oak Creek. The emergent wetland has developed in a low spot in the road where it crosses the stream (although a culvert is present at the crossing). Surface runoff and seasonal flood waters collect in and flow through the wetland area. Species in the wetland include smartweed (*Polygonum* sp.; OBL or FACW), false nettle (*Boehmeria cylindrica*; FACW), microstegium (*Microstegium vimineum*; FAC+), and sedges (*Carex* spp.; OBL or FACW). This wetland area is estimated to be less than 0.01 acre in size and appears to be fully within the site boundary.

An emergent wetland swale (WOM15) is immediately adjacent to Chestnut Ridge Road near the White Oak Creek crossing. The swale begins at a spring. The spring discharge flows through a swale on the side of the road and empties into White Oak Creek. Shrubs such as alder (*Alnus serrulata*; FACW+) and elderberry (*Sambucus canadensis*; FACW-) are growing along one side of the swale. The swale is vegetated with numerous OBL and FACW species including watercress (*Nasturtium officinale*; OBL), great lobelia (*Lobelia siphilitica*; OBL), cardinal flower (*Lobelia cardinalis*; OBL), turtlehead (*Chelone glabra*; OBL), smartweed (*Polygonum* sp.; OBL or FACW), and sedges (*Carex* spp.; OBL). The estimated size of the wetland is less than 0.1 acre. It is fully within the site boundary.

An emergent wetland (WOM14) was identified in an isolated depression. The depression is adjacent to the wetland swale (WOM15), but is separated from it by a vegetated berm. The berm may have been made during road construction. The depression does not appear to have a surface outlet to the swale or to White Oak Creek. There was no water in the depression on the day of the survey, but it is likely that it holds precipitation and surface runoff during the winter and spring and during periods of rain in the summer. The soil had hydric characteristics. Species included a fescue (*Festuca arundinaceae*), false nettle (*Boehmeria cylindrica*; FACW), smartweed, Frank=s sedge (*Carex frankii*; OBL), and other sedges. The estimated size of this wetland area is less than 0.03 acre. This wetland is fully within the site boundary.

A forested wetland (WOM16) was identified in a seep area along White Oak Creek immediately adjacent to the east side of Chestnut Ridge Road. This wetland area had initially been designated a Research Park Reference Area, but is now within Research Park Natural Area 55. *Carex leptalea* and *Bartonia paniculatum*, two species that are uncommon in east Tennessee, occur in this wetland. Dominant or common plant species in this wetland include sycamore (*Platanus occidentalis*; FACW-), red maple (*Acer rubrum*; FAC), green ash (*Fraxinus pennsylvanica*; FACW), spicebush (*Lindera benzoin*; FACW), microstegium, false nettle, cardinal flower, bugleweed (*Lycopus virginicus*; OBL), smartweed, and hog peanut (*Amphicarpa bracteata*; FAC). The estimated size of this wetland is 1.6 acres. Most or all of this wetland is within the site boundary

A forested wetland (WOM17) and a small, fringe, emergent wetland (WOM18) were identified in the upper reach of White Oak Creek. The forested wetland occurs in a seep area that appears to contribute a significant portion of the baseflow of upper White Oak Creek during this time of year. The stream channel was dry upstream from the ROW for about half the length of this portion of the stream. Upstream of this dry reach, there was flowing water that was contributed by springs and seeps along this part of the stream bottom. The stream channel was once again dry in the uppermost reach a short distance upstream of WOM18. Water levels in these headwater streams would be expected to be at or near their lowest level at this time of year. At other times of year, the entire stream channel would be expected to have flowing water.

The dominant vegetation species in WOM17 included sweetgum, red maple, ironwood, smartweed (*Polygonum punctatum*;), cardinal flower, microstegium, false nettle, and poison ivy (*Toxicodendron radicans*; FAC). The area was saturated and there was flowing water in surface channels. The approximate size of this wetland area is around 0.10 acre. This wetland is outside of the site boundary.

WOM18 consists of a narrow fringe (2' -3' wide) of emergent wetlands on the edge of the stream channel. This section of stream contained flowing water. Dominant species included microstegium, cardinal flower, smartweed, bugleweed, and sensitive fern (*Onoclea sensibilis*; FACW). The approximate size is less than 0.01 acre.

A forested wetland (WONT1-1) is located in the riparian zone of White Oak Creek north tributary 1 (WONT1). This tributary drainage is in Natural Area 55. The tributary is located in a forested drainage on the west side of Chestnut Ridge Road north of the powerline right-of-way (ROW). The stream crosses the powerline, flows through a culvert under Chestnut Ridge Road, and empties into White Oak Creek in the WOM16 wetland area south of the powerline ROW. The wetland is located along the middle reach of the stream. The size of the wetland area is roughly 2.5 acres. This wetland area is fully within the site boundary.

The primary water source for this wetland is groundwater in the form of perennial seeps and a seasonal high water table. Overbank flooding is a seasonal, but not a sustaining, source of water. Dominant species include sycamore, red maple, sweetgum (*Liquidambar styriciflua*; FAC), green ash, bugleweed, cardinal flower, and cinnamon fern (*Osmunda cinnamomea*; FACW). At a perennial seep which spread out over a wide area, the dominant species included smartweed, watercress, bugleweed, cutgrass (*Leersia oryzoides*; OBL), leathery rush (*Juncus coriaceous*; FACW), avens (*Geum* sp.; FACW- or FAC), and sticktights (*Bidens* sp.; OBL or FACW).

In the riparian zone of Bear Creek south tributary 4 are three small areas of forested wetlands and emergent wetlands at streamside seeps. These three areas are close together along the stream and were combined into one wetland area (BCST2-1)for purposes of mapping and description. The approximate size of the wetland area is 0.3 acre. It is downslope of, but not within, the site boundary. Dominant species include green ash, red maple, spicebush, microstegium, poison ivy, woodreed (*Cinna arundinacea*; FACW), and Virginia knotweed (*Tovara virginiana*; FAC).

3.4.2 Functional Assessment

The following section provides a brief description of the wetland functions that could be performed by the onsite wetlands. A qualititative assessment of these functions in the onsite wetlands was based on best professional judgement. A thorough wetland functional assessment is outside of the scope of the current work.

Wetland functions are physical, chemical, and biological processes or attributes of wetlands that are vital to the integrity of the wetland system (Adamus et al. 1991). Wetland functions include groundwater recharge and discharge, floodflow alteration, sediment stabilization, nutrient removal and transformation, sediment and toxicant retention, production export, and provision of wildlife and aquatic species habitat. Not all functions will be performed in every wetland. The factors that affect the performance of wetland functions are numerous and include geographic and topographic location; wetland position in the watershed; and physical, chemical, and biological characteristics of the wetland.

Wetland functions, as described by Adamus et al. (1991), include the following ones that could be present in headwater wetlands:

<u>Floodflow Alteration</u> - Floodflow alteration is the process by which peak flows from runoff, surface flow, groundwater interflow and discharge, and precipitation enter a wetland and are stored or delayed from their downstream movement. In order to provide effective storage, a wetland must not be filled to capacity with surface water. However, in developed watersheds, in the lower reaches of watersheds, and in watersheds with little wetland acreage, many wetlands become quickly saturated and filled to capacity (Adamus et al. 1991). The wetlands in the headwater areas on the site probably have limited influence on peak flows downstream because of their limited water storage capacity and small size in relation to the drainage area.

<u>Nutrient Removal and Transformation</u> - Nutrient removal and transformation includes the storage of nutrients (primarily macronutrients nitrogen and phosphorus) within the sediment or plant substrate, the transformation of inorganic nutrients to their organic forms, and the transformation and removal of nitrogen (Adamus et al. 1991).

The nitrogen and phosphorus loadings to the wetlands in undeveloped, forested headwater areas and other areas upstream of human activities would tend to be low; thus the opportunity for nutrient removal would be limited in the onsite wetlands. Nutrient transformation, such as denitrification of nitrogen introduced in groundwater and precipitation and conversion into organic forms, probably occurs to some degree in most of the wetlands onsite.

<u>Sediment and Toxicant Retention</u> - Sediment and toxicant retention is the process by which suspended solids and adsorbed contaminants are retained and deposited in a wetland. Toxicants can include heavy metals, radionuclides, pesticides, and other toxic organics (i.e., solvents and polychlorinated biphenyls). Toxicant retention is associated with sediment retention because many toxicants adsorb to solids and thus will be removed from the water column when the solids settle out. In the wetland, the toxicants can be permanently or temporarily sequestered in the sediments and in plant tissue, transferred to the atmosphere through volatilization, biochemically transformed to intermediate compounds that are less or more toxic than the parent compound, or completely mineralized to carbon dioxide and water. Sediments and associated toxicants can also be resuspended and exported from the wetland in subsequent flooding events (Adamus et al. 1991).

Because of their position in a relatively undisturbed forested headwater area, the opportunity for the sediment and toxicant reduction function to be expressed in the onsite wetlands is small. The value of this function, if it occurs, may be greatest in wetlands WOM16, WONT1-1, and BCST2-1 because of larger area and greater capacity (relative to the other onsite wetlands) for longer-term water retention and sediment settling.

Production Export - Production export refers to the flushing of organic material from the wetland to downstream or adjacent waters. Another mechanism of production export is insect emergence and consumption by vertebrates that travel out of the wetland.

The production export function may be a significant in the onsite wetlands and to the downstream aquatic system. Visual observations of the wetland and floodplain areas and the adjacent upland areas suggest that primary productivity in the shrub and herbaceous strata is greater in the wetlands, but it is not known if this translates into high production export from the sites.

Wildlife Diversity - Wildlife diversity is defined as Athe support of a notably great on-site diversity and abundance of wetland-dependent birds≅ (Adamus et al. 1991). However, the focus on birds should not imply that other wildlife species, such as many furbearers (mink), other mammals (e.g., shrews), many amphibians, and some reptiles (e.g., bog turtles, water snakes), are any less important or dependent on wetlands. Therefore, wildlife diversity includes all wildlife species that are wetland-dependent or that may use wetlands on a daily, seasonal, or intermittent basis. Wildlife species present on the ORR that use wetlands include raccoons, mink, beaver, turtles, salamanders, frogs, and bird species such as the Lousiana waterthrush.

Functions provided by the wetlands found in and adjacent to the proposed NSNS site include the provision of wildlife habitat, including amphibian breeding habitat, nutrient transformation, and organic material production and export. These areas also provide plant species diversity by supporting numerous plant species that will only grow in saturated conditions. These species include great lobelia, cardinal flower, turtlehead, smartweeds, cinnamon fern, some species of orchids, and various sedges.

4.0 SUMMARY

Ecological resource surveys were conducted on the proposed site of the National Spallation Neutron Source (NSNS) on the Oak Ridge Reservation (ORR), Oak Ridge, Tennessee, by the staff of JAYCOR Environmental in March, August, and September 1997. Reconnaissance surveys for potential habitat of state- and/or federally-listed plant and animal species, and surveys for jurisdictional wetlands were conducted.

Suitable habitat was located for nine animal species listed by the State of Tennessee as in-need-of-management, one species listed as State Threatened, and one federally listed species of concern. There appears to be no habitat suitable for any fish species that have been previously documented on the ORR or for other T&E fish known to occur in the region.

The actual presence or absence of the species for which potential habitat was found should be verified through scientific surveys prior to site development activities. Surveys for threatened and endangered species should be conducted during the proper sampling season to increase the probability of documenting animals present.

On-site exploratory level surveys for potential T&E plant habitat at the proposed NSNS site were conducted in March, August, and September 1997. Ten T&E plant species were recognized as potentially occurring within the proposed NSNS site. Two T&E plant speciesXpink ladys-slipper [*Cypripedium acaule*] and American ginseng [*Panax quinquifolius*]X were verified on site during this survey. Systematic surveys of these potential habitat areas during the specified verification time-frames would be necessary to confirm the presence or absence of T&E species at specific locations on site.

The site encroaches on an Environmental Research Park designated Natural Area (NA52) and three TNC Preliminary Conservation Sites* (BSR2-10, BSR3-16, and Landscape Complex 1). The forest area on the south-east facing slope of Chestnut Ridge drains toward ecologically sensitive streams and wetlands in NA55 (Chestnut Ridge Springs Area), ARA6 (Upper White Oak Creek), BSR3-22, and BSR4-3.

A wetland survey was conducted in September 1997. Jurisdictional wetlands were identified following the U.S. Army Corps of Engineers criteria. A total of eight wetlands were identified in (5 wetlands) and adjacent to (three wetlands) the site. The estimated size of the wetlands ranges from <0.01 acre to 2.7 acres. The functions that are likely to be performed by the onsite wetlands include nutrient transformation, production and export of organic material, production of invertebrates, and wildlife habitat, as well as providing plant species diversity.

Within the site boundary, one forested wetland (WOM16), an emergent wetland in a spring-fed swale (WOM15), and a small emergent wetland area in an isolated depression (WOM14) are adjacent to Chestnut Ridge Road at the White Oak Creek crossing. A small emergent wetland (WONT2-1) is in a low elevation area in an old road bed that crosses White Oak Creek north tributary 2. A forested wetland (WONT1-1) is located in the middle reach of White Oak north tributary 1 which is in the drainage to the west of Chestnut Ridge Road. Outside of the site boundary, a forested wetland (WOM17) and a fringe, emergent wetland (WOM18) were identified in the upper reach of White Oak Creek. An area of forested wetland and emergent wetland at streamside seeps was identified in the bottomland of Bear Creek south tributary 2 outside of the site boundary.

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APPENDIX 1:

WETLAND FIELD DATA SHEETS

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Wetland Delineation Data Sheet

Project site: Proposed site for National Spallation Neutron Source on the Oak Ridge Reservation

State: TN **County: Roane / Anderson** **Date: 5 Sept 1997**
Wetland ID: WOM14 **Wetland Class: PEM1A**
Description: Emergent wetland in a depression in a prior disturbed area

VEGETATION Dominant Species: Trees and shrubs	**Indicator Status**	**Dominant Species: Herbaceous**	**Indicator Status**
None		*Festuca arundinacea*	FAC-
		Boehmeria cylindrica	FACW
		Carex frankii	OBL
		Eupatorium fistulosum	FAC+
		Eupatorium coelestinum	FAC
		Sedges	OBL, FACW, or FAC

% of species that are OBL, FACW, and/or FAC: 100
Hydrophytic Vegetation: YES

SOILS Matrix	**Mottles**	**Texture/Other**
10YR 5/1	7.5YR 4/6	sandy silt loam / mottles are few and faint

Hydric Soils: YES
Basis: Matrix chroma and presence of mottles

HYDROLOGY
Inundated: NO **Depth to standing water: None**
Saturated: YES **Depth to saturated soil: Surface**
Other indicators: Patches of bare soil indicating ponded water

Wetland Hydrology: YES
Basis: Evidence of ponding; Moist soil following several weeks without significant rainfall

Atypical Situation: NO
Normal Circumstances: Possibly a manmade situation

Wetland Determination: **Wetland: YES** **Nonwetland**

Comments:
The depression in which the wetland occurs is separated from Chestnut Ridge Road and the wetland swale / spring by a vegetated berm that appears to be manmade. The depression does not have a surface outlet for water.

Determined by: B. A. Rosensteel, PWS, JAYCOR

Wetland Delineation Data Sheet

Project site: Proposed site for National Spallation Neutron Source on the Oak Ridge Reservation
State: TN **County: Roane / Anderson** **Date: 5 Sept 1997**
Wetland ID: WOM15 **Wetland Class: PEM1F**
Description: Emergent wetland in a spring run channel along Chestnut Ridge Road

VEGETATION Dominant Species: Trees and shrubs	**Indicator Status**	**Dominant Species: Herbaceous**	**Indicator Status**
Alnus serrulata	FACW	*Nasturtium officinale*	OBL
Sambucus canadensis	FACW-	*Lobelia siphilitica*	OBL
		Chelone glabra	OBL
		Carex lurida	OBL
		Mentha piperita	FACW
		Carex vulpinoidea	OBL
		Polygonum sp.	OBL or FACW
		Eupatorium fistulosum	FAC+
		Vernonia sp.	Depends on species

% of species that are OBL, FACW, and/or FAC: 100
Hydrophytic Vegetation: YES

SOILS Matrix	**Mottles**	**Texture/Other**
10YR 4/1		Stony, silty sand
10YR 5/1		Silty clay

Hydric Soils: YES
Basis: Matrix chroma

HYDROLOGY
Inundated: YES **Depth to standing water: 4" in boring on bank of swale**
Saturated: YES **Water in spring run channel was 2"+ deep**
Depth to saturated soil: At surface
Other indicators: Water was flowing through the swale from a perennial spring
Wetland Hydrology: YES

Atypical Situation: NO
Normal Circumstances: YES

Wetland Determination: **Wetland: YES** **Nonwetland**

Comments: This wetland should not be confused with a roadside runoff ditch, although it probably does carry storm runoff. The water source is a perennial spring.

Determined by: B. A. Rosensteel, PWS, JAYCOR

Wetland Delineation Data Sheet

Project site: Proposed site for National Spallation Neutron Source on the Oak Ridge Reservation
State: TN **County: Roane / Anderson** **Date: 5 Sept 1997**
Wetland ID: WOM16 **Wetland Class: PFO1C**
Description: Forested wetland along White Oak Creek on upstream side of Chestnut Ridge Road

VEGETATION Dominant Species: Trees and shrubs	**Indicator Status**	**Dominant Species: Herbaceous**	**Indicator Status**
Platanus occidentalis	FACW-	*Microstegium vimineum*	FAC+
Acer rubrum	FAC	*Boehmeria cylindrica*	FACW
Fraxinus pennsylvanica	FACW	*Lobelia cardinalis*	OBL
Alnus serrulata	FACW	*Lycopus virginicus*	OBL
		Polygonum sp.	OBL or FACW
		Leersia oryzoides	OBL
		Amphicarpa bracteata	FAC
		Juncus coriaceous	FACW
		Carex spp.	OBL or FACW

% of species that are OBL, FACW, and/or FAC: 100
Hydrophytic Vegetation: YES

SOILS Matrix	**Mottles**	**Texture/Other**
1.) 5/N	10YR 3/3	Stony, sandy silt loam - Saturated
2.) 10YR 5/1		Gravelly silt loam - Dry
3.) 10YR 5/1	7.5YR 4/6	Sandy silt loam - Saturated

Hydric Soils: YES
Basis: Matrix chroma and mottles

HYDROLOGY
Inundated: NO
Saturated: YES, except at outer edges
Other indicators: Presence of seeps
Depth to standing water: 12-13"
Depth to saturated soil: At surface except at the outer edges of the wetland.

Wetland Hydrology: YES

Atypical Situation: NO
Normal Circumstances: YES

Wetland Determination: **Wetland: YES** **Nonwetland**

Comments:

Determined by: B. A. Rosensteel, PWS, JAYCOR

Wetland Delineation Data Sheet

Project site: Proposed site for National Spallation Neutron Source on the Oak Ridge Reservation
State: TN **County: Roane / Anderson** **Date: 5 Sept 1997**
Wetland ID: WONT2-1
Wetland Class: PEM1
Description: Emergent wetland in an old road bed where the tributary stream crosses

VEGETATION Dominant Species: Trees and shrubs	**Indicator Status**	**Dominant Species: Herbaceous**	**Indicator Status**
None		*Microstegium vimineum*	FAC+
		Boehmeria cylindrica	FACW
		Polygonum sp.	OBL or FACW
		Geum sp.	FACW- or FAC
		Carex spp.	OBL or FACW

% of species that are OBL, FACW, and/or FAC: 100
Hydrophytic Vegetation: YES

SOILS Matrix	**Mottles**	**Texture/Other**

Unable to obtain a soil sample with the hand-held soil auger because the substrate primarily consists of the former compacted, gravel roadbed.

Hydric Soils: Inconclusive
Basis:

HYDROLOGY
Inundated: NO **Depth to standing water:**
Saturated: YES **Depth to saturated soil:**
Other indicators: Surface flow channels

Wetland Hydrology: YES

Atypical Situation: YES.
Normal Circumstances:

Wetland Determination: **Wetland: YES** **Nonwetland**

Comments: If soil has hydric characteristics, it would not be an atypical situation because all three criteria would be met. The wetland may have developed as a result of past development.

Determined by: B. A. Rosensteel, PWS, JAYCOR

Wetland Delineation Data Sheet

Project site: Proposed site for National Spallation Neutron Source on the Oak Ridge Reservation
State: TN | **County: Roane / Anderson** | **Date: 5 Sept 1997**
Wetland ID: WONT1-1 | **Wetland Class: PFO1C**
Description: Forested wetland in an area of seeps. One seep area is dominated by herbaceous species

VEGETATION Dominant Species: Trees and shrubs	**Indicator Status**	**Dominant Species: Herbaceous**	**Indicator Status**
Liquidambar styriciflua	FAC+	*Microstegium vimineum*	FAC+
Acer rubrum	FAC	*Cinna arundinacea*	FACW
Alnus serrulata	FACW+	*Lobelia cardinalis*	OBL
Lindera benzoin	FACW	*Toxicodendron radicans*	FAC
		Nasturtium officinale	OBL
Herbaceous		*Juncus coriaceous*	FACW
Geum sp.	FACW- or FAC	*Lycopus virginicus*	OBL
Osmunda cinnamomea	FACW+	*Bidens* sp.	OBL, FACW or FAC
		Leersia oryzoides	OBL

% of species that are OBL, FACW, and/or FAC: 100
Hydrophytic Vegetation: YES

SOILS Matrix	**Mottles**	**Texture/Other**
10YR 6/2	7.5YR 5/8	Silt loam

In flowing seep area, the substrate is a very stony, gravelly, sand. In one sample: 3" of an organic silty sand underlain by a gray silty sand with dark brown/ black organic streaking.

Hydric Soils: YES
Basis: Matrix chroma and mottles; Sandy layer with organic streaking; Inundation in seep areas

HYDROLOGY
Inundated: YES (in seep areas)
Saturated: YES (in seep areas)
Other indicators: surface flow features
Depth to standing water: Above surface in seep areas; no water in soil borings at upstream edges of wetland area
Depth to saturation: At surface in seep areas; soil is dry in some upstream and outer edges of wetland

Wetland Hydrology: YES

Atypical Situation:
Normal Circumstances: YES

Wetland Determination: **Wetland: YES** **Nonwetland**

Comments: The areas near the wetland margins and in upstream sections had soils with hydric characteristics, but there was no saturation of the soils on the day of the survey. This is not unexpected during the dry season when there had been no significant rainfall for several weeks.

Determined by: B. A. Rosensteel, PWS, JAYCOR

Wetland Delineation Data Sheet

Project site: Proposed site for National Spallation Neutron Source on the Oak Ridge Reservation
State: TN **County: Roane / Anderson** **Date: 16 Sept 1997**
Wetland ID: BCST2-1 **Wetland Class: PFO1C; PEM1C**
Description: An area of forested wetland and small emergent wetlands at seeps

VEGETATION Dominant Species: Trees and shrubs	**Indicator Status**	**Dominant Species: Herbaceous**	**Indicator Status**
Fraxinus pennsylvanica	FACW	*Microstegium vimineum*	FAC+
Acer rubrum	FAC	*Lycopus virginicus*	OBL
Liquidambar styriciflua	FAC+	*Tovara virgininana*	FAC
Carpinus caroliniana	FAC	*Cinna arundinacea*	FACW
Lindera benzoin	FACW	*Cryptotaenia canadensis*	FAC+
		Lobelia cardinalis	OBL
		Toxicodendron radicans	FAC

% of species that are OBL, FACW, and/or FAC: 100
Hydrophytic Vegetation: YES

SOILS Matrix	**Mottles**	**Texture/Other**
10YR 6/1	7.5YR 4/6 and 4/4	Silt loam / Manganese concretions

Hydric Soils: YES

Basis: Matrix chroma and mottles

HYDROLOGY
Inundated: In some areas **Depth to standing water: At or near surface near stream channel; None in riparian zone.**
Saturated: Yes
Other indicators: ____________ **Depth to saturated soil: At surface ____________**

Wetland Hydrology: YES

Atypical Situation:
Normal Circumstances: YES

Wetland Determination: **Wetland: YES** **Nonwetland**

Comments: Area subject to flooding. Parts of the wetland that occur on alluvial deposits in the stream were inundated on the day of the survey. The remainder of area was not inundated, but soils were saturated.

Determined by: B. A. Rosensteel, PWS, JAYCOR

Wetland Delineation Data Sheet

Project site: Proposed site for National Spallation Neutron Source on the Oak Ridge Reservation
State: TN **County: Roane / Anderson** **Date: 18 Sept 1997**
Wetland ID: WOM17 **Wetland Class: PFO1C**
Description: A seep area in a forested riparian zone

VEGETATION **Dominant Species: Trees and shrubs**	**Indicator Status**	**Dominant Species: Herbaceous**	**Indicator Status**
Acer rubrum	FAC	*Microstegium vimineum*	FAC+
Liquidambar styriciflua	FAC+	*Lycopus virginicus*	OBL
Carpinus caroliniana	FAC	*Lobelia cardinalis*	OBL
		Toxicodendron radicans	FAC
		Polygonum sp.	OBL or FACW
		Boehmeria cylindrica	FACW

% of species that are OBL, FACW, and/or FAC: 100
Hydrophytic Vegetation: YES

SOILS **Matrix**	**Mottles**	**Texture/Other**
10YR 5/1	7.5YR 4/6 and 4/4	Gravelly silt loam

Hydric Soils: YES
Basis: Matrix chroma and mottles

HYDROLOGY
Inundated: In some areas **Depth to standing water: not recorded**
Saturated: Yes **Depth to saturated soil: At surface**
Other indicators: ______________________________

Wetland Hydrology: YES

Atypical Situation:
Normal Circumstances: YES

Wetland Determination:	**Wetland: YES**	**Nonwetland**

Comments: Area subject to flooding. Parts of the wetland that occur on alluvial deposits in the stream were inundated on the day of the survey. The remainder of area was not inundated, but soils were saturated.

Determined by: B. A. Rosensteel, PWS, JAYCOR

Wetland Delineation Data Sheet

Project site: Proposed site for National Spallation Neutron Source on the Oak Ridge Reservation
State: TN **County: Roane / Anderson** **Date: 18 Sept 1997**
Wetland ID: WOM18 **Wetland Class: PEM1C**
Description: Emergent wetland in a narrow band on edge of stream channel

VEGETATION Dominant Species: Trees and shrubs	**Indicator Status**	**Dominant Species: Herbaceous**	**Indicator Status**
None		*Microstegium vimineum*	FAC+
		Lycopus virginicus	OBL
		Lobelia cardinalis	OBL
		Onoclea sensibilis	FACW
		Boehmeria cylindrica	FACW

% of species that are OBL, FACW, and/or FAC: 100
Hydrophytic Vegetation: YES

SOILS Matrix	**Mottles**	**Texture/Other**
10YR 6/1	7.5YR 4/6 and 4/4	Gravelly silt loam

Hydric Soils: YES
Basis: Matrix chroma and mottles

HYDROLOGY
Inundated: No **Depth to standing water: Within a few inches of surface**
Saturated: Yes **Depth to saturated soil: At surface**
Other indicators:

Wetland Hydrology: YES

Atypical Situation:
Normal Circumstances: YES

Wetland Determination:	**Wetland: YES**	**Nonwetland**

Comments: Area subject to flooding. Parts of the wetland that occur on alluvial deposits in the stream were inundated on the day of the survey. The remainder of area was not inundated, but the soil was saturated.

Determined by: B. A. Rosensteel, PWS, JAYCOR

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Alternate Siting Study
Preliminary Environmental Information Document for
Los Alamos National Laboratory

Author(s): Todd Haagenstad

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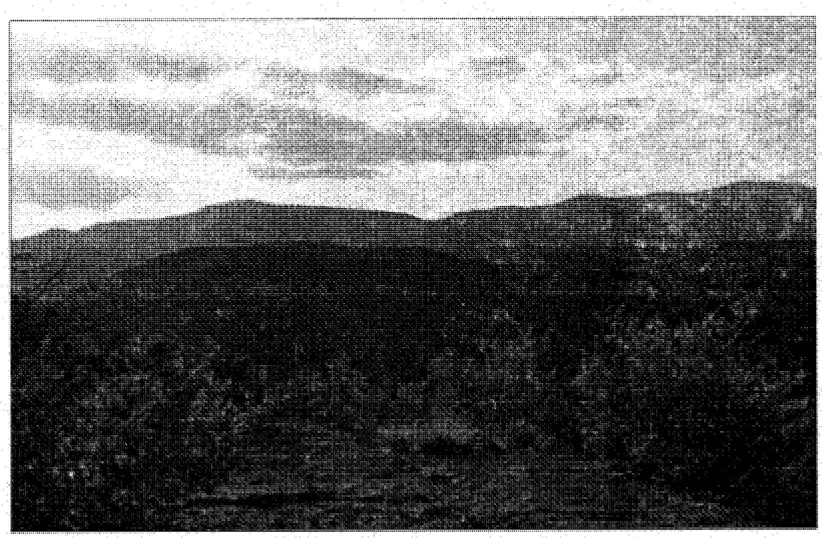
Los Alamos, NM 87545

Submitted to: US Department of Energy
Oak Ridge Operations Office
June 5, 1998



Los Alamos
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1.0 INTRODUCTION

This Preliminary Environmental Information Document (PEID) has been prepared and submitted by the Ecology group (ESH-20) at Los Alamos National Laboratory (LANL) as closure of a task performed in response to a request from the Department of Energy (DOE) Oak Ridge Operations Office in Oak Ridge, Tennessee. The DOE Oak Ridge Operations Office asked LANL to provide technical support in preparing an Environmental Impact Statement (EIS) for the proposed Spallation Neutron Source (SNS) facility. Through a mutual agreement with the DOE Oak Ridge Operations Office, ESH-20 has provided this PEID as closure on this task; no additional site assessment, analysis, or documentation is required.

In the SNS EIS, DOE's "preferred alternative" is to construct and operate the SNS facility at Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. DOE has also completed a process that identified suitable alternatives to the preferred alternative, and LANL was subsequently selected as one of three alternative sites. In support of this process, LANL conducted a siting study that analyzed the feasibility of constructing and operating the SNS facility at one of four different locations within LANL. Of the four potential locations, LANL has recommended analyzing a remote site located in the southeastern region of the reservation within Technical Area 70 (TA-70). The site evaluation process considered the following information in implementing the steps used to select one recommended LANL site:

- A list of the SNS facility physical design parameters
- The inventory of candidate LANL sites based on attributes and constraints
- Determination of the candidate site with the best attributes and least restrictions to accommodate the SNS facility

The information presented in this PEID is designed to provide preliminary information regarding the affected environment descriptions for the LANL alternative portion of the SNS facility EIS. This PEID presents current and existing preliminary environmental information regarding the LANL region, LANL, and the proposed SNS facility site at TA-70. Information regarding threatened or endangered species, wetlands, and cultural resources is based on recent surveys and site assessments. The individual sections of the document are intended to provide preliminary information that addresses resource topics identified as important in developing the SNS facility EIS.

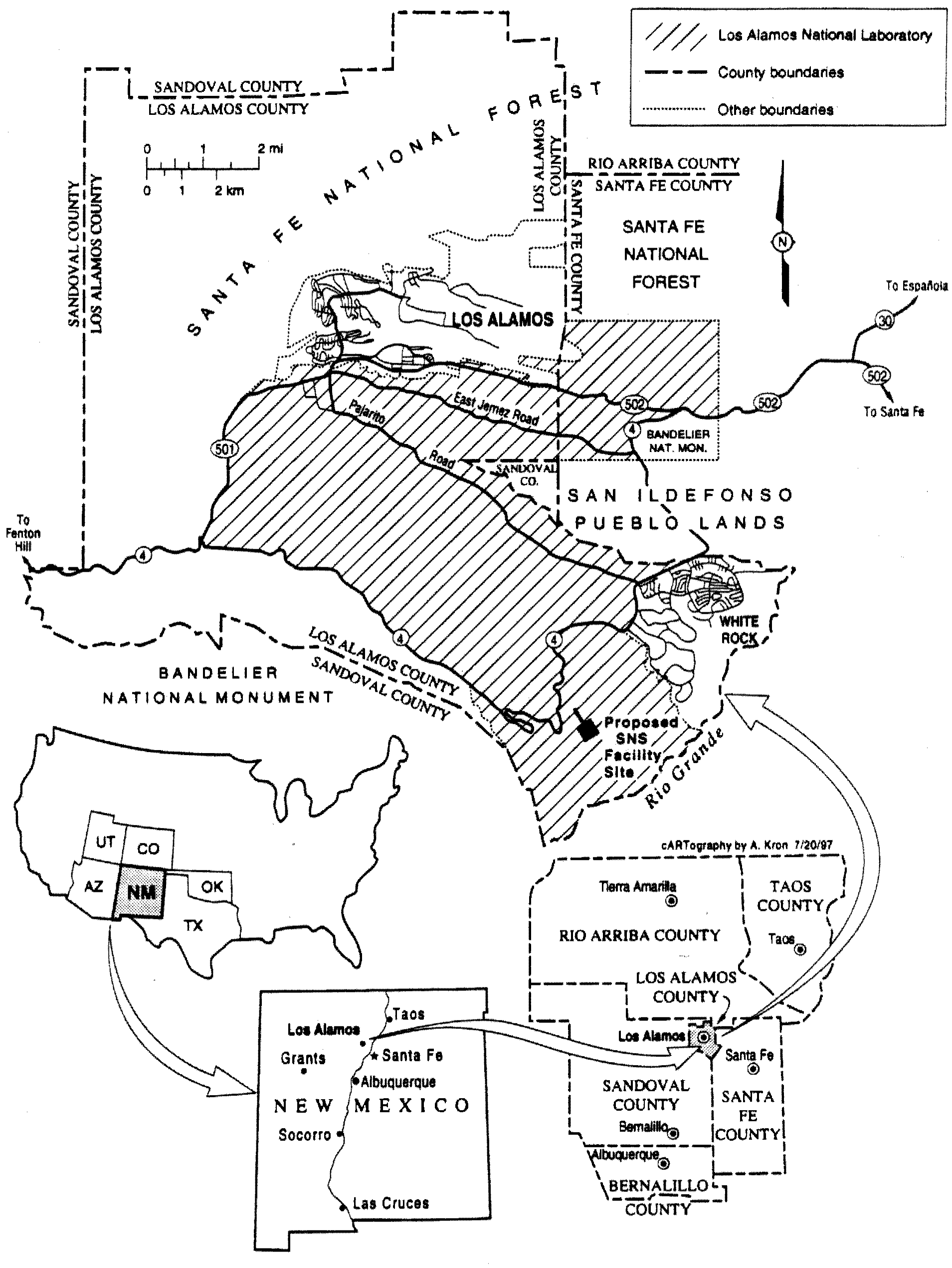
2.0 GENERAL SITE DESCRIPTION

LANL is a government-owned, contractor-operated multidisciplinary research facility that is located on 43 mi^2 (111 km^2) of land in north-central New Mexico approximately 60 mi (100 km) north of Albuquerque. It comprises a significant portion of Los Alamos County and extends into Santa Fe County (Figure 2-1).

Commercial and residential development in Los Alamos County is confined primarily to several mesa tops lying north of the core LANL facility, in the case of the Townsite, or southeast, in the case of White Rock and Pajarito Acres communities. The lands surrounding the Los Alamos County are largely undeveloped wooded areas with large tracts located to the north, west, and south of LANL administered by the U.S. Forest Service (Santa Fe National Forest), the National Park Service (Bandelier National Monument), and the Bureau of Land Management (to the east). The San Ildefonso Pueblo borders LANL to the east. The industrially developed acreage at LANL consists of approximately 30 active Technical Areas (TAs).

Recreational resources such as hiking trails, parks, and athletic facilities are abundant in Los Alamos County. Recreational opportunities such as camping, fishing, and hunting (U. S. Forest

Figure 2-1: Regional location of Los Alamos National Laboratory



Service lands) are available on the surrounding Federal lands. In 1976, the US Energy Research and Development Administration designated LANL as a National Environmental Research Park (NERP), which is used by the national scientific community as an outdoor laboratory to study the impacts of human activities on the Southwest woodland ecosystems existing at the site.

Four publicly accessible vehicle routes convey traffic to and from LANL (Figure 2-2). State Road 502 (Main Hill Road) is heavily used by commuter traffic from Santa Fe and Española. State Roads 4 and 501 provide access to LANL for small communities to the west of LANL. East Jemez Road and Pajarito Road are DOE owned and provide public access to many of the TAs at LANL. In addition to private vehicles, DOE and LANL employee and government vehicles contribute extensively to the volume of traffic on each of these roadways.

The proposed SNS facility site is located within TA-70 in the southeastern region of LANL (Figure 2-2). This is a remote and undeveloped area of LANL, situated less than 0.22 mi (.35 km) east of State Road 4. The area is situated at an elevation of approximately 6,445 ft (1,965 m) and located within a piñon-juniper woodlands with scattered juniper savannas. The mesa top is bordered by an unnamed canyon to the north, Ancho Canyon to the south, and White Rock Canyon and the Rio Grande to the east. The mesa top is unfenced and open to the public for recreational hiking and sight-seeing.

3.0 ENVIRONMENTAL FEATURES AND RESOURCES

This section of the PEID describes important environmental features and resources within the LANL region and proposed SNS facility site. The features and resources described in this section have been identified as important in developing the preliminary LANL-specific discussion in the SNS facility EIS.

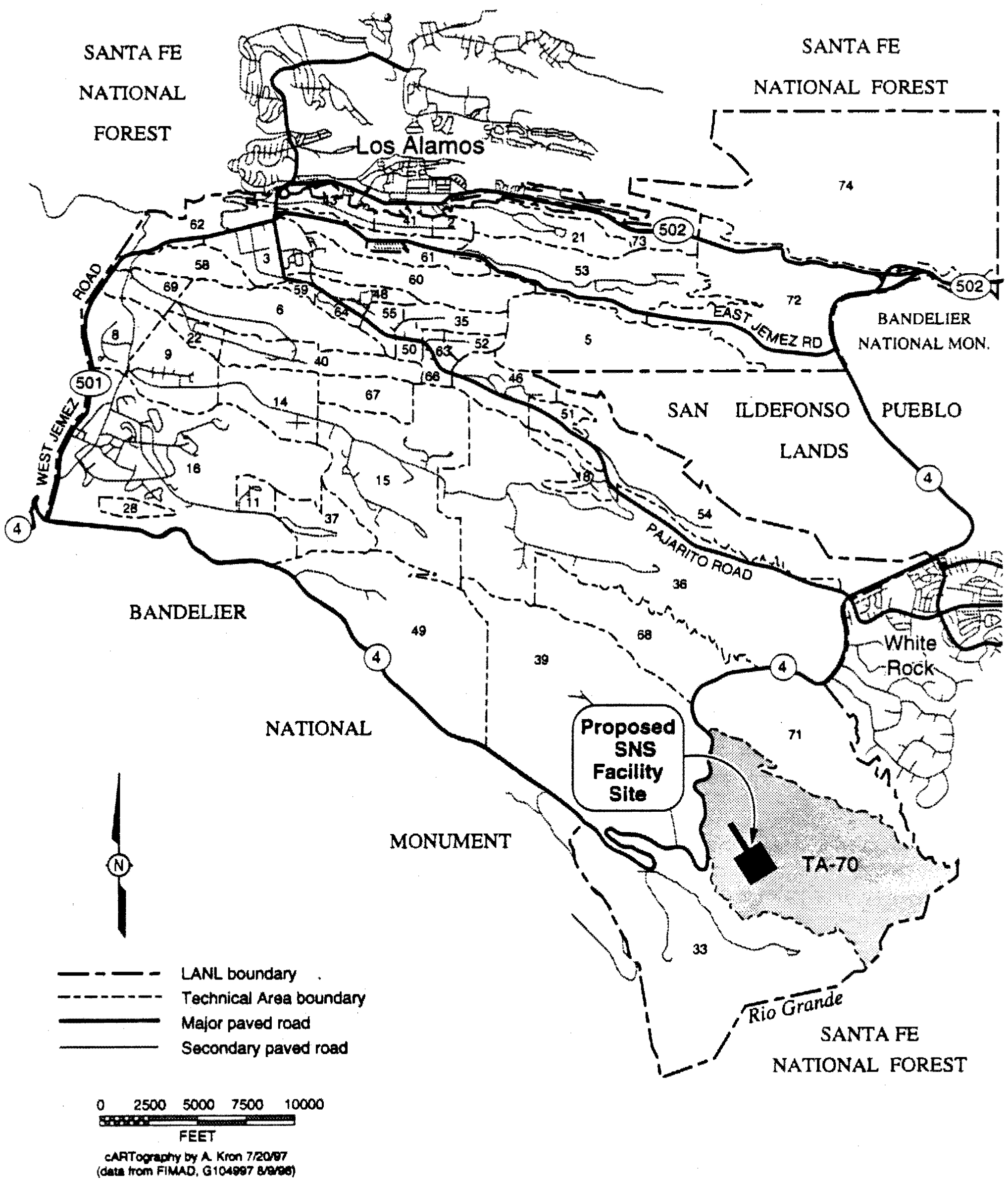
3.1 Land Use

Approximately 88 percent of the land in Los Alamos County is owned by the Federal government, including holdings controlled by DOE, the Department of Agriculture (Santa Fe National Forest), and the Department of the Interior (Bandelier National Monument). About 12 percent of the land in Los Alamos County is in private or local government ownership. Most of the private land has been developed and is a mix of residential, commercial, and industrial uses.

The majority of land within the LANL boundary has been designated as an environmental research and buffer zone. The next largest land use designation has been reserved for high explosives research and development and testing. The remaining areas of LANL are designated for use in experimental science, special nuclear materials research and development, physical support and infrastructure, waste management, and administrative and technical services.

Currently, the proposed SNS facility site is used as an environmental research and buffer zone for LANL operations. This site is remote, unoccupied, and mostly undeveloped except for an existing 115-kV electrical transmission line. Although land use policy and planning is under consideration at LANL, according to the 1990 LANL Site Development Plan, the existing land use is designated as "an undeveloped buffer area...reserved for future large-scale experimental science." The area surrounding the proposed SNS facility site has likewise been designated as an "environmental research/buffer" (LANL 1990). The proposed SNS facility site and the adjacent LANL buffer areas are not fenced. The site is open for use by the general public, and includes several unpaved paths and trails used for recreational hiking.

Figure 2-2: Location of the proposed SNS facility at Los Alamos National Laboratory



3.2 Visual Resources

The LANL region includes spectacular scenery. The orientation and geographic features of the Pajarito Plateau provide a dramatic circular view of landscapes ranging from arid desert grasslands to alpine and subalpine mountains. Looking southward from most locations at LANL, one can see the Sandia Mountains near Albuquerque, and the upper Rio Grande Valley and the Sangre de Cristo Mountains can be seen eastward and northward. The Jemez Mountains can be viewed directly west of the Pajarito Plateau. The elevation gradient from the Rio Grande to the Jemez Mountains is 12 mi (20 km), and the Pajarito Plateau is composed of a series of finger-like mesas separated by deep canyons running east to west from the Jemez Mountains towards the Rio Grande. This dramatic variation creates fascinating landscape features and supports many biologically diverse ecosystems.

The proposed SNS facility site is currently a remote and undisturbed piñon-juniper woodlands. The site is visible from State Road 4 traveling from Bandelier National Monument toward White Rock. The site is not visible from White Rock or from popular recreational use areas within Bandelier National Monument. Further visual resources analyses would be required to determine the visibility of the site from other potentially sensitive view sheds and locations within the region.

Based on a subjective assessment of the proposed SNS site, facility workers would have access to views of the Rio Grande valley and Sangre de Cristo Mountains to the northeast, east, and southeast, and could see the Jemez Mountains to the east. The Sandia Mountains near Albuquerque could be seen southward, and a mesa-top, piñon-juniper woodlands could be seen in the area surrounding the proposed SNS facility site.

3.3 Geology

3.3.1 Structure, Faults, and Fractures

The LANL site is located on the Pajarito Plateau, which is composed of very thick deposits of volcanic ash and ejected material collectively referred to as Bandeilier Tuff. On the Pajarito Plateau, the Bandelier Tuff consists of the Otowi and Tshirege members that were formed by cataclysmic eruptions from the Jemez Mountains 1.6 and 1.2 million years ago, respectively. This tuff includes ash fall, ash fall pumice, and rhyolite tuff, and ranges from welded to nonwelded. The tuff is more than 1000 ft (300 m) thick in the western part of the plateau near the Jemez Mountains, and thins to about 260 ft (80 m) at the eastern edge of the plateau above the Rio Grande.

Surface geology at the site proposed for the SNS facility is characteristic of the lower elevation mesa tops at LANL. The site has a gentile 20-degree slope from the northwest to the southeast towards White Rock Canyon and the Rio Grande. The surface of the mesa top is composed of bare tuff bedrock with interspersed areas of soil. The bedrock at this site is referred to as the Puye Formation; the specific depth of this formation at the proposed SNS site has not yet been determined.

There are two prominent canyons located adjacent to the site; Ancho Canyon, is located 0.27 mi (0.47 km) to the southwest, and an unnamed canyon is located 0.27 mi (0.47 km) to the northeast. The canyon slopes and bottoms adjacent to the site contain a variety of loose soils, cobble, and larger boulders from mass wasting of the canyon edges. The ground is considered stable at the site, and liquefaction and mass movement are generally not considered an issue.

3.3.2 Seismicity

The status and history of seismology within LANL and the surrounding region are the subject of ongoing and new investigations. Several prehistoric faults, running generally north and south along the base of the Jemez Mountains, transect the LANL site. The most prominent fault within this region is the Pajarito Fault. This fault and other regional faults are the subject of ongoing studies that are not yet conclusive. LANL researchers are in the process of updating a 1994 study that defined the extent and prehistoric activity of the regional faults. Final data regarding the history, frequency, magnitude, and probability of seismic activity at LANL are not yet available.

3.3.3 Soils

Large areas of soil are not common within the proposed SNS facility site. The majority of the site consists of exposed tuff bedrock with soils accumulated in low spots or along bedrock outcrops. Surface deposits on the mesa top include locally derived soils and, in places, a thin cover of fine-grained eolian sediment. The soil that does occur on the site has been identified as a Hackroy sandy loam. Based on current knowledge of soils at LANL, there are no prime farmlands within or directly adjacent to the proposed SNS facility site.

3.4 Climate

3.4.1 General Climate

The LANL region has a temperate, semiarid mountain climate that is strongly influenced by elevation and topography. The Pajarito Plateau has four distinct seasons. Precipitation occurs primarily during the summer and winter seasons. Los Alamos County has a semiarid, temperate mountain climate. This climate is characterized by seasonal, variable rainfall with precipitation rates ranging from 10 to 20 in. (25 to 51 cm) per year. Average minimum and maximum temperatures, based on 19- and 15-year means for the community of Los Alamos, have dropped as low as -18 F (-28 C) and have reached as high as 95 F (35 C). The average mean annual precipitation rate for Los Alamos from 1961 to 1990 was approximately 19 in. (48 cm).

3.4.2 Severe Weather

Thunderstorms are common at LANL, with 61 occurring in an average year. A thunderstorm day is defined as a day in which either a thunderstorm occurs or thunder is heard nearby. Most thunderstorm days occur during July and August, the so-called monsoon season. During this time of year, large-scale southerly and southeasterly winds bring moist air into New Mexico from the Gulf of Mexico and the Pacific Ocean. The combination of moist air, strong sunshine, and warm surface temperatures encourages the formation of afternoon and evening thundershowers, especially over the Jemez Mountains. No tornadoes have been reported to touch down in Los Alamos County.

Lightning in LANL can be frequent and intense during some thunderstorms. Because lightning can cause occasional brief power outages, lightning protection is an important design factor for most facilities at LANL and the surrounding area.

Hail is also very common at LANL during the so-called monsoon season. In fact, the area around Los Alamos has the most frequent hailstorms in New Mexico. Typically, the hailstones have diameters of about 0.25 in. (0.6 cm), with a few somewhat larger. Some storms produce measurable accumulations on the ground. Rarely, hailstorms cause significant damage to property and plants.

Large-scale flooding is not common in New Mexico. However, flash floods from heavy thunderstorms are possible in susceptible areas, such as arroyos, canyons, and low spots. Severe flooding has never been observed in Los Alamos. Light-to-moderate flooding is possible in the spring from snowmelt, although snowmelt flooding is usually confined to the larger rivers in New Mexico.

3.5 Air Quality

Air quality is a measure of the amount and distribution of potentially harmful pollutants in ambient air. The Environmental Protection Agency (EPA) has identified six criteria pollutants: carbon monoxide, lead, ozone, sulfur dioxide, nitrogen oxides, and particulate matter. The presence of forests and irregular and complex terrain in the Los Alamos area affects atmospheric dispersion of pollutants. The terrain and forests create an aerodynamically rough surface, forcing increased horizontal and vertical turbulence and other dispersion. The dispersion generally decreases at lower elevations where the terrain becomes smoother and less vegetated. The canyons surrounding LANL channel the airflow, which also limits dispersion. The frequent clear skies and light winds typical of the summer season cause daytime vertical air dispersion.

Los Alamos County, LANL, and the proposed SNS facility site are remote from major metropolitan areas and major sources of pollution. Air quality is better than ambient air quality standards set by EPA and the New Mexico Environment Department (NMED). All radioactive and nonradioactive air emissions are in compliance with the Clean Air Act and the New Mexico Air Quality Control Act (LANL 1996a).

LANL is subject to regulation under the following Federal and State air quality statutory requirements: National Emissions Standards for Hazardous Air Pollutants (NESHAP); National Ambient Air Quality Standards; New Source Performance Standards; Stratospheric Ozone Protection (SOP); and Operating Permit Program. All of these regulations, with the exception of radionuclide NESHAP and SOP, have been adopted by the State of New Mexico as part of a State Implementation Plan. The State of New Mexico Environmental Improvement Bureau, as provided by the New Mexico Air Quality Control Act, regulates air quality through a series of air quality control regulations in the New Mexico Administrative Code. These regulations are administered by NMED and define a series of permits that are issued for specific LANL operations.

3.6 Surface Water Resources

Surface water in the LANL area occurs primarily as short-lived or intermittent reaches of streams. Perennial springs on the flanks of the Jemez Mountains supply base flow into upper reaches of some canyons, but the volume is insufficient to maintain a constant surface flow across the entire length of LANL before being depleted by evaporation, transpiration, and infiltration. Runoff from heavy thunderstorms or heavy snowmelt reaches the Rio Grande several times a year in some of the major canyon system drainages within LANL. Effluents from sanitary sewage, industrial waste treatment plants, and cooling-tower blowdown enter some canyons at rates sufficient to maintain surface flows for varying distances.

There are no permanent surface water resources within 0.25 mi (0.44 km) of the proposed SNS facility site. The drainages in Ancho Canyon and the unnamed canyon are classified as intermittent riverine wetlands by the US Fish and Wildlife Services' National Wetlands Inventory. These dry and sandy drainages (arroyos) occasionally contain water after snowmelt or heavy rainstorm events. Riparian vegetation is supported in some portions of these arroyos.

Although a formal floodplain assessment has not been completed for the proposed SNS facility at LANL, the proposed SNS site does not appear to be within a 50- or 100-year floodplain.

3.7 Groundwater Resources

Groundwater in the LANL area occurs in three modes: (1) water in shallow alluvium in canyons, (2) perched water (a body of groundwater above a less permeable layer that is separated from the underlying main body of groundwater by an unsaturated zone), and (3) the main aquifer of the LANL area. Perched groundwater may occur within the Bandelier Tuff in the western portion of LANL just east of the Jemez Mountains. The source of this perched groundwater may be infiltration from streams discharging from the mouths of canyons along the mountain front and underflow of recharge from the Jemez Mountains. The main aquifer within the LANL area serves as the Los Alamos County municipal water source. Depth to the main aquifer is about 1,000 ft (300 m) beneath the mesa top in the central portion of the Pajarito Plateau. At this location, the main aquifer is separated from alluvial and perched waters by about 350 to 620 ft (110 to 190 m) of tuff and volcanic sediments with low (less than 10 percent) moisture content.

The main aquifer below the Pajarito Plateau has not officially been designated as a sole-source aquifer (class 1). However, according to specifications within the Clean Water Act, the aquifer meets all of the criteria for a sole-source aquifer. The aquifer is currently designated as a class 2 aquifer or high-quality drinking water.

LANL has not conducted a depth to groundwater assessment at the proposed SNS facility site; however, a groundwater monitoring well located directly adjacent and parallel to TA-70 indicates that the depth to the main aquifer is approximately 840 ft (257 m). The depth to groundwater at the bottom of Ancho Canyon along the southern edge of TA-70 is 600 ft (184 m).

LANL has conducted groundwater monitoring annually for several years as part of a groundwater protection program. Results of groundwater monitoring are reported annually in LANL's Environmental Surveillance Report. LANL has recently developed, and is in the early stages of implementing, a new site-wide groundwater monitoring program. The program will involve the installation of several new, strategically located, groundwater monitoring wells.

3.8 Ecological Resources

3.8.1 Terrestrial

The proposed project area and its surroundings are located on the Pajarito Plateau on the east-central edge of the Jemez Mountains. The plateau is composed of layers of volcanic sedimentary rocks, and is dissected into a number of narrow mesas by southeast-trending canyons. Most of these canyons support intermittently flowing streams. The stream drainages ultimately descend into White Rock Canyon and converge with the Rio Grande near the eastern boundary of LANL. The Rio Grande is the only permanently flowing river near the project area.

Three major vegetation zones have been identified within the boundaries of LANL; juniper savannas at the lowest elevations in White Rock Canyon, piñon-juniper woodlands at intermediate elevations on the mesas, and ponderosa pine forests at higher elevations on the mesas. Mixed-conifer forests also occur on the north-facing slopes of some canyons. Riparian zones occur in many of the drainages and along the Rio Grande. Wetlands of varying sizes also occur throughout LANL, particularly in the canyons.

LANL evaluated landscapes within a 0.25-mi (0.44-km) radius of the proposed project site, using a Geographic Information System (GIS) and site surveys. The preferred site is located on a mesa flanked by Ancho Canyon 0.27 mi (0.47 km) to the southwest and a small unnamed drainage an equal distance to the northeast. To the southeast, the Rio Grande flows through nearby White Rock Canyon, at a distance of approximately 1.2 mi (1.9 km) from the preferred site. The site is located 0.22 mi (0.35 km) to the east of State Road 4; a two-lane paved road (see Figure 2-1). Elevations within the proposed project area range from 6,410 ft (1,954 m) to 6,490 ft (1,978 m).

The vegetation in the proposed project area is dominated by piñon-juniper woodlands, with scattered juniper savannas. Additionally, much of the land in and bordering the adjacent canyons is bare rock. Overstory plant species include piñon (*Pinus edulis*) and one-seed juniper (*Juniperus monosperma*). Scattered grasses, primarily blue grama (*Bouteloua gracilis*), shrubs, and forbs are found in the understories. In sites where bedrock is near the soil surface, the most common shrubs include wavy-leaf oak (*Quercus undulata*), hedgehog prickly pear (*Opuntia erinacea*), and sticky rabbitbrush (*Chrysothamnus viscidiflorus*). In areas with deeper soils, big sagebrush (*Artemisia tridentata*) is common. Forbs on both deep and shallow soils include greenthread (*Thelesperma trifidum*), golden aster (*Chrysopsis villosa*), thelypody (*Thelypodium wrightii*), and trailing fleabane (*Erigeron flagellaris*).

3.8.2 Unique or Rare Communities

No unique or rare biological communities have been identified within LANL or within the proposed SNS facility project area.

3.8.3 Wildlife

Lists of species found to be occurring in the proposed project area are located in Foxx (1996). Rocky Mountain elk (*Cervus elaphus nelsoni*) use piñon-juniper woodlands for wintering habitat and some year-round use. Mule deer (*Odocoileus hemionus*), coyote (*Canis latrans*), grey fox (*Urocyon cinereoargenteus*), rock squirrel (*Spermophilus variegateus*), and desert cottontail (*Sylvilagus auduboni*) are common mammals. Common bird species include common raven (*Corvus corax*), scrub jay (*Aphelocoma coerulescens*), piñon jay (*Gymnorhinus cyanocephalus*), plain titmouse (*Parus inornatus*), and ash-throated flycatcher (*Myiarchus cinerascens*).

3.8.4 Special Uses and Designations

In 1976 when LANL was identified as Los Alamos Scientific Laboratory, the DOE designated the site a NERP. LANL remains a NERP site. The preferred site is currently open to the public for some recreational non-motorized uses, including hiking and picnicking.

3.8.5 Aquatic Biota

The canyons adjacent to TA-70 and the proposed SNS facility site contain some surface water. Lists of aquatic biota found within the general area can be found in Foxx (1996). There are no aquatic areas within 0.25 mi (0.44 km) of the proposed project site. Lists of aquatic biota within the general area can be found in Foxx (1996).

3.8.6 Research and Monitoring

Current monitoring programs at LANL include local and regional surveys of air quality and surface and groundwater quality. These projects at LANL involve monitoring for radionuclides and contaminants in soil, flora, and fauna, as well as estimating potential human dose exposures to radioactivity. Annual surveys are conducted for breeding birds and all threatened or endangered species that may occur on the Laboratory (LANL 1996a). Previous floristic surveys have been conducted near the proposed project site. In 1991, a biological assessment that included the proposed project area was initiated. This study was completed in 1996 (Foxx 1996).

3.9 Wetlands

The drainages in Ancho Canyon, 0.27 mi (0.47 km) to the southwest, and in an unnamed canyon, 0.27 mi (0.47 km) to the northeast, of the project area are classified as intermittent riverine wetlands by the National Wetlands Inventory. These dry and sandy drainages (arroyos) occasionally contain water after snowmelt or heavy rainstorm events. Riparian vegetation is supported in some portions of these arroyos.

3.10 Threatened and Endangered Species

Potential threatened and endangered species at LANL are listed in Table 3-1. The habitat within the proposed project area is unsuitable for Mexican spotted owl (*Strix occidentalis lucida*), black-footed ferret (*Mustela nigripes*), and southwestern willow flycatcher (*Empidonax traillii extimus*). Therefore, these species were dismissed from consideration. The proposed project area includes foraging habitat for American peregrine falcon (*Falco peregrinus anatum*) and foraging and roosting habitat for bald eagle (*Haliaeetus leucocephalus*). Previous survey results indicate that the area surrounding the preferred site is unlikely to receive concentrated use from peregrine falcons for foraging, and that nesting habitat was marginal. The nearest identified peregrine falcon nesting habitat is in White Rock Canyon, approximately 1.2 mi (1.9 km) from the preferred site. Wintering bald eagles forage and roost within White Rock Canyon and connecting canyons, including Ancho Canyon. Additionally, bald eagles, whooping cranes (*Grus americana*), American peregrine falcon (*Falco peregrinus anatum*), and Arctic peregrine falcon (*Falco peregrinus tundrius*) may use White Rock Canyon as a migration route.

Table 3-1: Threatened and Endangered Species Potentially Occurring on LANL

Species	Scientific Name	Habitat Associations
American peregrine falcon	*Falco peregrinus anatum*	Nests on cliff faces. Forages in all habitat types within LANL.
Whooping crane	*Grus americana*	Migrates along Rio Grande in White Rock Canyon.
Southwestern willow flycatcher	*Empidonax traillii extimus*	Inhabits riparian areas with established willow stands.
Black-footed ferret	*Mustela nigripes*	Inhabits established prairie dog towns.
Arctic peregrine falcon	*Falco peregrinus tundrius*	Potentially migrates along the Rio Grande in White Rock Canyon.
Bald eagle	*Haliaeetus leucocephalus*	Inhabits riparian areas along permanent water ways such as lakes and rivers.
Mexican spotted owl	*Strix occidentalis lucida*	Inhabits multistoried mixed conifer and ponderosa pine forests.

3.11 Cultural Resources

3.11.1 Background

Los Alamos County, including LANL, is rich in cultural resources that include archeological sites, historic buildings and sites, and Traditional Cultural Properties (TCPs). As required under Executive Order 13007, the four Accord Pueblos with whom DOE has formal agreements (Cochiti, Jemez, Santa Clara, and San Ildefonso) and the Mescalero Apache, have been asked to identify any sacred or TCP issues that may apply to various locations throughout LANL. The TCP data are considered extremely sensitive data, and are under the control of the DOE Albuquerque Field Office in Albuquerque, New Mexico.

For the purpose of cultural resources assessment in this PEID, a "site" is defined as a location where a significant human activity has occurred. The visible indications of such behavior may include (but not be limited to) bedrock mortars, game traps, petrogylphs, steps and roads, water-catching devices as well as habitations, terraces, shrines, and artifact scatters. For an artifact scatter to be defined as a site, the artifacts present must be indicative of purposeful human use of the area, that is, they must be present in either variety, quantity, or integrity of location to show that the area in which they are located is a loci of cultural activity. In general, all artifact scatters are considered as sites unless they, by their topographical situation, have obviously been transported by natural environmental forces away from clearly defined sites. Artifact scatters that are associated with clearly defined sites will be included in descriptions of the parent site. Artifacts located during survey, which do not meet these criteria, have been noted and described as isolated occurrences (IOs). For example, lone projectile points, artifacts washed downslope from obvious nearby sites and pot drops (potsherds obviously derived from the same vessel) have not been recorded as sites but as IOs. The area of potential effect (APE) for the SNS project contains numerous IOs, mostly lithic debris collecting in shallow drainages. These were not recorded as separate sites and are likely to be the result of moderate to severe erosion in the APE as well as a diffuse prehistoric use of the area.

3.11.2 Survey Results

Approximately 65 percent of the proposed SNS facility site, or APE, was surveyed for cultural resources. The total APE was estimated to be 70 ac (28 ha), including a 100-ft (30.5-m) buffer area around the project. The survey was accomplished by linear pedestrian transects spaced 16-33 ft (5-10 m) apart. All cultural features were noted and entered into a computerized database and GIS. A total of 5 archaeological sites were found in the 70 acres surveyed. The site number, site type, size, cultural affiliation, and National Register eligibility, are found in Table 3-2.

Table 3-2: Cultural Resource Assessment Survey Results

Laboratory of Anthropology Site Number	Field Site Number	Site Type	Site Size	Time Period	National Register Eligibility
LA12676-B	Parp-34	Field House	1-2 rooms	Coalition	Yes Criterion D
LA12676-C	Parp-33/L-153	Pueblo	8-10 rooms	Early Coalition	Yes Criterion D
(not assigned)	L-154	Pueblo	2-4 rooms	Classic	Yes Criterion D
LA6786	LA6786	Pueblo	6-8 rooms	Early Coalition	Yes Criterion D
(not assigned)	L-155	Field House	1 room	Classic	Yes Criterion D

3.12 Socioeconomic Environment

3.12.1 General Description

A socioeconomic assessment focuses on the social, economic, and demographic characteristics of an area. The socioeconomic environment can be affected by changes in employment, income, and population, which, in turn, can affect area resources such as housing, community services, and infrastructure.

Preliminary figures for 1995 indicated that Los Alamos County had an estimated population of 18,604 (Sunwest 1996, preliminary figure for 1995). Statistics for population, housing, and public infrastructure are based on the region of influence (ROI), a three-county area in which approximately 90 percent of LANL employees reside. This figure includes University of California, Johnson Controls, Inc., and Protection Technology of Los Alamos employees only; residence and employment figures do not include contract labor, affiliates, or special program guests. The ROI includes the counties of Los Alamos (with 50.4 percent of LANL employees), Rio Arriba (21.0 percent), and Santa Fe (18.3 percent) (LANL 1997). The ROI experienced a population growth of approximately 13.6 percent between 1990 and 1995, with a 1995 total population of about 172,000 persons (Sunwest 1996). Preliminary estimates indicate that by the year 2000, population in the ROI is expected to be approximately 195,000 persons (projection is based on figures in Sunwest 1996).

In January 1996, LANL employed approximately 8,936 persons in the ROI accounting for 10.4 percent of the total ROI employment (85,721) (LANL 1996b and Sunwest 1996). Nonagricultural employment in New Mexico increased by 4.9 percent in 1995; Los Alamos and Santa Fe counties had a 2.9 percent increase. Unemployment in the ROI for 1995 was 5.76 percent (Sunwest 1996). Information regarding employment status within the ROI for 1995-1997 is not available at this time.

3.12.2 Housing

The number of vacant housing units in the ROI increased from approximately 4,358 units in 1980 to 6,872 units in 1990, a 58 percent increase in ten years (BER 1992). In the year 2000 there would be about 10,858 total vacant units if current trends continue, however, more current figures are not available at this time.

3.12.3 Public Services

Los Alamos County is responsible for residential and commercial distribution of gas, water, electricity, and sewer services to the community on the north side of Los Alamos Canyon Bridge. DOE currently owns and operates all utilities on the south side of Los Alamos Canyon Bridge on LANL property. DOE also owns and operates the Los Alamos County-wide water production and distribution system. Transfer or lease of the water production system to Los Alamos County is being contemplated. The utilities usage and capacity are presented in Table 3-3.

In 1985, DOE and Los Alamos County agreed to pool their electrical generating and transmission resources and to share costs based on usage. Electrical power sources for the Los Alamos Resource Pool include a number of coal, natural gas, and hydroelectric power generators throughout the western United States. As needed, power can also be generated locally at LANL's TA-3 power plant that has an approximately 9- to 12-MW maximum output. Although power generation at the various sources is not a problem, regional and contractual electrical power transmission limitations have affected the amount of power available for DOE, LANL, and Los Alamos County.

Preliminary estimates indicate that approximately 3,550 students are enrolled in Los Alamos public schools (19 percent of Los Alamos County's population) (LAPS 1997). The ratio of uniformed police officers to residents is currently 1 to 581 (LAPD 1997). The ratio of uniformed firemen to residents is 1 to 177.

Most of the revenue (approximately 73.6 million dollars) generated by Los Alamos County in fiscal year 1996 (June 1995 through July 1996) can be broken down as follows: 53 percent from utilities, 15 percent from gross receipts tax, 11 percent from the DOE fire contract, 7 percent from investment income, 4 percent from DOE assistance payments, and 4 percent from property taxes. The remaining revenue comes from other taxes, other service charges, and other intergovernmental sources (LA Finance Department 1997).

In October 1996, the President signed the Energy and Water Development Appropriations Act of 1997 authorizing a lump sum payment to Los Alamos County of about 22.6 million dollars. This payment is a buyout of DOE assistance payments in compliance with the Atomic Energy Commission Act. The last monthly assistance payment was made in June 1997. On April 15, 1997, Los Alamos County received the largest portion of the buyout money, 17.6 million dollars. The remaining 5 million dollars is subject to future transfers of DOE facilities to Los Alamos County, including the water system and the airport.

Table 3-3: Utilities: Usage and Capacity

Utilities	LANL	Los Alamos County
Electrical	peak Los Alamos Resource Pool usage per hour - 76 MW[c] (LANL metered usage – 366,158 MWh per year[a]) peak Los Alamos Resource Pool capacity - (maximum output per hour) - 104 to 119 MW	peak Los Alamos Resource Pool usage per hour - 76 MW[c] (County metered usage - 87,139 MWh per year[b]) peak Los Alamos Resource Pool capacity - (maximum output per hour) - 104 to 119 MW
Water	usage- 262,955,000 gallons per year[a] (*995,284,670 liters*) capacity- 1,406,058,000 gallons yearly production[a] (*5,321,929,500 liters*) [includes both the LANL and County water supply] (DOE water rights - 5,541.3 ac-ft/year* from main aquifer. DOE can buy an additional 1,200 ac-ft/year from San Juan-Chama Transmountain Diversion Project[d])	usage- 970,195,000 gallons per year[b] (*3,672,188,000 liters*) capacity- see LANL water capacity
Natural Gas	usage- 1,365,996 million Btu per year[a] capacity (contractual)- 10,000 million Btu per day or 3,650,000 million Btu per year[a]	usage- 1,059,420 million Btu per year[b] capacity (contractual)- 10,101 million Btu per day or 3,686,865 million Btu per year[e]

a Information from Jerome Gonzales, LANL FSS-8, personal communication, 4/16/97.

b Information from John Arrowsmith, Los Alamos County Utility Department, Final Sales Revenue Report: Electric, Gas, and Water (County FY96).

c Information from Mark Hinrichs, LANL FSS-8, personal communication, 5/9/97; FY 96 Los Alamos Resource Pool data (numbers reflect combined LANL and County peak usage per hour).

d Information from Timothy Glasco, Los Alamos County Utility Department, personal communication, 4/15/97, and Jerome Gonzales, LANL, FSS-8, personal communication, 4/23/97.

e Information from Los Alamos County's Utility Department for County FY96, Chris Ortega, personal communication, 4/15/97.

* 1,805,909,670 gallons per year or 6,835,368,100 liters per year

3.12.4 Transportation

Highways provide the primary access to LANL and the rest of Los Alamos County from the Rio Grande Valley, Santa Fe, and Albuquerque. Los Alamos has no bus or rail connections, but commuter air service is available between Los Alamos and Albuquerque. Slightly less than half of the employees at LANL commute from Santa Fe, Española, and other areas in the region.

Highway access to the Los Alamos County is by State Road 4 from the west and State Road 502 from the east. There are four main access points to LANL, which convey about 40,000 average daily trips (ADTs). They are Diamond Drive across the Los Alamos Canyon bridge (28,000 ADTs), Pajarito Road (8,000 ADTs), East Jemez Road (6,000 ADTs), and State Road 4/West Jemez Road from the west (1,000 ADTs).

The proposed SNS facility site can be accessed from State Road 4 via a primitive dirt road through a three-strand barbed wire fence with a locked gate. State Road 4 is used by LANL employees accessing experimental sites in the southern and southeastern reaches of LANL. The general public uses State Road 4 to access the Jemez Mountains, White Rock, and Bandelier National Monument. The traffic on the section of State Road 4 between White Rock and Bandelier National Monument is generally considered to be light, however, the road may receive slightly more use during the summer tourist season (May through September).

3.13 Ambient Noise

Noise is defined as unwanted sound. Sound is a form of energy that travels as invisible pressure vibrations in various media, such as air. The auditory system of the human ear is specialized to sense the sound vibrations. Noise is categorized into two types: *Steady-State Noise* which is characterized as longer duration and lower intensity such as a running motor and *Impulse or Impact Noise* which is characterized by short duration and high intensity such as the detonation of high explosives. The intensity of sound is measured in decibel (dB) units. In sound measurements relative to human auditory limits, the decibel scale is modified into an A-Weighted Frequency scale (dBA).

Noise measured at LANL is primarily from occupational exposures. These measurements take place inside buildings and are made using personal noise dosimeters and instruments. Occupational exposure data are compared against an established Occupational Exposure Limit (OEL). LANL defines the OEL administratively as noise to which a worker may be exposed for a specific work period without probable adverse effects on hearing acuity. The OEL for steady-state and impulse or impact noise at the Laboratory is based on U. S. Air Force Regulation 161-35, "Hazardous Noise Exposure," which has been adopted by DOE. The maximum permissible OEL for steady-state noise is 84 dBA for each 8-hour work period. The OEL for impulse/impact noise is not fixed because the number of impacts allowed per day would vary depending on the dBA of each impact. LANL Action Levels for steady-state noise and impulse/impact noise are 80 dBA for each 8-hour day and 140 dBA, respectively. The Action Levels trigger the implementation of a personnel hearing conservation program.

Environmental noise exposure is measured outside of buildings. The sound levels measured vary and are dependent on the generator. The following are typical examples of sound levels (dBA) generated by barking dogs (58), sport events (74), local cars (63), aircraft overhead (66), children playing (65), and birds chirping (54). LANL sources of environmental noise consist of background sound, vehicular traffic, routine operations, and periodic high-explosive testing. Measurements of environmental noise in and around LANL average around 80 dBA. Some measurements have been made to evaluate environmental impacts from operational and high-explosive detonation noise. For example, the peak noise level measured at one of LANL's explosives test facilities from a 20-lb (9-kg) trinitrotoluene (TNT) explosion ranged from 140 to 148 dBA at a distance of 750 ft (229 m).

The values from limited ambient environmental sampling in Los Alamos County are within the expected sound levels (55 dBA) for outdoors in residential areas. Background sound levels at the White Rock community ranged from 38 to 51 dBA (Burns 1995) and 31 to 35 dBA at the entrance of Bandelier National Monument (Vigil 1995). The minimum and maximum values for Los Alamos County in this study were 40 dBA and 96 dBA, respectively.

Ambient noise levels at the proposed SNS facility site have not been recorded. However, given the remoteness of the site and the distance from industrialized or populated areas, the ambient noise levels are generally considered low. Test shots conducted within the explosives testing areas west of the site may be vaguely heard on occasion.

3.14 Radiation Environment

The radiation environment at LANL and the surrounding communities is continuously monitored and characterized. These results are reported in annual LANL environmental surveillance reports (LANL 1996a). Air emissions are routinely sampled at locations on LANL property, along the DOE boundary perimeter, and in more distant areas that serve as regional background stations. Atmospheric concentrations of radioactive nuclides (radionuclides) are measured to estimate internal radiation doses. Thermoluminescent dosimeters are used to determine external penetrating radiation doses in the area. Background dose estimates are subtracted from the measured values to determine the effective dose equivalents (EDE) to the public outside the site boundary and at the nearest residence. The EDE is a term for the estimated radiation dose to the whole body that would result from a dose to any one or more body organs.

The radiation environment at LANL consists of both (1) natural background radiation and induced background levels of radioactivity in the surrounding communities and (2) the workers' radiation environment within their work areas. All individuals are subject to some irradiation although they may not work with radioactive substances. The annual average EDE from background and induced radiation for 1995 to nearby residents in Los Alamos and White Rock was 349 mrem and 336 mrem, respectively (LANL 1996a). The average EDE attributable to 1995 LANL operations was 0.5 mrem and 0.2 mrem for residents in Los Alamos and White Rock, respectively (LANL 1996a). The maximum annual dose to a potentially exposed member of the public from 1995 LANL operations is estimated to be approximately 2.3 mrem per yr. DOE's public dose limit is 100 mrem per yr EDE from all pathways, and the dose received through the air pathway is restricted by EPA's dose standard of 10 mrem per year. Table 3-4 summarizes the various estimated annual exposures to the public associated with LANL operations during 1995. The annual average EDE from background and induced radiation for the proposed SNS facility site has not been specifically calculated as part of this PEID.

Table 3-4: Summary of Annual Effective Dose Equivalents for 1995

Dose Source	Maximum Dose to an Individual[a,b]	Average Dose to Nearby Residents; Los Alamos and White Rock		Collective Dose to Population within 50 mi (80 km) of LANL[b]
Dose Attributable to LANL Operations	2.3 mrem	0.5 mrem	0.2 mrem	3.2 person-rem
Background Dose	349 mrem	349 mrem	336 mrem	82,000 person-rem

a Maximum dose to an individual is the dose to any individual at or outside LANL where the highest dose rate occurs (i.e., residence north of TA-53).

b Doses reported are average doses.

Source: (LANL 1996a)

3.15 Waste Management and Environmental Restoration

3.15.1 Waste Management

LANL and Los Alamos County have established procedures for maintaining compliance with applicable laws and regulations for collecting, storing, processing, and disposing of industrial and municipal solid waste. LANL's solid sanitary waste is disposed of at the Los Alamos County landfill, which is operated by Los Alamos County on DOE property within LANL. Preliminary estimates indicate that LANL disposes of an average of about 31,270 yd^3 (23,910 m^3) of solid waste annually at the County landfill (DOE 1996). Current preliminary estimates indicate that this landfill has an expected use life of about 15 more years. Trash from commercial companies in Los Alamos County is collected in County trucks on a regular, and special request, basis and disposed of at the County landfill. In 1996, about 20,000 yd^3 (15,300 m^3) of commercial trash was disposed of at the County landfill. Rubble from LANL, the County, contractors, and individuals is accepted at the County landfill. In 1996, 15,600 tons (14,200,000 kg) of rubble were disposed of at this location. Los Alamos County also maintains a separate location at the landfill for construction debris that is available for reuse by individuals or companies. In 1996, about 5,870 tons (5,340,000 kg) of construction debris were disposed of at the County landfill. Another location within the Los Alamos County landfill is used to process green waste such as tree limbs, brush, leaves, and grass. This material is shredded and some of it is composted on-site. The processed materials are available to the public, schools, County, and LANL for use as a ground cover or soil conditioner. About 13,200 yd^3 (10,100 m^3) of green waste was disposed of at the County landfill in 1996 (LAC 1996).

LANL operates a low-level waste disposal area at TA-54 for the management of radioactive wastes generated by LANL activities. There is no permitted treatment, storage, and disposal facility in New Mexico for radioactive waste generated by commercial companies, hospitals, and universities. Envirocare Inc., a facility in Utah, may accept radioactive waste from these types of generators.

Los Alamos County operates two sanitary wastewater treatment facilities, one in White Rock and one in Bayo Canyon. The latter sewage treatment plant processes the sewage from Los Alamos Townsite. Nearly all of the sanitary wastewater generated at LANL goes to the LANL Sanitary Wastewater Systems Consolidation (SWSC) plant at TA-46. Table 3-5 shows the preliminary estimates of volume of sewage processed each day at these three sewage treatment plants and the capacity of the three plants.

Table 3-5: Sanitary Sewer Usage and Capacity

Facility	Usage (gal per day)	Capacity (gal per day)	Usage (liters per day)	Capacity (liters per day)
Bayo Canyon Sewage Treatment Plant[a]	900,000	1,370,000	3,400,000	5,200,000
White Rock Sewage Treatment Plant[a]	500,000	820,000	1,900,000	3,100,000
LANL SWSC Plant[b]	400,000	600,000	1,350,000	2,300,000

a Information from Keith Schwertfeger, Los Alamos County Utility Department, telephone conversation with Ellen McGehee, Ecology Group, Los Alamos National Laboratory, April 15, 1997.

b Information from Ed Hoth, Utilities and Infrastructure Group, Los Alamos National Laboratory, telephone conversation with Ellen McGehee, Ecology Group, Los Alamos National Laboratory, April 16, 1997.

The Bayo Canyon sewage treatment plant is operating below capacity and could handle more sewage per day. There are, however, other constraints on the sanitary system as a whole, such as the size of existing pipes and the capabilities of existing lift stations.

The SWSC plant is operating below capacity as shown in Table 3-5. The sewage from different parts of TA-3 is collected and merged before it goes to the SWSC plant at TA-46. The size of these existing pipes limits the amount of sewage that can be handled from TA-3 and, as a result, the TA-3 portion of LANL's sewer system is operating close to capacity.

These sanitary waste treatment systems are all a considerable distance from the proposed SNS facility site. Further analysis and planning is required in order to establish the feasibility of using these systems in support of the operation of the proposed SNS facility.

3.15.2 Environmental Restoration

The Environmental Restoration (ER) Project at LANL is part of a national effort by DOE to clean up the facilities involved in its past or present weapons production program. The goal of this effort is to ensure that DOE's past operations do not threaten human or environmental health and safety. The ER Project is governed primarily by the RCRA, which addresses the day-to-day operations of hazardous waste management, treatment, storage, and disposal facilities; establishes a permitting system; and sets standards for all hazardous-waste-producing operations at these facilities. Under this law, LANL must have a permit to operate its facilities (LANL Permit is NM 0890010515). RCRA, as amended by the Hazardous and Solid Waste Amendments (HSWA) in 1984, prescribes a specific corrective action process for all potentially contaminated sites. The ER Project is investigating all sites that may have been contaminated by past operations to determine the nature and extent of any contamination. It is also exploring possible measures for cleaning up contamination and selecting and implementing remedies at these sites.

DOE provides the broad definition of activities undertaken by the ER Project at LANL. Budgets, schedules, and many procedural requirements for the ER Project have been set by DOE. DOE is accountable to two regulatory agencies: The EPA, Region 6, and the NMED. As required by the HSWA Module of LANL's permit to operate under RCRA, the ER Project established a Records-Processing Facility as the repository for all its documentation. The facility collects, organizes, indexes, stores, and protects all relevant information for use by all ER Project participants and stakeholders, including DOE, EPA, NMED, and the public. The references cited in this section can be found at the Records-Processing Facility or the LANL Community Reading Room; both are in Los Alamos.

EPA has the primary responsibility for developing, promulgating, and enforcing regulations to implement RCRA and HSWA, although it may delegate, and has delegated all of its regulatory authority to NMED. Whenever there is a need to change information in the HSWA Module, LANL and DOE prepare a proposal to the regulators to modify the permit, such as a Class III modification to remove a potential release site (PRS) from the list in the HSWA Module and take no further clean-up action on the PRS. Before a PRS can be removed from the HSWA permit, a Class III permit modification must be proposed to the regulator. Other changes in the permit also require a Class III permit modification.

Solid Waste Management Units (SWMUs) are potentially contaminated sites that are listed in the HSWA Module of LANL's RCRA Operating Permit. In addition, there are other sites that have been identified as areas of concern but that are not in the HSWA Module. The general term for all potentially contaminated sites is potential release sites (PRSs).

If approved, the PRS is removed from further consideration by the ER Project. If not approved, the ER Project proposes further actions that may include characterization, a corrective measures study, a clean-up plan, an interim action, or a best management practice. No PRS is removed from the HSWA module until the regulators approve no further action. While it is expected that construction would not occur within the lateral extent of a PRS still listed in the HSWA module, it is possible that any necessary remediation may be complicated by the presence of buildings or other infrastructure in the vicinity.

A LANL RCRA Facility Investigation conducted within and surrounding the proposed SNS facility site, determined that the site does not include any SWMUs or PRSs (LANL 1992).

4.0 Cumulative Impacts

This section considers a preliminary assessment of the potential sources of cumulative impacts resulting from the construction and operation of the proposed SNS facility, as well as other reasonably foreseeable future actions within and adjacent to the site. The sources of cumulative impacts on the environment result in the incremental effect of an action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions. Sources of cumulative impacts can be associated with individually minor, but collectively significant, actions taking place over a period of time (40 CFR 1508.7).

Past activities within and directly adjacent to the proposed SNS facility site have been limited to use by the public for general recreational uses such as day hikes and sightseeing. For several decades the area has not open to public vehicular traffic, however, there are a few primitive access roads that have been used by Federal personnel for occasional access. Approximately 40 years ago, the federal agency now referred to as the DOE, constructed a single 115-kV electrical transmission line. A portion of this transmission line crosses what is now the proposed SNS facility site.

Current activities within and directly adjacent to the proposed SNS facility site are very limited. The site continues to be used by the public for general recreational uses such as day hikes and sightseeing. Public vehicular traffic remains restricted at the site. The activities associated with the maintenance and operation of the 115-kV electrical power transmission line are anticipated to remain unchanged from previous conditions. Non-Federal construction projects or other similar activities are not expected to occur at the site under the current DOE ownership.

The only reasonably foreseeable DOE action at the proposed SNS facility site is the proposed construction and operation of a 345 kV-designed electrical power transmission line that would parallel the existing 115-kV transmission line that currently transects the proposed site. Although this proposed transmission line would be a 345 kV-designed system, it would be operated at 115 kV within the reasonably foreseeable future. Although the DOE is preparing an Environmental Impact Statement that considers an action to transfer selected parcels of LANL land to local Native American Indian tribes and Los Alamos County, the proposed SNS facility site is not within a parcel being considered for transfer.

Acknowledgements

We sincerely acknowledge the support of several members of the Ecology group staff in preparing and producing this preliminary report. Much of the information provided represents the combined and on-going effort of the following Ecology group NEPA Team members: Tony Ladino, Jocelyn Mandell, Ellen McGehee, Mary Mullen, Peggy Powers, Ruben Rangel, Barbara Sinha, and Patrick Valerio. The Cultural Resources survey data and other information was provided by Beverly Larson, Kari Garcia, Steve Hoagland, and Gerald Martinez. The Biological Resources survey data and information was provided by Randy Balice and Leslie Hansen. The final editing of this preliminary report was provided by DOE Oak Ridge SNS EIS Team members David Wilfert and David Bean, the DOE Los Alamos Area Office NEPA Compliance Office Elizabeth Withers, and LANL Ecology group members Tony Ladino and Hector Hinojosa. Finally, the cover page was designed and produced by LANL Ecology group member Kim Nguyen Gunderson.

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NSNS SITE SURVEY

BIOLOGICAL ASSESSMENT

The proposed site for the National Spallation Neutron Source (NSNS) at Brookhaven National Laboratory was surveyed on January 5, 8, 10 and 13, 1998. The site (Attachment 1) was subdivided into Area A, the narrow portion, and Area B, the wider portion. The dimensions of the site are approximately 1,000 m x 500 m. Ten stations for detailed site inspections were established. Stations 1-4 were located in Area A while Stations 5-10 were located in Area B. In addition, the ~45 m buffer zone surrounding the site was surveyed. The study consisted of a visual inspection of the dominant vegetation types **and a consideration of** the possibility of the site harboring threatened and/or endangered species.

SITE DESCRIPTION

The site is located on the Ronkonkoma Moraine and consists of undulating morainal topography of relatively low relief with erratics present throughout. The elevation of the area is approximately 25 m with a total relief of ~9 m. The area of greatest relief is in the southernmost portion of the site. The site contains no areas of unusual geomorphology.

VEGETATIONAL COMMUNITIES

The southern portion of Area 1 (Stations 1-3) consists of a stand of white pine (*Pinus strobus*) apparently planted during the 1930s, most likely as a Civilian Conservation Corps project. Communities composed of planted white pine are common in Suffolk County.

Within this area, at Stations 1-3, are scattered self-sown pitch pine (*Pinus rigida*). The understory is sparse due to shade and pine needle litter, and consists of huckleberry (*Gaylussacia* sp.) with lesser amounts of blueberry (*Vaccinium* sp.). Occasional oaks (*Quercus* sp.) are found along the edges of the firebreaks and lanes in this area.

The white pines appear to have been planted only at Stations 1, 2, and a portion of Station 3. The remainder of Station 3 (approximately 50%) and all of Station 4 consists of a native oak-pine woodland.

There is evidence of extensive disturbance associated with operations at Camp Upton during the First World War. These disturbed areas include an extensive system of trenches, as well as a complex of deep pits and banks that are found within Area A and in the adjacent buffer zone. Mounded disturbed areas formed in the course of trenching operations are vegetated by large white pines. The fact that these areas were disturbed during WW I is based on the presence of the white pine planted in the 1930s, which are presently overgrowing the trenches, pits, etc.

In the vicinity of the pits and banks (Station 1, Area A) there is an assemblage of species not found elsewhere in either Area A or B. These include the introduced ornamental shrubs, Japanese barberry (*Berberis thunbergii*) and jetbead (*Rhodotypos scandens*), as well as black locust (*Robinia pseudoacacia*). The native red maple (*Acer rubrum*), wild black cherry (*Prunus serotina*), and grape (*Vitis* sp.) are also present. The presence of these species may be due to the somewhat moister conditions within the deep pits.

In the more open areas along the firebreaks and lanes throughout Area A the vegetation primarily consists of broomsedge (*Schizachyrium* sp.), sedges (*Carex* spp.), including the Pennsylvania sedge (*C. pensylvanica*) and lichens (*Cladina* sp.).

The remainder of the entire area (Stations 5-10) is composed of either pine-oak or oak-pine communities. In the pine-oak community pitch pine may compose as much as 90% of the total, while in the oak-pine communities the oaks predominate. The only obvious recruitment of new individuals is along the edges of the firebreaks and lanes where pitch pine saplings are common.

The oaks inhabiting the entire site (Areas A and B) are predominantly scarlet oak (*Q. coccinea*) and white oak (*Q. alba*), with the scarlet oak the most common. The understory in Stations 5-10 is huckleberry and blueberry with occasional individuals of scrub oak (*Q. ilicifolia*) and, rarely, highbush blueberry (*V. corymbosum*).

The northwest portion of Station 9 approaches the wetlands associated with the headwaters of the Peconic River. The community structure in this section shifts abruptly from the upland vegetation of pitch pine, white and scarlet oak to a wetland vegetation of red maple, tupelo (*Nyssa sylvatica*), swamp azalea (*Rhododendron viscosum*) and sweet pepperbush (*Clethra alnifolia*). Widely dispersed, large individual pitch pine also occur in this area.

In severely disturbed portions of Area B, where the subsoils were exposed, monospecific stands of young pitch pines are found. In addition, a borrow pit approximately one hectare in area at Station 10 is exclusively occupied by a mature stand of pitch pines.

PROTECTED NATIVE PLANTS

Protected native plants in New York State are placed in four categories by the N.Y.S.D.E.C.: 1) Endangered, 2) Threatened, 3) Exploitably Vulnerable and 4) Rare.

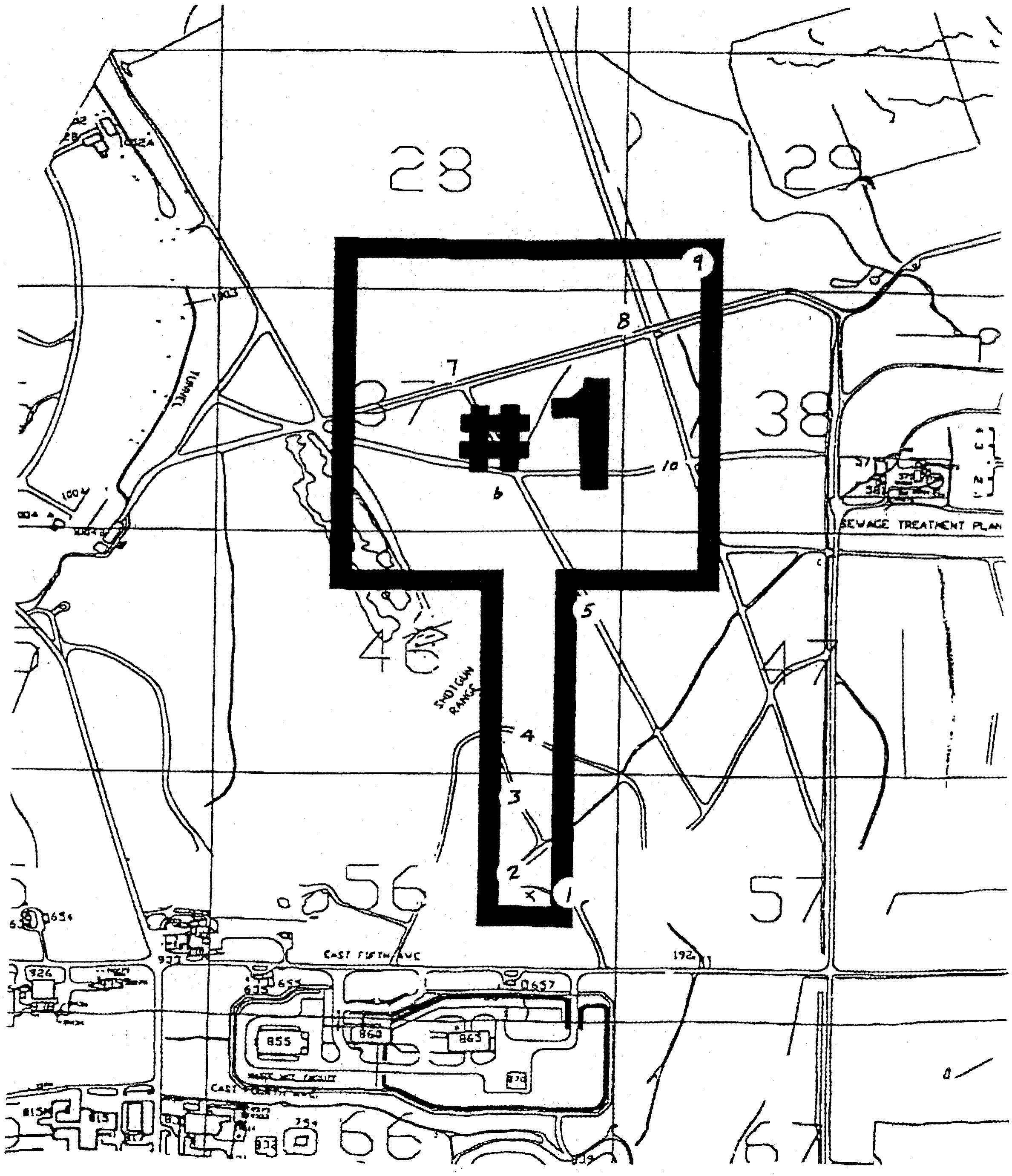
No rare, endangered or threatened species were noted during this survey. The following exploitably vulnerable species were observed on the site:

SPECIES	STATION
spotted wintergreen (*Chimaphila maculata*)*	4
bayberry (*Myrica pensylvanica*)*	6
swamp azalea (*Rhododendron viscosum*)*	9

*none of the above are uncommon on Long Island

The northwest portion of Station 9 approaches wetlands associated with the Peconic River. This area may be suitable habitat for the tiger salamander (*Ambystoma tigrinum tigrinum*) which is endangered in New York State, the spotted salamander (*A.maculatum*), a species of special concern, and the marbled salamander (*A. opacum*), the status of which is unknown in the state.

It is to be noted that this survey was conducted in mid-winter which prevents a complete evaluation of the possible presence of protected native plants on the site. However, all of the communities noted on the site proposed for the NSNS are common on Long Island.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APPENDIX E

DESCRIPTIONS OF ORNL RESEARCH PROJECTS IN THE WALKER BRANCH WATERSHED

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E. DESCRIPTIONS OF ORNL RESEARCH PROJECTS IN THE WALKER BRANCH WATERSHED

This appendix includes a response from the Oak Ridge National Laboratory (ORNL) regarding research land use on the Walker Branch Watershed. It includes brief descriptions of current and future research projects in the watershed area.

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OAK RIDGE NATIONAL LABORATORY
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March 13, 1998

Mr. Tracy C. Brown
Enterprise Advisory Services, Inc.
663 Emory Valley Road
Oak Ridge, Tennessee 37830-7751

Dear Mr. Brown:

Attached is our response to your questions regarding research land use on Walker Branch Watershed. You will note that our response in integrally linked, in the case of many projects, with determinations that will result from your information gathering with Ray Hosker and his people at NOAA/ATDD, and the modeling that I understanding your folks are doing in conjunction with them. We would appreciate the opportunity to be kept informed of modeling results as they are available, so that we might reevaluate current issues on the basis of that information.

This information reflects input and review from Drs. Amthor, Garten, Hanson, Huston, and Mulholland, all principal investigators on Walker Branch projects, and from Drs. Hildebrand, Jacobs, Loar, and myself on the Environmental Sciences Division management team.

Thank you for this opportunity to provide input to the NEPA process.

Sincerely,

David S. Shriner, Ph.D.
Head, Ecological Sciences Section
ENVIRONMENTAL SCIENCES DIVISION

DSS:lkm

Attachment

cc: J. S. Amthor
J. E. Cleaves
C. T. Garten
P. J. Hanson
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M. A. Huston
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J. M. Loar
P. J. Mulholland
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ornl - Bringing Science to Life

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Brief Description of Current Research Projects in the Walker Branch Watershed

General Comments

Walker Branch Watershed (WBW) is one of the Nation's leading long-term environmental monitoring and research sites, with greater than 30 years of record of hydrology, primary productivity, and soil chemistry measurements that serve as the baseline for quantifying forest ecosystem response to changes in climate and atmospheric deposition associated with energy technologies. The WBW is a core component of the Oak Ridge National Environmental Research Park, an ORNL user facility, which hosts researchers from numerous other federal agencies and universities who conduct research on the watershed's projects in conjunction with ORNL scientists. One of the key collaborations, is the long-term partnership with forest micrometeorologists of the NOAA Atmospheric Turbulence and Diffusion Division in Oak Ridge, and additional input should be solicited from the NOAA staff. As a general statement, evaluation of the long-term effects of SNS operation is limited by uncertainties associated with the availability of quantitative information related to SNS thermal, water vapor, and trace gas emissions, and issues such as the means by which algae associated with the cooling towers will be controlled, and possible chemical loading associated with algaecidal measures. Also unknown are issues such as the effects of large paved surfaces as a potential heat sink, or source of volatile organic compounds.

In summary, Walker Branch Watershed is a research facility whose value transcends the lifetime of individual projects, and whose value increases exponentially with time, due to the limited number of long-term sites with comparable data records. Those effects of greatest concern are those which might potentially alter the long-term record at the site in such a way as to make it less valuable. To some extent, at least, opportunity for follow-on research based on current project results could be affected, if pre- and post-SNS startup data on WBW were unable to be compared. The most important of the potential impacts of SNS siting that we can identify with the information currently available are those related to the long-term atmospheric and deposition measurements at the NOAA Tower and National Atmospheric Deposition Program sites on the WBW. A critical assumption for the watershed-scale research on biogeochemical cycling and ecosystem process-related research on the watershed is that the NADP monitoring site is representative of the entire watershed area. Because of the location of these monitoring stations with respect to the proposed SNS, it is possible that the spatial representativeness of these sites would be altered, requiring additional monitoring on the watershed to quantify the level of impact and to recalibrate watershed-level inputs. Additionally, there is uncertainty associated with potential impacts to the groundwater hydrology of the Walker Branch Catchment through the possibility of construction impacts on subsurface communication of hydrologic systems under the ridge, which could impact the long-term streamflow record if it were to occur.

Current Research

1. **Throughfall Displacement Experiment (TDE)**. This major experiment for the DOE Program for Ecosystem Research involves forest stand-level experiments that are being used to understand the mechanisms of forest ecosystem response to changes in regional rainfall that may result from a warming global climate. This work focuses on belowground tree response, and mechanisms of whole plant water use, carbon utilization and drought tolerance of the deciduous forest tree species which make up the forest at the experimental site. Objectives of this project are to test for the occurrence of these mechanisms at the stand level, to determine which tree species/genera exhibit the greatest adaptive potential by the use of these mechanisms, and to determine whether the survival of various tree species is enhanced by these adaptive mechanisms.

   - affected by SNS construction? No.
   - affected by SNS operation? Not expected to be. Important uncertainty is spatial extent and magnitude of water vapor and temperature impacts of cooling towers.
   - affected by SNS closure? No.

2. **Long-Term Ecological Measurements of Ecosystem Response**. Measurements of hydrologic inputs and outputs, forest biomass and species composition, and soil chemistry have been made on WBW over the past 30 years. These long-term measurements are being made to quantify the response of the forest ecosystem to changes in climate and atmospheric deposition that are expected to occur. Specific measurements being made include precipitation volume and chemistry, dry deposition quantity and chemistry, vegetation biomass and species composition, soil chemistry, streamflow, and stream water chemistry. These measurements support DOE's (1) local, regional, and global research, and (2) environmental restoration activities (baseline measurements). The measurements are also used to test and extrapolate results from the Walker Branch climate change experiment (TDE) to the ecosystem and watershed scales. These measurements will provide the catchment-scale input/output budgets for new process-level research on nitrogen cycling and retention in the forest and stream ecosystems of Walker Branch. Wet and dry deposition measurements are part of the long-term, 200 site National Atmospheric Deposition Program, National Trends Network (NADP/NTN), and the associated Mercury Deposition Network (MDN) and Atmospheric Integrated Research Monitoring Network (AIRMON) sites. The mercury deposition monitoring site is one of 18 such sites nationwide, while the AIRMON site is one of nine. The Walker Branch NADP/NTN site is approaching 20 years of continuous operation as a precipitation chemistry monitoring station.
   - affected by SNS construction?
     - — potentially, by dust deposition - NADP/NTN, MDN, AIRMON
     - — hydrology- potentially, if construction impacts subsurface systems.
     - — productivity - No

2

- affected by SNS operation?
  - NADP/NTN, MDN, AIRMON - potentially, if results in change in amount of wet deposition at site because of water from cooling tower.
  - hydrology, productivity - Not expected to be impacted unless fog events are very frequent.
  - will chemicals/algaecides be used to maintain cooling towers?
- affected by SNS closure? No.

3. **Terrestrial Feedbacks to Regional Hydrologic Budgets**. Walker Branch Watershed is one of five primary sites for this work. This project seeks to enhance understanding of the contributions of closed-canopy, deciduous forest stands to local/regional hydrologic budgets. We are establishing a distributed set of instrumented forest plots across the Ohio-Tennessee watershed for continuous, multi-year monitoring of climate variables, soil water conditions, and tree and forest stand evapotranspiration. Measurements at these sites will be used to derive mechanistic relationships between total canopy conductance and environmental variables, and to test models of atmosphere-soil-plant hydrologic flux. The research will provide critical, multi-year data on temporal and spatial dynamics of terrestrial evapotranspiration and multi-depth soil water dynamics for upland hardwood forest ecosystems. These data will resolve the range of day-to-day and site-to-site variability in evapotranspiration to be expected throughout much of the eastern United States. The data from this project will also be shared with research groups of the GEWEX Continental-scale International Project (GCIP) to enhance the data bases against which they can test macro- and mesoscale climate models.

- affected by SNS construction? No.
- affected by SNS operation? No.
  - project completed before operation begins; follow-up measurements may or may not be comparable
- affected by SNS closure? No.

4. **Nitrogen Uptake, Retention, and Cycling in Stream Ecosystems: An Intersite ^{15}N Tracer Experiment**. The work being conducted in Walker Branch involves: (1) short-term (several hours) injections of a conservative tracer and application of a transient storage model to define hydrodynamic characteristics, (2) short-term injections of nutrients (NH_4, NO_3, PO_4) to determine relative uptake lengths of different nutrients and potential N deficiency, (3) whole-stream measures of gross primary productivity (GPP) and community respiration (R) to define stream metabolic characteristics, and (4) long-term (6 weeks) additions of $^{15}NH_4$ at tracer levels to measure temporal and spatial (longitudinal) dynamics of nitrogen uptake, retention, and cycling rates through the stream ecosystem. The Walker Branch experiment began in April 1997 and will continue for about one year. Data from the Walker Branch experiment will be used with data from similar experiments at eight other sites to test hypotheses concerning relationships

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between N uptake, cycling, and turnover and stream hydrodynamics, chemistry, and metabolism.

- affected by SNS construction, operation, or closure? No. This project will be completed in FY 1999. Nitrogen dynamics is a long-term area of priority research for WBW.

5. __Development of Gene Probes for Nitrate Reduction in Environmental Media: A Tool to Evaluate Nitrogen Retention in Watersheds__. This research is developing and field testing molecular detection and quantification methods for assimilatory and dissimilatory nitrate reductase in environmental media (soils, aquatic sediments). Signature gene sequences for specific nitrate reductase types are being identified and used to amplify natural DNA and mRNA templates for quantification of biomass and activity. These methods will then be tested across natural gradients in nitrate availability in forest soils and stream sediments.

   - affected by SNS construction, operation, or closure? No; project completed in FY 1999.

6. __Experimental and Theoretical Studies on the Seasonal, Annual, and Inter-Annual Exchange of Water Vapor and Energy Exchange by a Temperate Forest Ecosystem in the Mississippi River Basin__. This project addresses a GCIP program objective to determine and explain seasonal, annual and inter-annual variability of water and energy cycles in the eastern portion of the Mississippi River basin. Our overarching goal is to use micrometeorological (eddy covariance), physiological (sap-flow) and hydrological (watershed) methods to quantify the seasonal and inter-annual rates of water vapor and energy exchange over a temperate, deciduous, broad-leaved forest, and ecosystem of major significance in the Mississippi River basin. This approach will allow us to study the impact of environmental, phenological, and ecological factors on the intra- and inter-annual variations of water vapor exchange at three important spatial scales, the tree, the canopy, and the watershed. In conjunction with this project, two coupled land-atmosphere energy exchange models are being developed and tested (CANVEG and INTRASTAND), that account for phenology and water deficits. Then, using a ten-year record of climate data, the roles of climate, phenology and leaf area are being examined on the year to year range of annual evaporation and energy balance partitioning.

   - affected by SNS construction, operation, or closure? No; project completes in FY 2000. Eddy covariance portion of project is done by NOAA/ATDD. Seek their comments on potential impact to eddy covariance measurements, as they are relevant to that portion of this project, as well, and would potentially affect follow-on work based on this line of investigation.

7. **Theoretical Studies of the Annual Exchange of CO_2 and Energy by a Temperate Forest Ecosystem**. A detailed model of deciduous forest ecosystem physiology and physics (LaRS) is being used to simulate responses of the forest near the NOAA/ATDD forest meteorology research site on Walker Branch Watershed to the environmental factors of air temperature, rainfall, wind speed, solar irradiance, atmospheric humidity, and atmospheric CO_2 concentration. The model simulations will be compared to independent measurements made at the research site. The model includes submodels of: leaf phenology and growth, bole growth, root growth, leaf respiration, bole respiration, root respiration, soil respiration, leaf photosynthesis, and photorespiration, soil surface evaporation, stomatal conductance, transpiration and root water uptake, soil surface sensible heat exchange, canopy sensible heat exchange, canopy radiation balance, soil surface radiation balance, vertical water transport within the soil profile, vertical heat transport within the soil profile, and ecosystem momentum exchange. The ultimate aim of model development and testing is to provide tools capable of realistically predicting terrestrial ecosystem responses to increasing atmospheric CO_2 concentration and any associated climate change. This capability is important because terrestrial ecosystem responses to global environmental change may be significant to the global carbon cycle and therefore, global climate.

- affected by SNS construction, operation, or closure? Potentially; Current project completed in FY 1999. However, a continuation proposal is anticipated. This work is linked to eddy covariance measurements conducted by NOAA/ATDD, and future work would potentially be impacted accordingly (seek NOAA/ATDD comments in this regard).

8. **Use of Multiscale Biophysical Models for Ecological Assessment: Applications in the Southeast**. Integrated biophysical models are being used to evaluate the predictable variability in four fundamental indicators of ecosystem condition: (1) spatial and temporal variation in primary productivity; (2) spatial variation in soil carbon and hydrologic storage capacity; (3) population size and dynamics of selected plant and animal species; and (4) bioaccumulation of lipophilic compounds in terrestrial and aquatic food webs. The basic physical models and model structure will be scale-independent, and applicable to scales ranging from first order watersheds to continents, with appropriate functional algorithms and parameterization. Implementations of the modeling system are being developed and tested at four spatial scales in the southeastern United States: $150km^2$, $2000km^2$, $150,000km^2$, and the entire southeast. Primary data collection for net primary productivity and soil carbon and nitrogen dynamics are being collected on Walker Branch Watershed.

- affected by SNS construction, operation, or closure? Not expected to be; current project completes in FY 1999, but follow-on work possible.

9. **Global Carbon Cycle Studies — Forest Soil Carbon Dynamics: Field Experiments and Model Validation**. Storage and properties of forest soil organic matter are being investigated along an elevation/climate gradient in the Southern Appalachian Mountains. Six sites, including Walker Branch Watershed on the ORNERP, were selected to span a range of temperature and moisture regimes, a range of soil N availability, and a range of forest community types. The sites were characterized with respect to differences in soil texture, pH, and aboveground carbon inputs. Soil moisture, air and soil temperatures, and the forest floor carbon dioxide flux were measured at regular intervals. Bulk soil carbon and nitrogen concentrations were measured to a depth of 30 cm. Patterns of abundance of ^{13}C in forest litter inputs, fine roots, and soil carbon at different depths were examined. Two climate variables are continuously monitored at each study site: (1) air temperature; and (2) soil temperature at a 10 cm soil depth. Between sampling intervals, throughfall is measured at each site as and indicator of precipitation inputs.

- affected by SNS construction, operation, or closure? No expected effects.

Brief Description of Future Research Projects in the Walker Branch Watershed

The projects listed below are of two categories above and beyond the continuation of projects listed as currently ongoing. The first of these categories is projects for which funding proposals are pending; and the second, a category of activities which are in Environmental Sciences Division Strategic Planning goals and objectives, but for which funding proposals do not yet exist.

Proposals Pending

1. **Ecosystem Effects of Climate Change: Experimental Alteration of the Spatio-Temporal Pattern of Net Primary Productivity in a Deciduous Forest Ecosystem**. This project proposes to experimentally simulate the large-scale effects of atmospheric changes on the net primary productivity (NPP) of an eastern deciduous forest and its streams, with a focus on the ecosystem impacts of changes in the spatial and temporal variability in NPP that we expect will result from the manipulation. The proposed experiment is a multi-disciplinary collaboration between Oak Ridge National Laboratory and the University of Tennessee, which is submitting a separate proposal that will address ecological responses to the NPP alteration. This proposal focuses on establishing and maintaining the experimental treatments and quantifying both the driving variables and ecosystem responses in order to develop a mechanistic understanding of ecosystem responses to climate change at the landscape scale. The experiment will alter the mean level and spatial variability of soil nitrogen and phosphorus in replicated forested catchments. All catchments on both Pine Ridge (3) and Chestnut Ridge (1, WBW) will have a northwest aspect, and extend from ridgetop to valley bottom.

- affected by SNS construction? Catchment on WBW potentially impacted by dry deposition input during construction from dust, primarily. Could impact spatial variability in the experimental area, an element of the experiment. Impacts will be quanitfiable and would be negligible if control and treatment areas are equally affected.

- affected by SNS operation? All sites depend on precipitation chemistry and amount data currently measured at WBW NADP site. Experiment is planned for up to 10 years, so could potentially be impacted if NADP site is affected by SNS operation (currently unknown). This is important, since the NADP site is currently assumed to be representative of the local terrain., If operation should result in a localized effect on that monitoring site, it would negate that assumption, and would also compromise the long-term value of the site's data. Other historical and inactive deposition monitoring sites exist on WBW. Those sites could be activated to test impacts of SNS construction and operation on our single active NADP site and to cross-calibrate that site, but this would require additional funds. To mitigate impacts on this proposed project, additional, more intensive monitoring sites would need to be added for the WBW and Pine Ridge catchments.

- affected by SNS closure? No.

2. **Ecosystem Effects of Climate Change: Responses to Experimental Alteration of the Spatio-Temporal Pattern of Net Primary Productivity in a Deciduous Forest Ecosystem**. This project will evaluate responses to altered NPP at several trophic levels in both the terrestrial and aquatic portions of the ecosystem. It will use recently-implemented methods for estimating Leaf Area Index (LAI) from LandSat imagery to quantify the spatiotemporal dynamics of canopy leaf area responses to variation in nitrogen and water across the experimental and control catchments (described above). Plant responses at the herbaceous, subcanopy, and canopy levels will be quantified using a combination of methods to measure structural components and patterns of NPP. Animal responses will be evaluated using forest floor, canopy, and stream invertebrates, as well as small mammal populations. This project is a companion to the one described above, and is interdependent on it.

   - affected by SNS construction, operation, or closure? See comments above.

3. **Retention and Fate of Atmospheric Nitrogen Deposition in Forests: Tracer ^{15}N Addition Experiments in Forests of Contrasting Nitrogen Status**. Retention and fate of atmospheric nitrogen deposition to forests will be studied by conducting pulse ^{15}N addition experiments in tow forests of contrasting nitrogen status; Walker Branch on the Oak Ridge National Environmental Research Park, a highly nitrogen deficient forest, and Noland Divide in the Great Smokey Mountains National Park, a nitrogen saturated forest. Tracer-level additions of ^{15}N as nitrate and as ammonium will be made to forest plots

during rainfall events in winter and again in summer each year for three years. Uptake and incorporation of ^{15}N in various ecosystem nitrogen pools will be measured over time following each ^{15}N addition. The research will test hypotheses dealing with mechanisms responsible for uptake and retention of nitrogen deposition and differences in retention and fate of N in forests of differing nitrogen status.

- affected by SNS construction, operation, or closure? Project depends on input characterizations from NADP site. This work will be completed by FY 2001, but long-term research on nitrogen dynamics in deciduous forest ecosystems is a priority area of research for WBW. Potential for impacts on follow-on research could be managed by additional, more intensive deposition monitoring.

4. **The Effect of Field-Scale Climate Manipulation on the Dynamics of Dissolved Organic Matter in Soil: Implications for Soil Carbon Pools**. Comparisons of paired control- and climate-manipulation regimes will assess differences in the concentration and chemical nature of dissolved organic matter (DOM) in soil and shallow groundwater, determine decomposition rates of DOM, measure differences in the flux of DOM mobilized from soil through storm flow, and evaluate the interactive effects of altered CO_2, precipitation, and temperature on the fate and transport of DOM in soil using the TDE and FACE sites. These data form the basis of innovative approaches to carbon management, in which soils would be managed to optimize processes favoring the sequestration of large pools of carbon with long turnover times.

- affected by SNS construction, operation, or closure? Not anticipated at the present time, pending better information on potential temperature, water vapor, and hydrologic impacts. Project completion scheduled for FY 2001, but soil carbon management is a priority area for long-term research initiatives on WBW.

Strategic Initiatives

In addition to the future projects above, the Environmental Sciences Division Strategic Plan identifies Large Scale Environmental Process Research as a priority area in the future of the Division. This priority is based, in large part on the historical record of research and understanding of the ecological processes regulating ecosystem structure and function on the Oak Ridge NERP, including WBW. The research park is the cornerstone for large field experimental campaigns for decades to come. Future initiatives will include:

- A Large-scale manipulation of the interacting stress factors associated with climate change: Temperature, precipitation, carbon dioxide, and nutrient status.

- A major initiative in belowground science; understanding the physical, biological, and chemical environment of the belowground ecosystem.

- Climate warming manipulations, terrestrial and aquatic.
- Nitrogen dynamics of a deciduous forest ecosystem.
- Soil carbon management, carbon sequestration in forest ecosystems.
- The baseline of research and monitoring activities on the WBW are intended to contribute to a new national, interagency program for long-term ecosystem monitoring, with the experimental catchments on the Oak Ridge NERP as an index site in that network.

At the present time, it is not possible to speculate on the potential affect that the SNS might have on these initiatives, however given the concern over atmospheric measurements, and uncertainties that currently exist, it is likely that there would be some level of effect of the SNS siting that would need to be assessed relative to these future initiatives.

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APPENDIX F

ATMOSPHERIC DISPERSION AND DOSE CALCULATIONS FOR NORMAL AND ACCIDENT CONDITIONS

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F. ATMOSPHERIC DISPERSION AND DOSE CALCULATIONS FOR NORMAL AND ACCIDENT CONDITIONS

F.1 INTRODUCTION

This appendix describes the data, methods, and assumptions used to estimate dose to workers and to the public from emissions of radioactive and toxic materials from the SNS. The steps in estimating dose are as follows:

- Identify and quantify emissions (source terms),
- Identify and select human exposure pathways,
- Analyze transport of contaminants through each exposure pathway, and
- Calculate dose.

This sequence of steps was repeated several times as new or more realistic data became available and assumptions refined. The purpose of these dose calculations is to provide reasonable but conservative dose estimates that allow impacts of the alternative actions analyzed in the EIS to be compared.

The radionuclides that would be discharged into the environment by the SNS would be produced in spallation reactions initiated by the high-energy protons generated in the linac. These reactions occur in cascades or "stars" as fragments and neutrons from atomic nuclei struck by high-energy protons strike and react with other atoms until the energy of the initial collision is dissipated. The spectrum of radionuclides and the number of neutrons produced by spallation depend on the energy and intensity of the proton beam and the nature of the material it strikes.

The purpose of the mercury target is to generate neutrons by spallation. The radionuclides formed directly by spallation and by reactions with the neutrons in the target and surrounding materials are waste products. A small fraction of the particles in the beam would also escape from the confining magnetic fields and induce spallation reactions in the components and structures in the linac, beam storage, beam transfer tunnels, in the beam stops, and in the target areas.

Many of the spallation products are short-lived and some decay through a chain of radioactive atoms. Several of the products are isotopes of mercury with decay chains consisting mainly of relatively short-lived progeny that are not usually encountered in dose assessments. Several of these decay chains have progeny with half-lives somewhat longer than their parent and comparable to the time required to travel from the SNS to potential receptors. As a result, the radiological characteristics of a plume of these spallation products can change significantly as it moves through the environment.

F.2 Source Terms for Normal and Accident Conditions

This section provides a summary discussion of source terms for normal and accident conditions at the SNS and tables listing source terms for individual radionuclides. A report providing the details of the bases for these source terms is included as Appendix A of this EIS.

F.2.1 Radionuclide Inventories

Radionuclide inventories used to derive source terms are based on a 1 MW beam power. Source terms for 4 MW operations assume that the specific activity (Ci/g, Ci/ml) of the materials released is four times the specific activity at 1 MW. Inventories for source terms for isotopes of mercury and iodine released from irradiated mercury assume that the SNS operates continuously at 1 MW beam power for 30 years with a single charge of mercury. Radionuclide inventories for source terms for other systems assume continuous operation at 1 MW for 1 year.

Both assumptions are conservative. When the particle beam is turned on, the activities of radionuclides begin to increase towards a "steady state" unique to each radionuclide and dependant on the beam power and intensity. Many nuclides reach a steady state after days, or even hours, of irradiation; however, some do not attain a steady state even after 30 years of continuous irradiation. The particle beam would be switched on and off many times over the 40-year life of the facility, and would be off much more than on; therefore, these inventories become increasingly conservative as the time necessary for a radionuclide to reach steady state increases. Inventories used to estimate source terms of specific radionuclides may be found in References 1 and 2 and in Appendix A of this EIS.

F.2.2 Normal Conditions

Source terms for annual emissions of normal operations from the Tunnel Confinement Exhaust Stack and the Target Building Exhaust Stack are shown in Table F-1. The base source terms were provided by the Department of Energy (DOE) (DeVore 1998b; DeVore 1998a) and have been adjusted when necessary for particle beam power. With the exception of mercury releases from the target cell (discussed below), DOE reduced radionuclide inventories by an availability factor of 0.559. This factor assumes that the beam is on 85 percent of the 240 days per year that the SNS is projected to be in use.

Assumptions on facility design are presented in the Conceptual Design Report (ORNL 1997a). For upgrade from 1 MW to 4 MW, a linear scaling of off-gases from the cooling system and the target are anticipated. Off-gases from the beam stops and exhausts from the various tunnels through the Tunnel Confinement Exhaust do not scale linearly, because of specifics of the proposed upgrade design.

F.2.2.1 Tunnel Confinement Exhaust

Radionuclides discharged from the Tunnel Confinement Exhaust Stack are gases and concrete dust particles activated as a result of beam interactions in the tunnels. Only a few have half-lives as long as a few minutes. It was estimated that, on average, 28.5 seconds would elapse between activation and discharge of the air (DeVore 1998a). The source term shown in Table F-1 reflects this decay.

F.2.2.2 Target Building Exhaust

Source terms for releases from the Target Building Exhaust include the affects of radioactive decay ingrowth, off-gas treatment, and HEPA filtration.

Table F-1
Projected Annual Emissions of Radionuclides from SNS Facilities During Normal Operations.

	Target Building Exhaust (Ci)						Tunnel Confinement Exhaust (Ci)	
	Cooling Systems[a]		Target Off-Gas[a]		Beam Stops[b]		Linac, Ring, and Beam Transfer Tunnels[b]	
Nuclides[c]	**1 MW**	**4 MW**	**1 MW**	**4 MW**	**1 MW**	**4 MW**	**1 MW**	**4 MW**
H-3	2.76E-00	1.11E+01	2.24E+01	8.96E+01	2.39E-00	4.46E-00	1.22E-07	1.22E-07
He-6	0	0	0	0	0	0	1.50E-08	2.36E-08
Li-8	0	0	0	0	0	0	1.31E-08	1.73E-08
Be-7	3.14E-03	1.26E-02	0	0	0	0	0	0
Be-10	2.62E-10	1.05E-09	0	0	0	0	0	0
C-10	0	0	0	0	0	0	2.55E+01	4.04E+01
C-11	0	0	0	0	0	0	4.06E+01	6.04E+01
C-14	1.33E-01	5.31E-01	0	0	1.37E-02	2.56E-02	1.08E-04	1.08E-04
N-13	0	0	0	0	0	0	3.18E+02	4.83E+02
N-16	0	0	0	0	0	0	7.92E-00	1.15E+01
O-14	0	0	0	0	0	0	8.99E+01	1.33E+02
O-15	0	0	0	0	0	0	3.41E+02	5.19E+02
F-18	5.85E-10	2.34E-09	0	0	0	0	0	0
F-20	0	0	0	0	0	0	2.97E-02	2.97E-02
Ne-23	0	0	0	0	0	0	1.90E-02	1.90E-02
Na-22	2.07E-08	8.29E-08	0	0	0	0	1.12E-02	1.12E-02
Na-24	0	0	0	0	0	0	2.46E-00	2.46E-00
Mg-27	0	0	0	0	0	0	1.05E-01	1.05E-01
Al-26	3.99E-13	1.60E-12	0	0	0	0	1.69E-06	1.69E-06
Al-28	0	0	0	0	0	0	8.61E-00	8.61E-00
Al-29	0	0	0	0	0	0	2.70E-02	2.70E-02
Si-31	0	0	0	0	0	0	7.34E-01	7.34E-01
Si-32	2.78E-10	1.11E-09	0	0	0	0	0	0
P-32	3.43E-08	1.37E-07	0	0	0	0	0	0
P-33	1.85E-09	7.40E-09	0	0	0	0	0	0
S-35	9.03E-09	3.61E-08	0	0	0	0	0	0
Cl-36	5.58E-12	2.23E-11	0	0	0	0	1.81E-06	1.81E-06
Cl-38	0	0	0	0	0	0	5.21E-04	5.21E-04
Ar-37	1.26E+02	5.02E+02	0	0	2.50E+02	4.67E+02	3.81E-01	3.81E-01
Ar-39	1.46E-01	5.83E-01	0	0	2.06E-01	3.85E-01	1.27E-02	1.27E-02
Ar-41	0	0	0	0	0	0	9.70E-04	9.70E-04
Ar-42	7.87E-02	3.15E-01	0	0	2.66E-02	4.97E-02	1.05E-06	1.05E-06
K-38	0	0	0	0	0	0	7.02E-04	7.02E-04
K-40	2.90E-15	1.16E-14	0	0	0	0	3.15E-07	3.15E-07

Table F-1
Projected Emissions of Radionuclides from SNS Facilities During Normal Operations. (Continued)

	Target Building Exhaust (Ci)						Tunnel Confinement Exhaust (Ci)	
	Cooling Systems[a]		Target Off-Gas[a]		Beam Stops[b]		Linac, Ring, and Beam Transfer Tunnels[b]	
Nuclides[c]	1 MW	4 MW	1 MW	4 MW	1 MW	4 MW	1 MW	4 MW
K-42	5.91E-13	2.37E-12	0	0	0	0	1.00E-00	1.00E-00
K-43	1.46E-12	5.85E-12	0	0	0	0	2.94E-04	2.94E-04
K-44	0	0	0	0	0	0	5.44E-04	5.44E-04
Ca-41	7.33E-11	2.93E-10	0	0	0	0	3.16E-03	3.16E-03
Ca-45	3.36E-08	1.35E-07	0	0	0	0	7.30E-01	7.30E-01
Ca-47	1.72E-10	6.90E-10	0	0	0	0	1.56E-03	1.56E-03
Ca-49	0	0	0	0	0	0	8.00E-02	8.00E-02
Sc-43	2.75E-22	1.10E-21	0	0	0	0	0	0
Sc-44	1.06E-21	4.23E-21	0	0	0	0	0	0
Sc-46	1.42E-07	5.70E-07	0	0	0	0	0	0
Sc-47	1.94E-08	7.77E-08	0	0	0	0	1.57E-03	1.57E-03
Sc-48	1.30E-09	5.19E-09	0	0	0	0	0	0
Sc-49	0	0	0	0	0	0	7.97E-02	7.97E-02
Ti-44	1.24E-08	4.97E-08	0	0	0	0	0	0
Ti-45	2.97E-26	1.19E-25	0	0	0	0	0	0
V-48	1.86E-06	7.45E-06	0	0	0	0	0	0
V-49	4.10E-06	1.64E-05	0	0	0	0	0	0
V-50	3.06E-22	1.22E-21	0	0	0	0	0	0
Cr-48	1.87E-10	7.49E-10	0	0	0	0	0	0
Cr-51	2.34E-04	9.35E-04	0	0	0	0	3.42E-04	3.42E-04
Mn-52	4.10E-06	1.64E-05	0	0	0	0	3.21E-05	3.21E-05
Mn-53	1.27E-10	5.07E-10	0	0	0	0	7.49E-09	7.49E-09
Mn-54	1.33E-05	5.30E-05	0	0	0	0	5.15E-03	5.15E-03
Mn-56	1.34E-28	5.35E-28	0	0	0	0	5.85E-03	5.85E-03
Fe-52	3.00E-14	1.20E-13	0	0	0	0	0	0
Fe-55	3.24E-04	1.29E-03	0	0	0	0	5.69E-01	5.69E-01
Fe-59	7.07E-06	2.83E-05	0	0	0	0	1.72E-02	1.72E-02
Fe-60	2.96E-13	1.18E-12	0	0	0	0	0	0
Co-55	4.87E-09	1.95E-08	0	0	0	0	0	0
Co-56	4.91E-05	1.96E-04	0	0	0	0	0	0
Co-57	1.15E-04	4.60E-04	0	0	0	0	0	0
Co-58	4.09E-05	1.64E-04	0	0	0	0	0	0
Co-60	5.11E-06	2.05E-05	0	0	0	0	0	0
Ni-56	1.03E-06	4.11E-06	0	0	0	0	0	0

Table F-1
Projected Emissions of Radionuclides from SNS Facilities During Normal Operations. (Continued)

	Target Building Exhaust (Ci)						Tunnel Confinement Exhaust (Ci)	
	Cooling Systems[a]		Target Off-Gas[a]		Beam Stops[b]		Linac, Ring, and Beam Transfer Tunnels[b]	
Ni-57	7.30E-07	2.92E-06	0	0	0	0	0	0
Ni-59	2.06E-06	8.23E-06	0	0	0	0	0	0
Ni-63	2.56E-04	1.02E-03	0	0	0	0	0	0
Ni-65	5.82E-26	2.33E-25	0	0	0	0	0	0
Cu-61	6.07E-25	2.43E-24	0	0	0	0	0	0
Cu-64	9.94E-14	3.98E-13	0	0	0	0	0	0
Sb-119	0	0	2.42E-02	9.67E-02	0	0	0	0
Te-119	0	0	1.67E-02	6.70E-02	0	0	0	0
Te-121	0	0	2.38E-02	9.53E-02	0	0	0	0
Te-123	0	0	1.61E-01	6.43E-01	0	0	0	0
I-121	0	0	4.96E-26	1.98E-25	0	0	0	0
I-122	0	0	5.22E-04	2.09E-03	0	0	0	0
I-123	0	0	4.43E-04	1.77E-03	0	0	0	0
I-124	0	0	5.69E-04	2.27E-03	0	0	0	0
I-125	0	0	3.91E-02	1.56E-01	0	0	0	0
I-129	0	0	3.58E-10	1.43E-09	0	0	0	0
I-130	0	0	1.76E-05	7.05E-05	0	0	0	0
Xe-122	0	0	1.04E-00	4.17E-00	0	0	0	0
Xe-123	0	0	1.72E-23	6.87E-23	0	0	0	0
Xe-125	0	0	1.18E-00	4.71E-00	0	0	0	0
Xe-127	0	0	8.05E+01	3.22E+02	0	0	0	0
Hg-192	0	0	1.19E-02	4.77E-02	0	0	0	0
Hg-193	0	0	4.84E-03	1.94E-02	0	0	0	0
Hg-194	0	0	2.25E-02	9.01E-02	0	0	0	0
Hg-195	0	0	1.21E-01	4.84E-01	0	0	0	0
Hg-197	0	0	3.60E-00	1.44E+01	0	0	0	0
Hg-203	0	0	3.29E-00	1.32E+01	0	0	0	0
Total	1.29E+02	5.15E+02	1.12E+02	4.50E+02	2.52E+02	4.72E+02	8.37E+02	1.26E+03

[a] DeVore 1998i.
[b] DeVore 1998h.
[c] Nuclides with activities of less than 1.0 x 10^{-30} Ci are not shown.

F.2.2.3 Cooling Water Systems

The source term for cooling water systems (DeVore 1998b) includes the contributions of D_2O and H_2O cooling water systems in the Target Building and H_2O cooling water systems in the beam stops. It includes two components: off-gas consisting of H-3 vapor and gaseous radionuclides, and mist from cooling water assumed to be at 90ºF. The mist was assumed to contain entrained activated metal corrosion products from the systems being cooled and to have the same radionuclide concentrations as the liquid low-level waste (see Section 4, Appendix A).

Mist eliminators in the system were assumed to have an efficiency of 70 percent. Emissions were assumed to occur over a 24-hour period, each time quarterly maintenance would be performed. Radionuclides emissions would be decayed for a total of 8 days before release (24 hours of emission evolution and 7 days hold-up in the decay tank). The total annual emissions are shown in Table F-1.

F.2.2.4 Beam Stop Emissions

Beam stop emissions were assumed to consist of activated air in the beam stop buildings and to be discharged via the gas decay tanks after 7 days total decay (DeVore 1998a). Emissions from cooling water systems in the beam stops are included in the previous source term.

F.2.2.5 Target Off-Gas Emissions

The source term for Target Off-Gas combines the tritium vapor, xenon gas, and mercury vapor in target off-gas with mercury vapor and mercuric iodide evaporating from mercury spilled in a target cell during target change-outs (DeVore 1998b). DOE assumed that iodine in the target would be chemically bound in non-volatile compounds of mercury.

Target off-gases would be collected and processed in the hot off-gas and off-gas decay systems. Air from the target cell would be vented through the cell ventilation system. The source term for mercury is based on its vapor pressure at –20º C, the temperature of the Mercury chiller/condenser, and off-gas system flow rate. The small quantity of mercury vapor that would not be condensed was assumed to decay for 7 days before release. The source term does not include the ingrowth of mercury progeny during this 7 days. Source terms for tritium and xenon were based on the quantities of these radionuclides generated in the first 10 seconds of irradiation. The quantities were corrected for decay of xenon and ingrowth of iodine over the 7 days required to fill a decay tank and the 7 additional days of decay before the tank would be discharged (DeVore 1998b). The tellurium and antimony progeny were assumed to be in equilibrium with their parents. It was assumed that HEPA filters and iodine absorbers would remove 99.95 percent of xenon progeny.

Mercury and mercuric iodide releases from the target cell were based on the vapor pressure of mercury at the temperatures and air flow rate in the cell. The mercury was assumed to be present as small droplets that accumulate each time the target mercury is replaced. The evaporation rate was based on the surface area of these droplets. It was assumed that there would be a 24-hour delay prior to each change-out to allow the system to cool completely and the short-lived radionuclides to decay. The availability factor was not applied to the target cell component.

Table F-2 Summary of SNS accident scenarios and source terms[a].

ID	Event	Hazard	Driving Force	Barriers[b]	Frequency[c]	Source Term[d]	Duration
			A. Accidents Involving the SNS Target or Target Components				
1	Loss of Particle Beam focus or directional control (Appendix A, Section 3.1)	Radionuclides and Hg in target	Heating of target by proton beam	a) Automatic beam cutoff system	Anticipated	None	None
				b) Operator manual beam cutoff	Extremely Unlikely	Bounded by Event 3b	Bounded by Event 3b
2	Major loss of integrity of Hg Target Vessel or piping (Appendix A, Section 3.2)	Radionuclides and Hg in target	Hg pump	a) Automatic beam cutoff system, Mercury enclosure	Unlikely	Percent Inventory Mercury Iodine 0.002 0.002 0.14 0.14 0.142 0.142	 Interval 0 - 10 min 10 min - 3 days
				b) None	Extremely Unlikely	Percent Inventory Mercury Iodine 0.015 0.015 0.19 33 0.038 67 0.243 100.	 Interval 0 - 10 min 10 min - 10 days 10 - 30 days
3	Loss of Hg flow in Target (Appendix A, Section 3.3)	Radionuclides and Hg in target	Heating of target by proton beam	a) Automatic beam cutoff system	Anticipated	None	None
				b) Operator manual beam cutoff	Beyond Extremely Unlikely	Bounded by Event 16	Bounded by Event 16

Table F-2 Summary of SNS accident scenarios and source terms[a] - Continued.

ID	Event	Hazard	Driving Force	Barriers[b]	Frequency[c]	Source Term[d]	Duration
4	Loss of water flow in Hg Target Heat Exchanger (Appendix A, Section 3.4)	Radionuclides and Hg in target	Heating of target by proton beam	a) Automatic beam cutoff system	Anticipated	None	None
				b) Operator manual cutoff	Extremely Unlikely	Bounded by Event 3b	Bounded by Event 3b
5	Loss of water flow in Target Cooling Shroud (Appendix A, Section 3.5)	Radionuclides in target cooling water	Heating of target by proton beam	a) Automatic beam cutoff system	Anticipated	None	None
				b) Operator manual beam cutoff	Extremely Unlikely	Bounded by Event 8	Bounded by Event 8
6	Loss of water flow to Proton Beam Window (Appendix A, Section 3.6)	Radionuclides in cooling water	Heating of window by proton beam	a) Automatic beam cutoff system	Anticipated	None	None
				b) Operator manual beam cutoff	Extremely Unlikely	Bounded by Event 8	Bounded by Event 8
7	Loss of water flow to Target Component Cooling Loop (Appendix A, Section 7)	Radionuclides in cooling water	Heating of core vessel components by proton beam	a) Automatic beam cutoff system	Anticipated	None	None
				b) Operator manual cutoff	Unlikely	Bounded by Event 8	Bounded by Event 8

Table F-2 Summary of SNS accident scenarios and source terms[a] - Continued.

ID	Event	Hazard	Driving Force	Barriers[b]	Frequency[c]	Source Term[d]	Duration
				c) None	Extremely Unlikely	Bounded by Event 16	Bounded by Event 16
8	Loss of integrity in Target Component Cooling Loop (Appendix A, Section 3.8)	Radionuclides in cooling water	Heating of core vessel components by proton beam	a) Stack monitor	Anticipated	Bounded by annual release limits	Bounded by annual release limits
				b) Complete evaporation (utility vault)	Anticipated	Gases + Mist + 150 L of D_2O	5 min 30 min
				c) Complete evaporation (core vessel)	Anticipated	18 L of D_2O	30 days
				d) Complete evaporation	Anticipated	Gases + Mist + 150 L of H_2O	5 min 30 min
9	Loss of integrity in Cryogenic Moderator (Appendix A, Section 3.9)	Hydrogen gas	Hydrogen pressure in moderator system	None	Extremely Unlikely	No radionuclides.	Not specified
10	Loss of Core Vessel integrity (Appendix A, Section 3.10)	Activated air	Helium pressure in system	None	Unlikely	Not specified	Not specified
11	Loss of He flow to Core Vessel (Appendix A, Section 3.11)	Activated air	Helium pressure in system	None	Anticipated	Not specified	Not specified
12	Loss of Target Cell Ventilation (Appendix A, 3.12)	Mercury and radionuclides in Hg off-gas	Gaseous diffusion	None	Anticipated	Not specified	Not specified

Table F-2 Summary of SNS accident scenarios and source terms[a] - Continued.

ID	Event	Hazard	Driving Force	Barriers[b]	Frequency[c]	Source Term[d]	Duration
13	Loss of Offsite Power (Appendix A, Section 3.13)	Not specified	None	See Events 1 through 12	Not specified	Bounded by Events 1 through 12	Bounded by Events 1 through 12
14	Fire (Appendix A, Section 3.14)	See Events 1 through 12	Heating and/or Events 1 through 12	See Events 1 through 12	Not specified	Bounded by Events 1 through 13	Bounded by Events 1 through 13
15	Natural Phenomena (Appendix A, Section 3.15)	Mercury and radionuclides in target, radionuclides in cooling water, activated air	Tornadoes and earthquakes	None	Unlikely	Bounded by Events 1 through 14	Bounded by Events 1 through 14
16	Beyond Design Basis Hg Spill (Appendix A, Section 3.16)	Radionuclides and Hg in target	a) Heating by 1-MW proton beam plus decay heat	None	Beyond Extremely Unlikely	Percent Inventory Mercury / Iodine 0.0066 / 14.0 0.80 / 20.0 0.30 / 60.0 1.11 / 100.	 Interval 0 - 10 min 1 - 7 days 7 - 30 days
		Radionuclides and Hg in target	b) Heating by 4-MW proton beam plus decay heat	None	Beyond Extremely Unlikely	Percent Inventory Mercury / Iodine 0.183 / 14.0 0.800 / 20.0 0.300 / 60.0 1.28 / 100.	 Interval 0 - 10 min 1 - 7 days 7 - 30 days
			B. Accidents Involving SNS Waste Systems				
17	Hg Condenser Failure (Appendix A, Section 4.1.1)	Hg radionuclides in off-gas	Offgas blowers	None	Anticipated	13.7 g mercury	48 hours

Table F-2 Summary of SNS accident scenarios and source terms[a] - Continued.

ID	Event	Hazard	Driving Force	Barriers[b]	Frequency[c]	Source Term[d]	Duration
18	Hg Charcoal Absorber Failure [e] (Appendix A, Section 4.1.2)	Hg radionuclides in offgas	Offgas blowers	Stack monitor	Unlikely	14.8 g mercury	10 days
19	He Circulator Failure (Appendix A, Section 4.2.1)	Tritium in offgas	Offgas blowers	Circulator replacement	Anticipated	1 day tritium production	24 hours
20	Oxidation of Getter Bed (Appendix A, Section 4.2.2)	Tritium in offgas	Offgas blowers	Bed replacement	Unlikely	1 day tritium production	24 hours
21	Combustion of Getter Bed (Appendix A, Section 4.3.1)	Tritium absorbed on bed, depleted uranium in bed.	Combustion	Complete combustion	Extremely Unlikely	1 year tritium production, 200 g depleted uranium	1 hour
22	Failure of Cryogenic Charcoal Absorber [f] (Appendix A, Section 4.4.1)	Noble gases and iodine	Offgas blowers	System repair	Unlikely	1 day xenon production	24 hours
23	Valve sequence error in Tritium Removal System (Appendix A, Section 4.5.1)	Tritium accumulated in system	Offgas blowers	None	Unlikely	1 year tritium production	20 min
24	Valve sequence error in Offgas Decay System (Appendix A, Section 4.5.2)	Radionuclides accumulated in decay tank	Offgas blowers	None	Anticipated	7 days xenon accumulation (1 decay tank)	1 hour

Table F-2 Summary of SNS accident scenarios and source terms[a] - Continued.

ID	Event	Hazard	Driving Force	Barriers[b]	Frequency[c]	Source Term[d]	Duration
25	Spill during filling of tanker truck for LLLW[g] Storage Tanks (Appendix A, Section 4.5.3)	Radionuclides in tank	Evaporation and diffusion	Tank vault and HEPA filters	Anticipated	0.00005% of contents of LLLW tank	1 hour
26	Spray during filling of tanker truck for LLLW[g] (Appendix A, Section 4.5.6)	Radionuclides in tank	Pressure in transfer pipe	Operator cutoff and HEPA filters	Anticipated	1.9 mil of LLLW	20 min
27	Spill during filling of tanker truck for Process Waste Storage Tanks[g] (Appendix A, Section 4.5.5)	Radionuclides in tank.	Transfer pump	None	Anticipated	51,100 L Process Waste to surface water + 57 L to atmosphere	3.5 hours
28	Spray during filling of tanker truck for Process Waste[g] (Appendix A, Section 4.5.7)	Radionuclides in tank	Pressure in transfer pipe	Operator cutoff	Anticipated	28.4 L of Process Waste	20 min
29	Offgas Treatment pipe break (Appendix A, Section 4.6.1)	Radionuclides in target offgas	Cell ventilation blowers	Pipe repair	Unlikely	24 hours xenon production	24 hours
30	Offgas Compressor Failure (Appendix A, Section 4.6.2)	Radionuclides in target offgas.	Cell ventilation blowers	Compressor repair	Unlikely	1 hour xenon production	1 hour

Table F-2 Summary of SNS accident scenarios and source terms[a] - Continued.

ID	Event	Hazard	Driving Force	Barriers[b]	Frequency[c]	Source Term[d]	Duration
31	Offgas Decay Tank Failure (Appendix A, Section 4.6.3)	Radionuclides in target offgas	Cell ventilation blowers	None	Extremely Unlikely	7 days xenon accumulation	1 min
32	Offgas Charcoal Filter Failure (Appendix A, Section 4.6.4)	Iodine radionuclides in target offgas	Offgas blowers	None	Unlikely	7 days iodine production	24 hours
33	LLLW System piping failure (Appendix A, Section 4.6.5)	Radionuclides in waste.	Pumping	Linac tunnel and HEPA filters	Unlikely	0.00005% of contents of LLLW tank	1 hour
34	LLLW Storage Tank Failure (Appendix A, Section 4.6.6)	Radionuclides in tank	Gravity	Tank vault and HEPA filters	Extremely Unlikely	0.00005% of contents of LLLW tank	1 hour
35	LLLW pump failure (Appendix A, Section 4.6.7)	Radionuclides in waste	Gravity	Backup pumps and pump containment	Anticipated	None	None
36	Process Waste System piping failure (Appendix A, Section 4.6.8)	Radionuclides in waste	Pumping	None	Anticipated	10% of annual flow (no airborne release specified)	1 year
37	Process Waste Storage Tank Failure (Appendix A, Section 4.6.9)	Radionuclides in tank	Gravity	Dike/sump	Extremely Unlikely	57 L to atmosphere	1 hour
38	Process Waste System pump failure (Appendix A, Section 4.6.10)	Radionuclides in waste	Gravity	Backup pumps and pump containment?	Anticipated	None	None

Table F-2 Summary of SNS accident scenarios and source terms[a] - Continued.

ID	Event	Hazard	Driving Force	Barriers[b]	Frequency[c]	Source Term[d]	Duration
39	LLLW Transportation Accident [g] (Appendix A, Section 4.7.1)	Radionuclides in 800 gal LR-56 tanker truck	Collision/gravity	None	Extremely Unlikely 1.8×10^{-8}/trip 1.0×10^{-6}/year	800 gal LLLW (no airborne release specified)	24 hours
40	Process Waste Transportation Accident [g] (Appendix A, Section 4.7.2)	Radionuclides in 15,000 gal tanker truck	Collision/gravity	None	Unlikely 1.8×10^{-6} /trip 2.0×10^{-5}/year	15,000 gal process waste (no airborne release specified.	1 hour

[a] This table was compiled as a summary of information prepared by Lockheed Martin Energy Research (LMER) (refer to Sections 3.0 and 4.0 of Appendix A).

[b] The barriers listed are those that are assumed to prevent or terminate the release of radioactive or hazardous materials. Generally, one or more additional barriers such as HEPA filters or automatic alarms are present but have been ignored to increase the conservatism of the estimated source terms.

[c] Refer to Table 5.1.9-2 for the numerical ranges associated with accident frequencies categories.

[d] Source terms are expressed in units that are independent of power level. Except for Beyond Design Basis accidents (ID 16a, 16b), the radioactivity released in accidents at 4 MW is four times that released at 1 MW.

[e] Installation of sulfur-impregnated charcoal filters is being considered to serve as a "polishing filter" for the Mercury Condenser (refer to Event 17).

[f] Cryogenic charcoal absorbers are being considered as an alternative to the offgas compressor, decay storage tanks, and ambient temperature charcoal filters (see Events 24, 30, 31, and 32).

[g] Accidents involving tanker truckers are applicable for an SNS facility at ORNL where liquid wastes would be trucked to existing facilities for treatment but may not be applicable for a facility at LANL, ANL, or BNL. Frequencies may differ based on the size of tankers and distances traveled at the other sites.

F.2.3 Accident Conditions

A total of 40 accident scenarios are described in Appendix A and summarized in Table F-2. This is not an indication that the proposed SNS would be a particularly accident-prone facility, but is the result of the rigorous hazard analysis that DOE requires even for low-hazard facilities such as the proposed SNS. Since the proposed SNS is still in the conceptual design stage and dose estimates had not been made previously for these potential accidents, the full set of accident scenarios has been retained in this EIS. Secondary stages of some accidents are conservatively assumed to last from 7 to 30 days, while in reality, administrative and emergency response actions would more probably terminate the release in a shorter time period.

The bases for the source terms used for accident conditions are discussed in Sections 3.0 and 4.0 of Appendix A of this EIS. The source terms in Appendix A do not always explicitly show the activity of each radionuclide. This is done here in Tables F-3 through F-11 for accident scenarios that release radioactive materials to the atmosphere. Each table assigns an accident ID, identifies the section of Appendix A where the basis for the source term is discussed, lists the nature and frequency of occurrence of the accident event, lists the duration and total activities of each radionuclide released in each stage of the accident, and lists the total duration and activities for each accident.

All source terms discussed in this section would be released from the Target Building Exhaust Stack except for that for the LLLW pipe break in the linac tunnel (Tunnel Confinement Exhaust Stack) and all process waste source terms (ground-level releases assumed near the Target Building).

F.2.3.1 Mercury Spills

Table F-3 lists source terms for spills of irradiated mercury that could occur within the limits established by the design basis for the target system. The activities shown are for a beam power of 1 MW and would be four times greater at a beam power of 4 MW. Table F-4 lists source terms for beyond-design-basis spills at power levels of 1 MW and 4 MW. In addition to the 4:1 ratio in activities, the 4 MW source term assumes boiling of the mercury during the first stage of the accident (refer to Exhibit F of Appendix A). Both sets of source terms are bounding source terms for reasonably foreseeable mercury spills that could occur within or beyond the design basis.

The radionuclide activities shown in these tables reflect adjustment of the source terms from Appendix A to account for radioactive decay. Decay to the mid-point of the cumulative accident duration at the end of each phase was used to approximate the average release rate for each phase. Since the model for these source terms assumes that only mercury and mercuric iodide are volatile, their progeny are not included in the source terms; however, they were taken into account in the transport and dose calculations. (Sections F.4 and F.5).

F.2.3.2 Cooling Water System Leaks

Bounding source terms for accident involving leaks in the D_2O and H_2O cooling systems are listed in Table F-5. Leaks in the Utility Vault are assumed to be rapid (i.e., pipe breaks) so that dissolved gases would be released suddenly. The leak in the Core Vessel is assumed to be a slow leak so that dissolved gases are released at essentially the same rate as under normal conditions and can, therefore, be ignored. The activities shown correspond to the beginning of the release. Decay to the appropriate mid-points was performed during transport calculations.

F.2.3.3 Off-Gas Decay System Failures

Bounding source terms for accidents involving failures of the Off-Gas Decay System are listed in Table F-6. Cryogenic Charcoal failure is included here since the primary function of this device is to condense and hold relatively short-lived radionuclides until they decay. It is a alternative to the decay tanks. Source terms involving the Decay Tank (ID 24, 31) were assumed to occur immediately after the tank is filled. These source terms account for decay of xenon and ingrowth of iodine as the tank is filled and assume that tellurium and antimony progeny are in equilibrium with their iodine parents. All activities correspond to the beginning of the release. Decay during release is accounted for in the transport calculations.

Table F-3.
Source Terms for Design Basis Target Mercury Spill Scenarios.

ID [a]				2a				2b
Section [b]				3.2				3.2
Event	Spill Contained in Hg Enclosure				Spill Not Contained in Hg Enclosure			
Probability [c]				Unlikely				Extremely Unlikely
Duration [d] **(sec)**	600	690,600	0	691,200	600	863,400	1,728,000	2,592,000
Nuclide	**Ci**	**Ci**	**Ci**	**Total Ci**	**Ci**	**Ci**	**Ci**	**Total Ci**
I-119	1.16E-04	0	0	1.16E-04	8.72E-04	0	0	8.72E-04
I-120	1.95E-04	5.54E-24	0	1.95E-04	1.46E-03	5.81E-27	0	1.46E-03
I-121	3.97E-04	6.65E-16	0	3.97E-04	2.98E-03	6.13E-17	0	2.98E-03
I-122	2.59E-04	0	0	2.59E-04	1.94E-03	0	0	1.94E-03
I-123	7.40E-04	3.45E-04	0	1.09E-03	5.55E-03	2.32E-02	1.13E-09	2.88E-02
I-124	3.39E-04	1.33E-02	0	1.37E-02	2.54E-03	2.72E+00	7.34E-01	3.46E+00
I-125	1.49E-03	9.92E-02	0	1.01E-01	1.11E-02	2.31E+01	3.98E+01	6.30E+01
I-126	6.75E-05	3.83E-03	0	3.89E-03	5.06E-04	8.55E-01	8.28E-01	1.68E+00
I-128	6.01E-05	0	0	6.01E-05	4.51E-04	0	0	4.51E-04
I-129	1.77E-10	1.24E-08	0	1.26E-08	1.33E-09	2.92E-06	5.93E-06	8.85E-06
I-130	3.37E-05	1.09E-05	0	4.46E-05	2.53E-04	6.68E-04	8.89E-12	9.21E-04
Hg-180	1.38E-29	0	0	1.38E-29	1.03E-28	0	0	1.03E-28
Hg-181	5.86E-25	0	0	5.86E-25	4.39E-24	0	0	4.39E-24
Hg-182	7.58E-11	0	0	7.58E-11	5.68E-10	0	0	5.68E-10
Hg-183	1.26E-11	0	0	1.26E-11	9.42E-11	0	0	9.42E-11
Hg-184	8.27E-06	0	0	8.27E-06	6.20E-05	0	0	6.20E-05
Hg-185	1.14E-04	0	0	1.14E-04	8.56E-04	0	0	8.56E-04
Hg-186	1.25E-03	0	0	1.25E-03	9.40E-03	0	0	9.40E-03
Hg-187	6.25E-03	0	0	6.25E-03	4.69E-02	0	0	4.69E-02
Hg-188	1.96E-02	0	0	1.96E-02	1.47E-01	0	0	1.47E-01
Hg-189	5.02E-02	0	0	5.02E-02	3.77E-01	0	0	3.77E-01
Hg-190	9.24E-02	0	0	9.24E-02	6.93E-01	0	0	6.93E-01
Hg-191	1.27E-01	0	0	1.27E-01	9.49E-01	0	0	9.49E-01
Hg-192	1.77E-01	1.42E-05	0	1.77E-01	1.33E+00	6.29E-07	1.96E-28	1.33E+00
Hg-193	2.06E-01	3.72E-07	0	2.06E-01	1.54E+00	6.37E-09	0	1.54E+00
Hg-194	2.26E-02	1.58E+00	0	1.61E+00	1.70E-01	2.15E+00	4.30E-01	2.75E+00
Hg-195	3.46E-01	2.91E-02	0	3.75E-01	2.59E+00	7.34E-03	8.67E-14	2.60E+00
Hg-197	2.32E+00	5.76E+01	0	5.99E+01	1.74E+01	6.03E+01	3.20E-01	7.81E+01
Hg-203	1.65E+00	1.09E+02	0	1.11E+02	1.24E+01	1.46E+02	2.37E+01	1.82E+02
Hg-205	4.10E-02	0	0	4.10E-02	3.07E-01	0	0	3.07E-01
Total	5.06E+00	1.68E+02	0	1.73E+02	3.80E+01	2.35E+02	6.58E+01	3.39E+02

[a] Accident identification number from Table 5.1.9-3.
[b] Section number of Appendix A of this EIS.
[c] See Table 5.1.9-2 for numerical ranges corresponding to description.
[d] Time over which activity is released for an accident scenario. Release occurs in more than one phase for some scenarios.

Table F-4
Source Terms for Beyond Design Basis Target Mercury Spill Scenarios.

ID[a]				16a				16b
Section[b]				3.16				3.16
Event	Loss of Hg Flow/Delayed Beam Cutoff (1 MW)				Loss of Hg Flow/Delayed Beam Cutoff (4 MW)			
Probability[c]	Reasonably Foreseeable				Reasonably Foreseeable			
Duration[d] **(sec)**	600	604,200	1,987,200	2,592,000	600	604,200	1,987,200	2,592,000
Nuclide	**Ci**	**Ci**	**Ci**	**Total Ci**	**Ci**	**Ci**	**Ci**	**Total Ci**
I-119	8.14E-01	0	0	8.14E-01	3.26E+00	0	0	3.26E+00
I-120	1.36E+00	3.75E-19	0	1.36E+00	5.45E+00	1.50E-18	0	5.45E+00
I-121	2.78E+00	4.80E-12	0	2.78E+00	1.11E+01	1.92E-11	0	1.11E+01
I-122	1.81E+00	0	0	1.81E+00	7.25E+00	0	0	7.25E+00
I-123	5.18E+00	9.23E-02	1.69E-10	5.27E+00	2.07E+01	3.69E-01	6.77E-10	2.11E+01
I-124	2.37E+00	2.05E+00	5.83E-01	5.00E+00	9.48E+00	8.18E+00	2.33E+00	2.00E+01
I-125	1.04E+01	1.43E+01	3.85E+01	6.32E+01	4.16E+01	5.70E+01	1.54E+02	2.53E+02
I-126	4.73E-01	5.61E-01	7.54E-01	1.79E+00	1.89E+00	2.24E+00	3.01E+00	7.15E+00
I-128	4.21E-01	0	0	4.21E-01	1.68E+00	0	0	1.68E+00
I-129	1.24E-06	1.77E-06	5.84E-06	8.85E-06	4.95E-06	7.08E-06	2.34E-05	3.54E-05
I-130	2.36E-01	3.05E-03	1.16E-12	2.39E-01	9.45E-01	1.22E-02	4.65E-12	9.57E-01
Hg-180	4.54E-29	0	0	4.54E-29	5.04E-27	0	0	5.04E-27
Hg-181	1.93E-24	0	0	1.93E-24	2.14E-22	0	0	2.14E-22
Hg-182	2.50E-10	0	0	2.50E-10	2.77E-08	0	0	2.77E-08
Hg-183	4.15E-11	0	0	4.15E-11	4.60E-09	0	0	4.60E-09
Hg-184	2.73E-05	0	0	2.73E-05	3.03E-03	0	0	3.03E-03
Hg-185	3.76E-04	0	0	3.76E-04	4.17E-02	0	0	4.17E-02
Hg-186	4.14E-03	0	0	4.14E-03	4.59E-01	0	0	4.59E-01
Hg-187	2.06E-02	0	0	2.06E-02	2.29E+00	0	0	2.29E+00
Hg-188	6.46E-02	0	0	6.46E-02	7.17E+00	0	0	7.17E+00
Hg-189	1.66E-01	0	0	1.66E-01	1.84E+01	0	0	1.84E+01
Hg-190	3.05E-01	0	0	3.05E-01	3.38E+01	0	0	3.38E+01
Hg-191	4.18E-01	7.63E-29	0	4.18E-01	4.63E+01	3.05E-28	0	4.63E+01
Hg-192	5.84E-01	4.49E-04	9.14E-30	5.85E-01	6.48E+01	1.80E-03	3.65E-29	6.48E+01
Hg-193	6.79E-01	1.89E-05	0	6.79E-01	7.53E+01	7.56E-05	0	7.53E+01
Hg-194	7.47E-02	9.05E+00	3.39E+00	1.25E+01	8.28E+00	3.62E+01	1.36E+01	5.80E+01
Hg-195	1.14E+00	3.85E-01	5.49E-14	1.53E+00	1.26E+02	1.54E+00	2.20E-13	1.28E+02
Hg-197	7.66E+00	3.75E+02	1.71E+00	3.84E+02	8.49E+02	1.50E+03	6.85E+00	2.36E+03
Hg-203	5.45E+00	6.27E+02	1.83E+02	8.15E+02	6.04E+02	2.51E+03	7.31E+02	3.84E+03
Hg-205	1.35E-01	0	0	1.35E-01	1.50E+01	0	0	1.50E+01
Total	4.26E+01	1.03E+03	2.28E+02	1.30E+03	1.96E+03	4.11E+03	9.10E+02	6.98E+03

Table F-5
Source Terms for Target Cooling Water Systems Failures.

ID[a]			8b			8c			8d
Section[b]			3.8			3.8			3.8
Event	Heavy Water Leak in Utility Vault			Heavy Water Leak in Core Vessel			Light Water Leak in Utility Vault		
Probability[c]			Anticipated			Anticipated			Anticipated
Duration[d] (sec)	300	1,800	2,100	2,592,000	0	2,592,000	300	1,800	2,100
Nuclide	**Ci**	**Ci**	**Total Ci**	**Ci**	**Ci**	**Total Ci**	**Ci**	**Ci**	**Total Ci**
H-3	1.88E+01	1.88E+02	2.06E+02	2.25E+01	0	2.25E+01	1.89E+00	1.88E+01	2.06E+01
Be-7	1.62E-03	0	1.62E-03	0	0	0	1.62E-03	0	1.62E-03
C-14	1.39E-05	0	1.39E-05	0	0	0	1.39E-05	0	1.39E-05
N-13	1.09E+02	0	1.09E+02	0	0	0	1.09E+02	0	1.09E+02
O-14	6.40E+00	0	6.40E+00	0	0	0	6.40E+00	0	6.40E+00
O-15	1.43E+02	0	1.43E+02	0	0	0	1.43E+02	0	1.43E+02
V-49	1.38E-05	0	1.38E-05	0	0	0	1.38E-05	0	1.38E-05
Mn-54	4.39E-05	0	4.39E-05	0	0	0	4.39E-05	0	4.39E-05
Fe-55	1.39E-03	0	1.39E-03	0	0	0	1.39E-03	0	1.39E-03
Fe-59	2.44E-06	0	2.44E-06	0	0	0	2.44E-06	0	2.44E-06
Co-56	5.24E-05	0	5.24E-05	0	0	0	5.24E-05	0	5.24E-05
Co-57	3.59E-04	0	3.59E-04	0	0	0	3.59E-04	0	3.59E-04
Co-58	3.68E-05	0	3.68E-05	0	0	0	3.68E-05	0	3.68E-05
Co-60	2.33E-05	0	2.33E-05	0	0	0	2.33E-05	0	2.33E-05
Ni-63	1.24E-03	0	1.24E-03	0	0	0	1.24E-03	0	1.24E-03
Total	2.77E+02	1.88E+02	4.65E+02	2.25E+01	0	2.25E+01	2.60E+02	1.88E+01	2.79E+02

Table F-6
Source Terms for Off-Gas Decay System Failure Scenarios.

ID[a]	22	24	29	30	31
Section[b]	4.4.1	4.5.2	4.6.1	4.6.2	4.6.3
Event	Cryogenic Charcoal Failure	Decay Tank Valve Sequence Error	Off-Gas Pipe Break	Off-Gas Compressor Failure	Decay Tank Failure
Probability[c]	Unlikely	Anticipated	Unlikely	Unlikely	Extremely Unlikely
Duration[d] **(sec)**	86,400	3,600	86,400	3,600	60
Nuclide	**Ci**	**Ci**	**Ci**	**Ci**	**Ci**
H-3	1.10E-01	7.69E-01	1.10E-01	4.58E-03	7.69E-01
C-10	4.38E-03	3.07E-02	4.38E-03	1.83E-04	3.07E-02
C-11	3.23E-01	2.26E+00	3.23E-01	1.35E-02	2.26E+00
C-14	1.62E-04	1.14E-03	1.62E-04	6.77E-06	1.14E-03
N-13	1.36E+00	9.51E+00	1.36E+00	5.66E-02	9.51E+00
N-16	1.23E-02	8.63E-02	1.23E-02	5.14E-04	8.63E-02
O-14	3.29E-01	2.30E+00	3.29E-01	1.37E-02	2.30E+00
O-15	6.14E+00	4.30E+01	6.14E+00	2.56E-01	4.30E+01
Ar-37	1.80E-01	1.26E+00	1.80E-01	7.51E-03	1.26E+00
Ar-39	1.78E-04	1.25E-03	1.78E-04	7.42E-06	1.25E-03
Ar-41	4.63E-03	3.24E-02	4.63E-03	1.93E-04	3.24E-02
Ar-42	9.59E-05	6.71E-04	9.59E-05	4.00E-06	6.71E-04
Sb-119	4.49E-07	3.23E+00	4.49E-07	1.87E-08	3.23E+00
Te-119	2.61E-03	3.23E+00	2.61E-03	1.09E-04	3.23E+00
Te-121	9.59E-07	1.69E+00	9.59E-07	4.00E-08	1.69E+00
Te-123m	4.58E-07	1.14E+01	4.58E-07	1.91E-08	1.14E+01
I-119	2.92E+01	3.23E+00	2.92E+01	1.22E+00	3.23E+00
I-120	6.11E-01	1.78E+00	6.11E-01	2.55E-02	1.78E+00
I-121	3.81E-01	1.69E+00	3.81E-01	1.59E-02	1.69E+00
I-122	2.64E+00	1.18E+01	2.64E+00	1.10E-01	1.18E+01
I-123	1.37E-01	1.14E+01	1.37E-01	5.71E-03	1.14E+01
I-125	4.74E-04	2.47E+01	4.74E-04	1.97E-05	2.47E+01
Xe-119	4.50E+02	3.23E+00	4.50E+02	1.87E+01	3.23E+00
Xe-120	4.26E+01	1.78E+00	4.26E+01	1.77E+00	1.78E+00
Xe-121	4.15E+01	1.69E+00	4.15E+01	1.73E+00	1.69E+00
Xe-122	9.62E+00	1.18E+01	9.62E+00	4.01E-01	1.18E+01
Xe-123	9.28E+01	1.14E+01	9.28E+01	3.87E+00	1.14E+01
Xe-125	3.52E+01	3.67E+01	3.52E+01	1.47E+00	3.67E+01
Xe-127	4.77E-01	3.17E+00	4.77E-01	1.99E-02	3.17E+00
Total	7.13E+02	2.03E+02	7.13E+02	2.97E+01	2.03E+02

Table F-7
Source Terms for Mercury Removal System Failure Scenarios.

ID [a]	17	18
Section [b]	4.1.1	4.1.2
Event	Hg Condensor Failure	Hg Charcoal Absorber Failure
Probability [c]	Anticipated	Unlikely
Duration [d] **(sec)**	172,800	864,000
Nuclide	**Ci**	**Ci**
Hg-184	1.20E-04	1.30E-04
Hg-185	1.91E-04	2.06E-04
Hg-186	5.25E-04	5.68E-04
Hg-187	1.11E-03	1.20E-03
Hg-188	2.47E-03	2.67E-03
Hg-189	4.29E-03	4.63E-03
Hg-190	5.43E-03	5.87E-03
Hg-191	6.84E-03	7.40E-03
Hg-192	9.01E-03	9.74E-03
Hg-193	9.77E-03	1.06E-02
Hg-194	5.71E-04	6.17E-04
Hg-195	1.77E-02	1.91E-02
Hg-197	1.18E-01	1.28E-01
Hg-203	8.46E-02	9.15E-02
Hg-205	3.64E-03	3.94E-03
Total	2.65E-01	2.86E-01

Table F-8
Source Terms for Tritium Removal System Failure Scenarios.

ID[a]	19	20	21	23
Section[b]	4.2.1	4.2.2	4.3.1	4.5.1
Event	He Circulator Failure	Oxidation of Tritium Getter Bed	Combustion of Tritium Getter Bed	Valve Sequence Error
Probability[c]	Anticipated	Unlikely	Extremely Unlikely	Unlikely
Duration[d] **(sec)**	86,400	86,400	3,600	1,200
Nuclide	**Ci**	**Ci**	**Ci**	**Ci**
H-3	4.58E-01	4.58E-01	4.00E+03	4.00E+03
U-234	0	0	1.25E-05	0
U-235	0	0	8.48E-07	0
U-236	0	0	3.88E-07	0
U-238	0	0	8.10E-05	0
Total	4.58E-01	4.58E-01	4.00E+03	4.00E+03

Table F-9
Source Term for Iodine Removal System Failure Scenario.

ID [a]	32
Section [b]	4.6.4
Event	Off-Gas Charcoal Filter Failure
Probability [c]	Unlikely
Duration [d] **(sec)**	86,400
Nuclide	**Ci**
I-119	2.92E+01
I-120	6.11E-01
I-121	3.81E-01
I-122	2.64E+00
I-123	1.37E-01
I-125	4.74E-04
Total	3.29E+01

Table F-10
Source Terms for Liquid Low-Level Waste System Failure Scenarios.

ID [a]	25	26	33	34
Section [b]	4.5.3	4.5.6	4.6.5	4.6.6
Event	Spill Filling Tanker Truck	Spray Filling Tanker Truck	Pipe Break in Linac Tunnel	Storage Tank Failure
Probability [c]	Anticipated	Anticipated	Unlikely	Extremely Unlikely
Duration [d] **(sec)**	3,600	1,200	3,600	3,600
Nuclide	**Ci**	**Ci**	**Ci**	**Ci**
H-3	4.96E-03	2.48E-02	4.96E-03	4.96E-03
Be-7	2.03E-05	1.01E-06	2.03E-05	2.03E-05
C-14	1.74E-07	8.71E-09	1.74E-07	1.74E-07
V-49	1.73E-07	8.65E-09	1.73E-07	1.73E-07
Mn-54	5.48E-07	2.74E-08	5.48E-07	5.48E-07
Fe-55	1.74E-05	8.68E-07	1.74E-05	1.74E-05
Fe-59	3.04E-08	1.52E-09	3.04E-08	3.04E-08
Co-56	6.55E-07	3.27E-08	6.55E-07	6.55E-07
Co-57	4.49E-06	2.24E-07	4.49E-06	4.49E-06
Co-58	4.60E-07	2.30E-08	4.60E-07	4.60E-07
Co-60	2.91E-07	1.46E-08	2.91E-07	2.91E-07
Ni-63	1.55E-05	7.73E-07	1.55E-05	1.55E-05
Total	5.02E-03	2.48E-02	5.02E-03	5.02E-03

Table F-11
Source Terms for Liquid Process Waste System Failure Scenarios.

ID[a]	27	28	37
Section[b]	4.5.5	4.5.7	4.6.9
Event	Storage Tank Failure	Spray Filling Tanker Truck	Spill Filling Tanker Truck
Probability[c]	Extremely Unlikely	Anticipated	Anticipated
Duration[d] **(sec)**	12,600	1,200	3,600
Nuclide	**Ci**	**Ci**	**Ci**
H-3	7.31E-05	3.66E-05	7.31E-05
Be-7	5.53E-05	2.77E-05	5.53E-05
C-14	5.01E-08	2.51E-08	5.01E-08
V-48	6.92E-09	3.46E-09	6.92E-09
V-49	4.52E-08	2.26E-08	4.52E-08
Cr-51	1.53E-08	7.65E-09	1.53E-08
Mn-52	1.40E-07	7.33E-09	1.40E-07
Mn-54	2.17E-12	1.09E-12	2.17E-12
Fe-55	5.94E-08	2.97E-08	5.94E-08
Fe-59	5.09E-06	2.54E-06	5.09E-06
Co-56	1.57E-07	7.87E-08	1.57E-07
Co-57	9.01E-07	4.50E-07	9.01E-07
Co-58	1.91E-06	9.53E-07	1.91E-06
Co-60	7.69E-07	3.84E-07	7.69E-07
Ni-59	0	2.56E-07	0
Ni-63	3.58E-08	1.79E-08	3.58E-08
Total	1.38E-04	6.90E-05	1.38E-04

F.2.3.4 Off-Gas Treatment System Failures

Tables F-7 through F-9 list bounding source terms for accidents involving failures of systems designed to remove mercury, tritium, and iodine from target off-gas. The Mercury Charcoal Absorber (Table F-7) is not currently part of the design but may be added if conditions warrant.

F.2.3.5 Liquid Low-Level Waste (LLLW) System Failures

Bounding source terms for failures of the LLLW System that result in releases to the atmosphere are listed in Table F-10. These source terms are the only ones that assume filtration by HEPA filters. All activities correspond to the beginning of the release. Decay during release is accounted for in the transport calculations.

F.2.3.6 Process Waste System Failures

Bounding source terms for failures of the Process Waste System that result in releases to the atmosphere are listed in Table F-11. All activities correspond to the beginning of the release. Decay during release is accounted for in the transport calculations.

F.2.3.7 Source Terms Not Considered

All of the source terms discussed in the preceding subsection are released directly to the atmosphere and were used in evaluating health impacts in this EIS. Appendix A includes four accident scenarios that involve direct releases to soil. One of these accidents also includes a release to surface water as well as a release to air. The release to air was included. This subsection provides the basis for excluding these additional source terms from consideration.

Section 4.5.5 of Appendix A discusses an “anticipated” spill of the contents of a Process Waste Storage Tank. The airborne source term for this accident is included in Table F-11. The scenario also assumes that 13,500 gal of process waste overflows the curb around the tank, enters the retention basin, and enters the receiving stream. The discharge points of the retention basins at the other SNS alternative sites are not specified. Other accident scenarios assume that only members of the public beyond the ORR boundary and boundaries of the other sites would be exposed. In addition, this EIS only considers exposures that are an immediate result of accidents (Section F.3). Accordingly, only the airborne source term applicable to all sites has been included in the health impacts assessment.

Section 4.6.8 of Appendix A discusses an “anticipated” break of an underground process waste pipe that releases 10 percent of the annual volume of process waste underground. It is assumed that the leak is discovered after one year. The scenario does not postulate that the liquid released pools on the surface of the ground or enters the groundwater system or discuss the depth of soil over the release. Since there is no surface pooling, the radioactivity released could reach humans only via groundwater transport. Any radionuclides would move in the direction of groundwater flow. Tritium would migrate at the velocity of groundwater flow and C-14 at a somewhat slower rate. Migration of other radionuclides in the waste would move much more slowly and could require many years to reach a location where human exposure could occur. Most of these radionuclides would decay to negligible concentrations before such migration could occur.

Section 4.7.1 of Appendix A discusses a transportation accident involving the release of LLLW from the LR-56 tanker truck and Section 4.7.2 discusses a similar accident involving process waste. Both accidents assume a total loss of tanker contents but do not postulate airborne release. The LR-56 is essentially a DOT Type B transport package with a capacity of 800 gallons but is not certified as such in the United States. No radioactive material has ever been released in a transportation accident involving a certified Type B package. The process waste tanker has a capacity of 15,000 gallons and no special resistance to severe transportation accidents. Based on the annual number of trips, the LLLW accidents would be "extremely unlikely" and the process waste accident would be "unlikely." In the absence of an airborne source term, it is unlikely that humans would be accidentally exposed before the spill was immobilized and assessed, and any appropriate remedial actions taken.

F.3 Selection of Exposure Pathways

This section identifies the potential pathways for exposure of human to radioactive materials that would or could be released from the SNS and discusses the rationale for selecting these pathways. This information is also applicable to assessment of the toxic effects of exposures to mercury.

Summary

This EIS evaluates health impacts of normal operations and accidents based on two exposure pathways for workers and the public:

- Inhalation of radionuclides released to air.
- Immersion in air containing radionuclides released to air.
- Ingestion of foods contaminated by radionuclides released to air.

For accidents, the ingestion pathway would be a delayed impact and impacts could, therefore, be controlled by impoundment of foodstuffs and by remedial actions.

Discussion

Radioactive materials released during normal and accident conditions may be released to air, soil, surface water, and/or groundwater. Each of these media have a number of primary and secondary exposure pathways that may be important. Which exposure pathways are important depends on the radiological characteristics of the radionuclides and the quantities of each released and on how the radionuclides would be diluted or concentrated as they are transferred from one medium or pathway to another.

All radioactive and toxic materials released to the environment during normal SNS operations are released to the atmosphere. The majority of the releases are continuous throughout the year. Under these conditions, the primary potential exposure pathways and groups exposed are:

- Inhalation of radionuclides released to air (workers, public),

- Immersion in air containing radionuclides released to air (workers, public), and

- Ingestion of foods contaminated by radionuclides released to air (public).

The ingestion pathway could include a number of sub-pathways. Radionuclides deposited on the surfaces of leafy plants could be absorbed by the plants and radionuclides deposited on the ground surface could be taken up by the roots of plants. Once in the plants, the radionuclides could be ingested by humans eating the plants, and/or eating animals that had eaten the plants, or by humans eating products such as milk or eggs from animals that had eaten the plants.

Potential secondary exposure pathways for releases to air involve radionuclides deposited on the ground surface. The pathways and the groups exposed are:

- Exposure to direct radiation from radionuclides deposited on the ground surface (workers, public),
- Inhalation of resuspended contaminated soil (workers, public), and
- Immersion in air containing resuspended contaminated soil (workers, public).

Doses from the secondary exposure pathways are usually much lower and often insignificant compared to doses from the primary pathways. The relative importance of the primary pathways to each other depends more directly on the specific radionuclides released.

These same potential exposure pathways exist for accidental releases; however, because accidental releases occur infrequently and over relatively short periods of time, the relative importance of pathways based on deposition of radionuclides on the ground surface is diminished. Radionuclides deposited on plants or the ground surface are removed by weathering and would not be replenished. In case of large accidental releases, the site emergency response plan may involve actions to prevent ingestion of contaminated foods and to remove contamination from the environment. Based on these considerations, accident impacts were evaluated in this EIS based on exposures of workers and the public via inhalation and immersion only.

An extensive EPA assessment of mercury exposure (EPA 1997) investigated atmospheric deposition of mercury. It found that the combined wet and dry deposition of elemental mercury vapor on the ground was very low and that approximately 5 to 10 percent of mercuric mercury (oxidized mercury) would be deposited within 100 km of the release point. It also found that elemental mercury was rarely absorbed by the leafy surfaces or root of plants. SNS source terms for normal emissions assume that all mercury would be released as elemental mercury vapor. Some accident scenarios do assume that iodine would be released as mercuric iodide, an oxidized mercury, but the amount of mercury released in this form would be many orders of magnitude less than the quantity of elemental mercury.

F.4 Environmental Transport

The assessment of health impacts in this EIS is based on evaluation of the consequences of elevated and ground-level releases of radioactive and toxic materials from the SNS. The materials released would be transported through the environment by atmospheric dispersion. During dispersion, additional factors could affect the concentrations of contaminants in the air. These plume depletion mechanisms include dry deposition (“fallout”), wet deposition (“rainout” and “washout”), and radioactive decay.

A number of computer codes are available to calculate dispersion, deposition, and radioactive decay of radionuclides released to the atmosphere and many of these codes also calculate transport of deposited radionuclides through the food chain. CAP88-PC is a widely-used code that performs such calculations for continuous releases such as SNS emissions in routine operations. GENII and MACCS2 can perform these calculations for both continuous and short-duration releases that would occur during accidents. None of these codes contain decay chain data, biotic transfer factors, or dose conversion factors for some of the mercury, xenon, and iodine radionuclides and associated progeny produced in the mercury target, and it would not be practical to make the necessary modifications to the codes and their data files.

F.4.1 Undepleted Atmospheric Dispersion Factors

For normal conditions, a set of Microsoft Excel97 spreadsheet and Visual Basic macros were developed to implement a slightly modified version of the methodology used in CAP88-PC. This methodology is described in the code user guide (EPA 402-B-92-001). The documentation for AIRDOS-EPA, a mainframe predecessor of CAP88-PC, contains additional detail and a source code listing (EPA 520/1/79-009).

The CAP88-PC methodology implemented in this analysis uses a Gaussian plume model to calculate sector-averaged deleted ground-level concentrations in air and the ground deposition rates of radionuclides. The depletion mechanisms considered are radioactive decay and ingrowth, precipitation scavenging, and dry deposition. In-growth of progeny of radionuclides deposited on the ground and on plant surfaces are also considered. Concentrations in vegetation, beef, and milk consumed by humans are calculated using soil-to-plant, animal feed-to-milk, and animal feed-to-beef transfer factors. Intake of radionuclides by humans is calculated based on agricultural production data for the appropriate state and consumption rates of leafy vegetables, produce, milk, and beef.

The following modifications were made to the CAP88-PC methodology:

- Plume rise was conservatively assumed to be zero.

- Dose and risk calculations and data were replaced by updated dose conversion factors discussed in Section F.5.2 and risk factors recommended by the ICRP.

- The CAP88-PC consideration of ingrowth of a small number of decay chains and the use of pre-calculated ingrowth factors in decay and buildup calculations were replaced with specific calculation of ingrowth of all decay chains.

- The time allowed for deposition and buildup of radionuclides was changed from 100 years to 40 years to match the operating life of the SNS.

- The maximally exposed individual was assumed to be a hypothetical individual located at the site boundary and to obtain all of his or her required dietary intake at this location. The CAP88-PC method of adjusting the relative amounts of food grown in a given segment, grown in the entire assessment area, and imported from outside the region that is ingested by the population in that segment was retained for population dose calculations.

- When calculating population doses, CAP88-PC determines the maximally exposed individual based only on results for segments that are specified in the population distribution as containing people. For this analysis, a hypothetical individual was placed in the sector where contamination would have the maximum impact on agricultural production in the region of the assessment [i.e., within 50 mi (80 km) of the site].

F.4.2 Depletion by Radioactive Decay – Normal Operations

Site-specific joint frequency distributions in STAR format were used to calculate the wind speed frequencies and averages and the stability class frequencies required for the CAP88-PC methodology. Site-specific precipitation data and atmospheric lid heights were used in dispersion and deposition calculations. Dry deposition rates for particulates (0.035 m/sec), iodine (0.0018 m/sec), and gases (0 m/sec) listed in the CAP88-PC user's guide were used; however, a deposition velocity of 0.0006 m/sec (ref 3) was used for mercury.

CAP88-PC biotic transfer factors were supplemented with data from ORNL-5786 (Baes 1984) and from http://risk.lsd.ornl.gov/cgi-bin/tox/TOX_9801. The CAP88-PC methodology uses transfer factors for vegetation consumed by humans based on the wet weight of the vegetation. ORNL-5786 contains factors based on dry weight but provides a conversion factor for adapting the data for use with CAP88-PC. Agricultural production data for Tennessee, New Mexico, Illinois, and New York were used in site-specific evaluations.

The analysis used CAP88-PC default values for fractions of vegetables, beef, and milk consumed by populations. Fractions assumed to be grown locally, in the assessment region, and imported were the CAP88-PC defaults for rural areas for ORNL and LANL and for urban areas for ANL and BNL. CAP88-PC consumption rates were also used. Site-specific populations distributions were used for the off-site public and for uninvolved workers.

F.4.3 Accident Conditions

Atmospheric dispersion calculations for short-term releases in accidents were performed using PAVAN, a computer code used by the U.S. Nuclear Regulatory Commission to evaluate ground-level concentrations of radioactive materials released in accidents at nuclear power plants (PNL 1982). PAVAN uses joint frequency distributions of wind speed and direction by stability class to calculate ground-level normalized atmospheric dispersion factors (ADFs or χ/Qs) for short-term elevated and ground-level releases. The code does not consider plume rise, radioactive decay, or any other depletion process. The short-term ADFs are normalized ground-level concentrations at the plume centerline in each 22.5 degrees sector surrounding the site.

PAVAN uses several methods to deal with the fact that meteorological conditions during a given short-term release will vary from release to release. For this EIS, direction-specific χ/Qs that would be exceeded no more than 0.5 percent of the total time were selected for short-term releases. PAVAN calculates sets of these χ/Qs for release durations of 0-2 hours, 0-8 hours, 8-24 hours, 1-4 days, and 4-30 days.

The wind speed, wind direction, and stability class data were for the most recent available one-year alternating period from the meteorological monitoring station nearest to the preferred SNS location at each site. ORNL provided 1996 data measured at heights of 10 m and 60 m at the Y-12 Plant western meteorological tower. LANL provided 1996 data measured at height of 10 m at the TA-53 tower. ANL provided 1997 data measured at a height of 60 m. BNL provided 1997 data measured at a height of 10 m. If 60 m data was available, it was used for elevated releases. Otherwise, 10 m data was used. PAVAN adjusts all wind speed data from the height of measurement to the height of release (10 m for ground-level releases).

For elevated releases, χ/Qs were calculated for 22.5 degree sectors centered on the principal compass directions. Distances spaced at increasing intervals from 100 m to 2 km were used for workers. Distances from each stack to the site boundary were used for the maximally exposed member of the public. Distances corresponding to those provided in offsite population distributions within 80 km of the site as provided by each site were used for the offsite populations calculation. Ground-level releases were assumed to occur near the Target Building Exhaust Stack. For uninvolved worker populations, χ/Qs were estimated by superimposing the 100-2000 m grid for individual workers on site maps. Worker populations in occupied structures were provided by ORNL and estimated for the other sites by querying electronic copies of site phone books.

The calculations for normal operations used 8-24 hour χ/Qs for releases from the cooling systems and annual average χ/Qs for other normal releases. The releases were modeled as elevated releases from the appropriate SNS stack. The heights of these stacks would be 80 feet above grade. No adjustments were made for terrain height. The calculations for accident conditions used the durations and source terms shown in Tables F-3 through F-11 and selected χ/Qs appropriate to each phase.

F.4.4 Depletion by Radioactive Decay – Accidental Releases

The spreadsheet macros also accounted for changes in concentrations of radionuclide in the plume due to radioactive decay and ingrowth during transport and, in the case of accidents, during release. This involved calculations for as many as 245 radionuclides. Many of these radionuclides have half-lives comparable to their travel times from the SNS to a distance of 80 km. Thus, the concentration and dose were very sensitive to distance. Elevated releases travel some distance, usually a few hundred meters, before the plume reaches the ground. As a result, χ/Qs initially increase and then begin to decrease with distance. For the radionuclides that would be emitted by the SNS, the total activity in the plume decreases with distance but activities of a number of progeny increase to some steady state or peak and then decline. This behavior can cause shifts in the relative importance of exposure pathways as the plume traverses the region of interest.

Since average wind speeds are not uniform in all directions, the spreadsheet macros used average wind speeds specific to each direction at a given site to calculate “in-flight” decay. These average wind speeds were calculated from joint frequency distributions of height-adjusted wind speeds and direction by stability class calculated by PAVAN from the original joint frequency distributions for each site.

The depleted uranium component of the source term for a fire in the tritium getter bed was not decayed. The half-lives of the uranium isotopes and their progeny is such that the progeny that have high dose conversion factors relative to the parent uranium require several thousand years to in-grow to levels that would affect dose.

F.5 Dose Calculations

This section discusses the calculation of dose to workers and the public from exposure to SNS emissions by inhalation and immersion, the selection of dose conversion factors from available data, and the basis for estimating ingestion dose to the public for inhalation dose.

F.5.1 Inhalation and Immersion

The total dose (rem) to an individual at a given distance and direction from the source of an airborne release due to radionuclide concentrations in the environment is given by:

$$Dose = \sum_{i=1}^{n} Q_i \cdot \frac{\chi}{Q} \cdot E \cdot \left(BR \cdot DCF_{inh_i} + DCF_{imm_i}\right)$$

where:

Qi	=	Depleted source term (Ci/sec) for the i-th radionuclide
χ/Q	=	Atmospheric dispersion factor (sec/m3) for the given distance, direction, and release duration
E	=	Exposure period (sec)
BR	=	Breathing rate (m3/sec)
DCF_{inh}	=	Inhalation dose conversion factor for the i-th radionuclide (rem/Ci)
DCF_{imm}	=	Immersion dose conversion factor for the i-th radionuclide (rem/sec per Ci/m3)
CR	=	Consumption rate (grams/day)
DCF_{ingi}	=	Ingestion dose conversion factor for the i-th radionuclide (rem/sec per g/d)

For exposures to continuous releases, exposure periods are 8,760 hr/yr for the public and 2,000 hr/yr for workers. For short-term releases, the exposure period for the public is equal to the release duration. For workers, it is the number of hours worked during the release based on 8-hours shifts starting at the beginning of the release. Dose conversion factors for inhalation and immersion are listed in Table F-12 and discussed in Section F.5.2.

F.5.2 Selection of Dose Conversion Factors

Most dose assessments use dose conversion factors published by the U.S. Environmental Protection Agency in *Federal Guidance Report No. 11* (Eckerman et al 1988) for internal exposures and *Federal Guidance Report No. 12* (Eckerman and Ryman 1993) for external exposures. The factors are applicable to exposures received by workers and the public and are reflected in current dose limits enforced by EPA, DOE, and NRC. These reports were the primary source of the dose conversion factor used to prepare this EIS; however, they do not include data for all of the mercury and iodine radionuclides or their progeny that are projected to be present in SNS emissions.

Table F-12
Dose Conversion Factors Used to Estimate SNS Impacts under Normal and Accident Conditions

Nuclide	Half Life	Inhalation	Immersion	Ground Plane	Ingestion
		Rem/Ci	Rem/sec per Ci/m3	Rem/sec per Ci/m2	Rem/Ci
H-3	12.6 y	6.40E+01	0	0	6.40E+01
He-6	0.81 s	#N/A	#N/A	#N/A	#N/A
Li-8	0.84 s	#N/A	#N/A	#N/A	#N/A
Be-7	53.3 d	3.21E+02	8.73E-03	1.81E-04	1.28E+02
Be-8	0.00 s	#N/A	#N/A	#N/A	#N/A
Be-10	1.55E+06 y	3.54E+05	4.14E-05	1.52E-06	4.66E+03
B-12	0.20 s	#N/A	#N/A	#N/A	#N/A
B-13	0.02 s	#N/A	#N/A	#N/A	#N/A
C-10	19.3 s	#N/A	#N/A	#N/A	#N/A
C-11	20.4 m	1.22E+01	1.81E-01	3.74E-03	1.22E+01
C-14	5,870 y	2.09E+03	8.29E-07	5.96E-08	2.09E+03
N-12	0.01	#N/A	#N/A	#N/A	#N/A
N-13	9.97 m	#N/A	1.81E-01	3.74E-03	#N/A
N-16	7.13 s	#N/A	#N/A	#N/A	#N/A
N-17	4.17 s	#N/A	#N/A	#N/A	#N/A
O-14	1.18 m	#N/A	#N/A	#N/A	#N/A
O-15	2.04 m	#N/A	1.82E-01	3.74E-03	#N/A
O-19	26.9 s	#N/A	#N/A	#N/A	#N/A
F-18	1.83 h	8.36E+01	1.81E-01	3.74E-03	1.22E+02
F-20	11.0 s	#N/A	#N/A	#N/A	#N/A
Ne-23	37.2 s	#N/A	#N/A	#N/A	#N/A
Na-22	2.67 y	7.66E+03	4.00E-01	7.77E-03	1.15E+04

Nuclide	Half Life	Inhalation	Immersion	Ground Plane	Ingestion
		Rem/Ci	Rem/sec per Ci/m3	Rem/sec per Ci/m2	Rem/Ci
Na-24	15.0 h	1.21E+03	8.07E-01	1.34E-02	1.42E+03
Mg-27	9.46 m	#N/A	#N/A	#N/A	#N/A
Al-26	7.59E+05 y	7.96E+04	5.03E-01	9.21E-03	1.46E+04
Al-28	2.24 m	#N/A	3.43E-01	5.99E-03	#N/A
Al-29	6.56 m	#N/A	#N/A	#N/A	#N/A
Si-31	2.62 H	2.23E+02	4.33E-04	1.11E-05	5.40E+02
Si-32	176 y	1.01E+06	1.94E-06	1.15E-07	2.18E+03
P-32	14.3 d	1.55E+04	3.66E-04	1.08E-05	8.77E+03
P-33	25.3 d	2.32E+03	3.05E-06	1.65E-07	9.18E+02
S-35	87.5 d	2.48E+03	8.99E-07	6.22E-08	7.33E+02
Cl-36	3.09E+05 y	2.19E+04	8.25E-05	2.49E-06	3.03E+03
Cl-38	37.2 m	1.34E+02	2.91E-01	4.96E-03	2.35E+02
Ar-37	35.0 d	#N/A	0	0	#N/A
Ar-39	276 y	#N/A	3.37E-05	1.25E-06	#N/A
Ar-41	1.82 h	#N/A	2.41E-01	4.44E-03	#N/A
Ar-42	33.7 y	#N/A	#N/A	#N/A	#N/A
Ar-43	5.37 m	#N/A	#N/A	#N/A	#N/A
K-38	7.64 m	#N/A	6.07E-01	1.08E-02	#N/A
K-40	1.31E+09 y	1.24E+04	2.98E-02	5.40E-04	1.86E+04
K-42	12.4 h	1.36E+03	5.40E-02	9.84E-04	1.13E+03
K-43	22.3 h	6.92E+02	1.73E-01	3.53E-03	7.70E+02
K-44	22.1 m	8.29E+01	4.40E-01	7.55E-03	1.73E+02

Table F-12
Dose Conversion Factors Used to Estimate SNS Impacts under Normal and Accident Conditions - Continued.

Nuclide	Half Life	Inhalation Rem/Ci	Immersion Rem/sec per Ci/m3	Ground Plane Rem/sec per Ci/m2	Ingestion Rem/Ci
Ca-41	1.06E+05 y	1.35E+03	0	0	1.27E+03
Ca-45	163 d	6.62E+03	3.19E-06	1.71E-07	3.16E+03
Ca-47	4.54 d	6.55E+03	1.98E-01	3.70E-03	6.51E+03
Ca-49	8.72 m	#N/A	6.40E-01	9.73E-03	#N/A
Sc-43	3.89 h	2.59E+02	1.95E-01	4.00E-03	7.62E+02
Sc-44	3.93 h	4.92E+02	3.89E-01	7.66E-03	1.43E+03
Sc-46	83.8 d	2.96E+04	3.69E-01	7.14E-03	6.40E+03
Sc-47	3.35 d	1.84E+03	1.90E-02	3.85E-04	2.23E+03
Sc-48	1.82 d	4.11E+03	6.22E-01	1.18E-02	7.25E+03
Sc-49	57.2 m	1.02E+02	7.14E-04	1.82E-05	2.52E+02
Ti-44	64.6 y	1.02E+06	2.05E-02	4.88E-04	2.31E+04
Ti-45	3.08 h	2.15E+02	1.55E-01	3.19E-03	5.99E+02
Ti-51	5.76 m	#N/A	#N/A	#N/A	#N/A
V-47	32.6 m	7.03E+01	1.77E-01	3.65E-03	1.75E+02
V-48	16.0 d	1.02E+04	5.37E-01	1.03E-02	8.58E+03
V-49	330 d	3.45E+02	0	0	6.14E+01
V-50	1.44E+17 y	#N/A	#N/A	#N/A	#N/A
V-52	3.74 m	#N/A	#N/A	#N/A	#N/A
Cr-48	21.6 h	8.77E+02	7.62E-02	1.57E-03	9.14E+02
Cr-49	42.3 m	7.25E+01	1.86E-01	3.85E-03	1.84E+02
Cr-51	27.7 d	3.34E+02	5.59E-03	1.14E-04	1.47E+02

Nuclide	Half Life	Inhalation Rem/Ci	Immersion Rem/sec per Ci/m3	Ground Plane Rem/sec per Ci/m2	Ingestion Rem/Ci
Cr-55	3.50 m	#N/A	#N/A	#N/A	#N/A
Cr-56	5.94 m	#N/A	#N/A	#N/A	#N/A
Mn-51	46.2 m	1.15E+02	1.78E-01	3.67E-03	2.78E+02
Mn-52	5.59 d	5.70E+03	6.36E-01	1.22E-02	7.59E+03
Mn-53	3.83E+06 y	5.00E+02	0	0	1.08E+02
Mn-54	312 d	6.70E+03	1.51E-01	3.00E-03	2.77E+03
Mn-56	2.58 h	3.77E+02	3.19E-01	5.85E-03	9.77E+02
Mn-57	1.42 m	#N/A	#N/A	#N/A	#N/A
Fe-52	8.28 h	2.19E+03	1.31E-01	2.69E-03	5.59E+03
Fe-53	8.51 m	#N/A	#N/A	#N/A	#N/A
Fe-55	2.80 y	2.69E+03	0	0	6.07E+02
Fe-59	44.5 d	1.48E+04	2.21E-01	4.14E-03	6.70E+03
Fe-60	1.54E+06 y	7.47E+05	7.22E-07	5.48E-08	1.52E+05
Fe-61	5.98 m	#N/A	#N/A	#N/A	#N/A
Co-55	17.5 h	2.09E+03	3.62E-01	7.14E-03	4.37E+03
Co-56	77.3 d	3.96E+04	6.77E-01	1.22E-02	1.26E+04
Co-57	272 d	9.07E+03	2.08E-02	4.26E-04	1.18E+03
Co-58	70.9 d	1.09E+04	1.76E-01	3.52E-03	3.58E+03
Co-60	5.41 y	2.19E+05	4.66E-01	8.70E-03	2.69E+04
Co-61	1.65 h	1.06E+02	1.46E-02	3.34E-04	2.63E+02
Co-62	1.50 m	#N/A	#N/A	#N/A	#N/A

Table F-12

Dose Conversion Factors Used to Estimate SNS Impacts under Normal and Accident Conditions - Continued.

Nuclide	Half Life	Inhalation Rem/Ci	Immersion Rem/sec per Ci/m3	Ground Plane Rem/sec per Ci/m2	Ingestion Rem/Ci
Co-63	27.4 s	#N/A	#N/A	#N/A	#N/A
Ni-56	6.08 d	4.03E+03	3.11E-01	6.14E-03	3.89E+03
Ni-57	1.48 d	1.89E+03	3.59E-01	6.66E-03	3.77E+03
Ni-59	77,900 y	1.32E+03	0	0	2.10E+02
Ni-63	103 y	3.10E+03	0	0	5.77E+02
Ni-65	2.52 h	2.42E+02	1.03E-01	1.91E-03	6.22E+02
Cu-60	23.7 m	6.92E+01	7.33E-01	1.34E-02	1.93E+02
Cu-61	3.33 h	1.87E+02	1.48E-01	3.02E-03	4.37E+02
Cu-62	9.74 m	#N/A	1.80E-01	3.70E-03	#N/A
Cu-64	12.7 h	2.77E+02	3.37E-02	6.92E-04	4.66E+02
Sb-119	1.59 d	1.25E+02	7.96E-04	8.03E-05	2.75E+02
Te-119	16.0 h	3.76E+02	1.36E-01	2.76E-03	6.46E+02
Te-119m	4.70 d	#N/A	#N/A	#N/A	#N/A
Te-121	16.8 d	1.91E+03	9.99E-02	2.11E-03	1.68E+03
Te-123	1.03E+13 y	1.05E+04	7.96E-04	7.22E-05	4.18E+03
Te-123m	120 d	1.06E+04	2.41E-02	5.29E-04	5.66E+03
I-119	19.1 m	5.18E+01	1.57E-01	3.23E-03	1.48E+02
I-120	1.35 h	3.69E+02	5.11E-01	9.47E-03	1.27E+03
I-121	2.12 h	1.02E+02	7.18E-02	1.51E-03	3.08E+02
I-122	3.63 m	1.27E+01	1.69E-01	3.48E-03	4.78E+01
I-123	13.3 h	2.78E+02	2.69E-02	6.14E-04	8.05E+02
I-124	4.81 d	1.64E+04	1.99E-01	3.89E-03	4.81E+04

Nuclide	Half Life	Inhalation Rem/Ci	Immersion Rem/sec Per Ci/m3	Ground Plane Rem/sec per Ci/m2	Ingestion Rem/Ci
I-125	59.0 d	1.93E+04	1.93E-03	1.58E-04	5.69E+04
I-126	13.1 d	3.65E+04	7.96E-02	1.65E-03	1.07E+05
I-128	25.0 m	4.85E+01	1.54E-02	3.24E-04	1.70E+02
I-29	1.61E+07 y	1.33E+05	1.41E-03	9.55E-05	3.91E+05
I-130	12.4 h	2.50E+03	3.85E-01	7.77E-03	7.27E+03
Xe-119	5.80 m	#N/A	#N/A	#N/A	#N/A
Xe-120	40.0 m	#N/A	7.18E-02	1.57E-03	#N/A
Xe-121	40.1 m	#N/A	3.38E-01	6.25E-03	#N/A
Xe-122	20.1 h	#N/A	9.10E-03	2.53E-04	#N/A
Xe-123	2.08 h	#N/A	1.12E-01	2.25E-03	#N/A
Xe-125	16.9 h	#N/A	4.40E-02	9.81E-04	#N/A
Xe-127	36.4 d	#N/A	4.63E-02	1.01E-03	#N/A
Yb-169	32.1 d	8.07E+03	4.77E-02	1.12E-03	3.00E+03
Yb-169m	46.0 s	#N/A	#N/A	#N/A	#N/A
Lu-168	5.50 m	#N/A	#N/A	#N/A	#N/A
Lu-169	1.42 d	1.35E+03	1.88E-01	3.65E-03	2.03E+03
Lu-169m	2.67 m	#N/A	#N/A	#N/A	#N/A
Lu-170	2.01 d	2.58E+03	4.74E-01	8.29E-03	4.55E+03
Lu-172	6.70 d	5.00E+03	3.42E-01	6.70E-03	5.66E+03
Lu-172m	3.70 m	#N/A	#N/A	#N/A	#N/A
Lu-173	1.40 y	2.25E+04	1.89E-02	4.74E-04	1.09E+03

Table F-12
Dose Conversion Factors Used to Estimate SNS Impacts under Normal and Accident Conditions - Continued.

Nuclide	Half Life	Inhalation Rem/Ci	Immersion Rem/sec Per Ci/m3	Ground Plane Rem/sec per Ci/m2	Ingestion Rem/Ci
Hf-168	26.0 m	#N/A	#N/A	#N/A	#N/A
Hf-169	3.20 m	#N/A	#N/A	#N/A	#N/A
Hf-170	16.0 h	1.20E+03	9.32E-02	1.99E-03	2.12E+03
Hf-172	1.92 y	3.18E+05	1.50E-02	4.18E-04	4.48E+03
Hf-173	23.6 h	4.77E+02	6.85E-02	1.47E-03	1.00E+03
Hf-175	70.0 d	5.59E+03	6.25E-02	1.34E-03	1.82E+03
Ta-168	2.07 m	#N/A	#N/A	#N/A	#N/A
Ta-169	4.90 m	#N/A	#N/A	#N/A	#N/A
Ta-170	6.77 m	#N/A	#N/A	#N/A	#N/A
Ta-172	36.8 m	5.66E+01	2.81E-01	5.48E-03	1.59E+02
Ta-173	3.14 h	3.20E+02	1.02E-01	2.10E-03	7.84E+02
Ta-174	1.05 h	6.73E+01	1.10E-01	2.25E-03	1.96E+02
Ta-175	10.5 h	3.81E+02	1.68E-01	3.25E-03	9.07E+02
Ta-176	8.08 h	6.90E+02	4.14E-01	7.51E-03	1.12E+03
Ta-177	2.36 d	3.07E+02	9.36E-03	2.43E-04	4.51E+02
Ta-178	9.32 m	8.29E+01	#N/A	#N/A	2.93E+02
Ta-179	1.87 y	6.51E+03	4.03E-03	1.17E-04	2.73E+02
W-168	51.0 s	#N/A	#N/A	#N/A	#N/A
W-169	1.33 m	#N/A	#N/A	#N/A	#N/A
W-170	2.42 m	#N/A	#N/A	#N/A	#N/A
W-172	6.60 m	#N/A	#N/A	#N/A	#N/A
W-173	7.60 m	#N/A	#N/A	#N/A	#N/A

Nuclide	Half Life	Inhalation Rem/Ci	Immersion Rem/sec per Ci/m3	Ground Plane Rem/sec per Ci/m2	Ingestion Rem/Ci
W-174	31.0 m	#N/A	#N/A	#N/A	#N/A
W-175	35.0 m	#N/A	#N/A	#N/A	#N/A
W-176	2.50 h	2.39E+02	2.60E-02	6.33E-04	3.60E+02
W-177	2.25 h	6.51E+01	1.58E-01	3.23E-03	2.48E+02
W-178	21.5 d	2.71E+02	1.71E-03	4.81E-05	1.02E+03
W-179	37.0 m	3.50E+00	6.77E-03	2.17E-04	1.01E+01
W-179m	6.40 m	#N/A	#N/A	#N/A	#N/A
W-181	122 d	5.00E+02	5.18E-03	1.46E-04	2.13E+02
Re-172	15.0 s	#N/A	#N/A	#N/A	#N/A
Re-172m	55.0 s	#N/A	#N/A	#N/A	#N/A
Re-173	1.98 m	#N/A	#N/A	#N/A	#N/A
Re-174	2.40 m	#N/A	#N/A	#N/A	#N/A
Re-175	5.88 m	#N/A	#N/A	#N/A	#N/A
Re-176	5.30 m	3.88E+01	1.91E-01	3.89E-03	8.40E+01
Re-177	14.0 m	2.39E+01	1.10E-01	2.18E-03	5.40E+01
Re-178	13.2 m	2.25E+01	2.25E-01	4.18E-03	5.77E+01
Re-179	19.5 m	#N/A	#N/A	#N/A	#N/A
Re-180	2.37 m	7.58E+00	2.10E-01	4.18E-03	7.39E+00
Re-181	19.8 m	9.16E+02	1.40E-01	2.88E-03	1.50E+03
Re-182m	12.7 h	#N/A	#N/A	#N/A	#N/A
Re-183	70.0 d	#N/A	#N/A	#N/A	#N/A
Os-172	19.2 s	#N/A	#N/A	#N/A	#N/A

Table F-12
Dose Conversion Factors Used to Estimate SNS Impacts under Normal and Accident Conditions - Continued.

		Inhalation	Immersion	Ground Plane	Ingestion
Nuclide	Half Life	Rem/Ci	Rem/sec per Ci/m3	Rem/sec per Ci/m2	Rem/Ci
Os-173	16.0 s	#N/A	#N/A	#N/A	#N/A
Os-174	44.0 s	#N/A	#N/A	#N/A	#N/A
Os-175	1.40 m	#N/A	#N/A	#N/A	#N/A
Os-176	3.60 m	#N/A	#N/A	#N/A	#N/A
Os-177	2.80 m	#N/A	#N/A	#N/A	#N/A
Os-178	5.00 m	#N/A	#N/A	#N/A	#N/A
Os-179	6.50 m	#N/A	#N/A	#N/A	#N/A
Os-180	20.8 m	4.54E+01	5.77E-05	9.18E-06	5.44E+01
Os-181	1.75 h	6.71E+00	6.40E-02	1.32E-03	7.19E+00
Os-182	22.1 h	1.38E+03	7.44E-02	1.57E-03	2.44E+03
Os-183	13.0 h	9.72E+02	1.08E-01	2.28E-03	2.66E+03
Os-183m	9.89 h	#N/A	#N/A	#N/A	#N/A
Os-185	93.6 d	4.27E+03	1.22E-01	2.49E-03	1.77E+03
Os-186	2.05E+15 y	#N/A	#N/A	#N/A	#N/A
Os-189m	5.81 h	2.99E+01	3.92E-07	1.16E-07	6.70E+01
Ir-176	8.00 s	#N/A	#N/A	#N/A	#N/A
Ir-177	30.0 s	#N/A	#N/A	#N/A	#N/A
Ir-178	12.0 s	#N/A	#N/A	#N/A	#N/A
Ir-179	1.32 m	#N/A	#N/A	#N/A	#N/A
Ir-180	1.50 m	7.66E+00	1.58E-01	3.17E-03	6.83E+00
Ir-181	4.90 m	6.66E+01	7.59E-01	1.41E-02	5.67E+01
Ir-182	15.0 m	4.85E+01	2.41E-01	4.85E-03	1.28E+02
Ir-183	58.0 m	1.54E+02	2.11E-01	4.00E-03	3.03E+02

		Inhalation	Immersion	Ground Plane	Ingestion
Nuclide	Half Life	Rem/Ci	Rem/sec per Ci/m3	Rem/sec per Ci/m2	Rem/Ci
Ir-184	3.08 h	2.30E+02	3.47E-01	6.73E-03	6.96E+02
Ir-185	14.4 h	6.56E+02	1.09E-01	2.04E-03	9.72E+02
Ir-186	16.6 h	1.20E+03	2.96E-01	5.70E-03	1.97E+03
Ir-186m	1.90 h	#N/A	#N/A	#N/A	#N/A
Ir-187	10.5 h	2.53E+02	5.66E-02	1.18E-03	3.99E+02
Ir-188	1.72 d	1.66E+03	3.96E-01	7.03E-03	2.75E+03
Ir-189	13.2 d	1.69E+03	1.15E-02	2.76E-04	8.12E+02
Pt-176	6.33 s	#N/A	#N/A	#N/A	#N/A
Pt-177	11.0 s	#N/A	#N/A	#N/A	#N/A
Pt-178	21.1 s	#N/A	#N/A	#N/A	#N/A
Pt-179	21.2 s	#N/A	#N/A	#N/A	#N/A
Pt-180	52.0 s	6.27E+00	0	0	3.92E+00
Pt-181	51.0 s	2.56E+01	1.17E+00	2.26E-02	2.04E+01
Pt-182	2.20 m	#N/A	#N/A	#N/A	#N/A
Pt-183	6.50 m	#N/A	#N/A	#N/A	#N/A
Pt-183m	43.0 s	#N/A	#N/A	#N/A	#N/A
Pt-184	17.3 m	5.05E+01	1.17E-01	2.48E-03	4.45E+01
Pt-185	1.18 h	2.47E+02	5.03E-01	1.02E-02	2.38E+02
Pt-186	2.00 h	1.95E+02	1.14E-01	2.36E-03	3.27E+02
Pt-187	2.35 h	2.18E+02	9.77E-02	2.02E-03	2.62E+02
Pt-188	10.2 d	6.48E+03	3.35E-02	7.33E-04	3.00E+03
Pt-189	10.9 h	5.76E+02	8.29E-02	1.73E-03	6.86E+02

Table F-12
Dose Conversion Factors Used to Estimate SNS Impacts under Normal and Accident Conditions - Continued.

Nuclide	Half Life	Inhalation Rem/Ci	Immersion Rem/sec per Ci/m3	Ground Plane Rem/sec per Ci/m2	Ingestion Rem/Ci
Pt-190	6.66E+11 y	#N/A	#N/A	#N/A	#N/A
Pt-191	2.80 d	6.14E+02	4.96E-02	1.10E-03	1.46E+03
Pt-193	51.4 y	2.27E+02	1.47E-06	4.40E-07	1.19E+02
Au-180	8.10 s	#N/A	#N/A	#N/A	#N/A
Au-181	11.4 s	#N/A	#N/A	#N/A	#N/A
Au-182	15.6 s	#N/A	#N/A	#N/A	#N/A
Au-183	42.0 s	#N/A	#N/A	#N/A	#N/A
Au-184	53.0 s	2.66E+00	0	0	2.24E+00
Au-185	4.25 m	7.03E+01	1.88E-01	3.81E-03	8.22E+01
Au-186	10.7 m	8.04E+01	3.67E-01	7.25E-03	1.77E+02
Au-187	8.40 m	5.68E+01	1.88E-01	3.52E-03	3.22E+02
Au-187m	2.30 s	#N/A	#N/A	#N/A	#N/A
Au-188	8.83 m	#N/A	#N/A	#N/A	#N/A
Au-189	28.7 m	1.47E+02	6.66E-01	1.33E-02	1.93E+02
Au-190	42.8 m	7.20E+01	4.37E-01	7.66E-03	1.23E+02
Au-191	3.17 h	1.46E+02	1.00E-01	2.09E-03	1.87E+02
Au-191m	0.92 s	#N/A	#N/A	#N/A	#N/A
Au-192	4.94 h	3.27E+02	3.59E-01	6.44E-03	6.22E+02
Au-193	17.6 h	2.89E+02	2.53E-02	5.66E-04	5.77E+02
Au-194	1.59 d	1.02E+03	1.96E-01	3.70E-03	1.88E+03
Au-195	186 d	1.30E+04	1.19E-02	2.90E-04	1.06E+03
Au-195m	30.5 s	#N/A	3.47E-02	7.14E-04	#N/A
Hg-180	3.00 s	#N/A	#N/A	#N/A	#N/A
Hg-181	3.60 s	#N/A	#N/A	#N/A	#N/A
Hg-182	10.8 s	#N/A	#N/A	#N/A	#N/A
Hg-183	9.40 s	#N/A	#N/A	#N/A	#N/A
Hg-184	30.6 s	1.17E+02	1.03E-01	2.13E-03	3.06E+00
Hg-185	49.1 s	1.02E+03	0	0	1.66E+01
Hg-186	1.38 m	4.84E+01	6.99E-02	1.48E-03	2.56E+01
Hg-187	2.40 m	1.56E+03	7.73E-01	1.48E-02	1.05E+02
Hg-188	3.25 m	3.10E+01	3.54E-02	7.81E-04	3.68E+00
Hg-189	7.60 m	#N/A	#N/A	#N/A	#N/A
Hg-190	20.5 m	1.95E+02	3.05E-02	6.55E-04	6.39E+01
Hg-191	50.8 m	7.31E+02	2.62E-01	5.14E-03	1.61E+02
Hg-192	4.86 h	3.71E+03	4.66E-02	9.99E-04	8.28E+02
Hg-193	3.81 h	4.20E+03	3.22E-02	7.10E-04	3.09E+02
Hg-194	455 y	1.49E+05	2.56E-06	7.59E-07	5.13E+03
Hg-195	9.89 h	5.26E+03	3.40E-02	7.18E-04	3.63E+02
Hg-197	2.67 d	1.61E+04	9.84E-03	2.38E-04	8.67E+02
Hg-203	46.6 d	2.59E+04	4.18E-02	8.58E-04	1.99E+03
Hg-205	5.20 m	4.64E+01	9.21E-04	1.88E-05	3.09E+01
U-234	2.57E+05 y	1.32E+08	2.82E-05	2.77E-06	2.83E+05
U-235	7.40E+08 y	1.23E+08	2.66E-02	5.48E-04	2.66E+05
U-236	2.46E+07 y	1.25E+08	1.85E-05	2.41E-06	2.69E+05
U-238	4.70E+09 y	1.18E+08	1.26E-05	2.04E-06	2.55E+05

DOE undertook an effort to calculate the missing data. In doing so, it assessed the new internal and external dosimetry models being used by EPA to develop Federal Guidance Report No. 13 (Eckerman et al 1998). DOE staff at ORNL had performed similar calculations for the two previous Federal Guidance Reports. When completed, Federal Guidance Report No. 13 will provide coefficients to allow risk from exposures of the public to be estimated directly for radionuclide concentrations in environmental media. These coefficients will not be applicable to exposures of workers and, depending on the dose and dose rate, may not be applicable to exposures during accidents. The interim report does contain data for isotopes of mercury or iodine or their progeny beyond that found in the earlier reports.

Because the Federal Guidance Report No 13 data was not appropriate for this EIS analysis, the ORNL staff developed inhalation and ingestion dose conversion factors for occupational and accident exposure to SNS mercury isotopes with half-lives of more than a few seconds and for SNS iodine isotopes. It also developed factors for immersion and ground plane exposures for the mercury and iodine isotopes (Eckerman 1998b). Dose conversion factors for internal exposures include the contributions of the progeny that are produced by decay in the body following the intake; however, unless the progeny have half-lives similar to or longer than the parent, separate factors are not usually calculated for direct intakes of the progeny. Several of the mercury decay chains do contain progeny with half-lives similar to or longer than the parent. DOE subsequently provided updated factors for mercury and these progeny (Eckerman 1998a).

The dose conversion factors used in this EIS for internal exposures are committed effective dose equivalents. Those used for external exposures are effective dose equivalents. The dose conversion factors listed in Table F-12 were selected from these four sources (Eckerman et al 1998; Eckerman 1998; Eckerman 1998b; Eckerman and Ryman 1993) using the following criteria in the order listed:

Inhalation

1. SNS updated DCFs (Eckerman et al 1998).

   - Mercury assumed to be elemental mercury vapor (Class V) based on EPA Mercury Study Report to Congress (PNL 1982) and DOE analysis of chemical forms emitted (Appendix A).

   - Iodine assumed to be Class F based on DOE analysis of the chemical forms emitted (Appendix A).

   - All others, maximum value for any class (Classes F, M, and S).

2. Federal Guidance Report No. 11.

   - Tritium (H-3) assumed be vapor (Class V).

   - Carbon (C) is maximum of value for organic, monoxide, and dioxide forms of carbon.

   - All others, maximum value (Classes D, W, and Y).

Immersion

1. SNS updated data (Eckerman 1998a).

2. Federal Guidance Report No. 12.

Ground Plane

1. SNS updated data (Eckerman 1998a).

2. Federal Guidance Report No. 12.

Ingestion (not used)

1. SNS updated data (Eckerman et al 1998), maximum value for any uptake factor category (f1).

2. Federal Guidance Report No. 11, maximum value for any uptake category (f1).

The classes referred to in these criteria (F, M, S and D, W, Y) are related to the rate an inhaled radionuclide is cleared from the lungs. Class V is a special class for vapors. The uptake factor (f1) is related to the fraction of the radionuclide transferred to blood in the small intestine. There may be several different uptake factors available for ingested radionuclides. This factor is also applicable to inhalation but has a single value for a given inhalation class.

The radionuclides listed in Table F-12 are all those that could reasonably be expected to be released from the SNS and their progeny. An entry of "0" in Table F-12 indicates that the radionuclide does not emit radiation that results in dose for the indicated exposure. An entry of #N/A indicates that no value was listed in the references used. This does not necessarily mean that the dose conversion factor is unknown. The radionuclide may not be absorbed by the body or may emit radiation that is too weak to travel through air to produce external exposure by immersion or standing on contaminated ground. The noble gas isotope Ar-37 is an example of both of the conditions. Ni-59 and Ni-63 are examples of radionuclides that if absorbed by inhalation or ingestion would cause internal exposure, but emit radiation too weak for external exposures to occur.

Toxic Materials Evaluations

This assessment uses Emergency Response Planning Guidelines (ERPGs) to provide estimates of concentration ranges where one might reasonably expect to observe adverse effects from exposure to toxic substances. The values derived for ERPGs are used for emergency planning purposes and are applicable to most individuals in the general population. The ERPG values are not regulatory exposure guidelines, and they do not incorporate the safety factors normally included in healthy worker exposure guidelines.

The ERPGs were developed by the American Industrial Hygiene Association to aid emergency planners and emergency responders in dealing with hazardous material incidents. The ERPG values are classified in three categories:

ERPG-1	Maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.
ERPG-2	Maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.
ERPG-3	Maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

In accident conditions at the SNS, the only anticipated hazardous material release is mercury, and mercury is not among the 69 chemicals for which ERPG values have been established. In such a situation, the DOE Emergency Management Advisory Committee, Subcommittee on Consequence Analysis and Protective Actions (SCAPA) have recommended Temporary Emergency Exposure Limits (TEELs). TEELs are interim, temporary or ERPG-equivalent exposure limits for 297 chemicals, including mercury, whose values have not been finalized as ERPGs. The TEEL levels for mercury (elemental and inorganic) adapted by SCAPA in 1996 include:

TEEL-0	0.05 mg/m3
TEEL-1	0.075 mg/m3
TEEL-2	0.1 mg/m3
TEEL-3	10 mg/m3

In this analysis, site-specific meteorology is used to estimate mercury concentrations at the position of the uninvolved worker (within 2000 m of the release point) and the maximum exposed individual of the general public (at the site boundary). The estimated concentrations are then compared to the mercury TEEL values in order to determine the anticipated consequences for comparison between alternative locations.

References

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3. External Exposure to Radionuclides in Air, Water, and Soil, Federal Guidance Report No. 12. EPA-402-R-93-081. Prepared by Keith F. Eckerman and Jeffrey C. Ryman, Oak Ridge National Laboratory. September 1993.

4. Federal Guidance Report No. 13. Part I - Interim Version. Health Risks from Low-Level Environmental Exposure to Radionuclides, EPA 402-R-97-014. Prepared by Keith F. Eckerman, Richard W. Legget, Christopher B. Nelson, Jerome S. Puskin, and

Allan C.B. Richardson, Oak Ridge National Laboratory for U.S. Environmental Protection Agency. January 1998.

5. Hg Daughter DCFs, e-mail from K. Eckerman, ORNL to R. Wild, D&M. June 18, 1998.

6. Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, Federal Guidance Report No. 11. EPA-520/1-88-020. Prepared by Keith F. Eckerman, Anthony B. Wolbarst, and Allan C.B. Richardson, Oak Ridge National Laboratory for U.S. Environmental Protection Agency. September 1988.

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APPENDIX G

PROJECTED AIR QUALITY MODELING EFFECTS AT NOAA'S WALKER BRANCH MONITORING TOWER

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G. PROJECTED AIR QUALITY MODELING EFFECTS AT NOAA'S WALKER BRANCH MONITORING TOWER

1.0 BACKGROUND

National Oceanic and Atmospheric Administration (NOAA) has an ongoing research program within the Walker Branch Watershed investigating the ramifications of global climate change. As part of this research program, NOAA has been collecting information on CO_2 and heat flux across the forest canopy for approximately 5 years. This research program is expected to continue for many years.

DOE is proposing to construct and operate the Spallation Neutron Source (SNS), on the preferred location, Chestnut Ridge, that is approximately 1.5 km west of the NOAA research tower. The SNS will have mechanical draft cooling towers to dissipate excess heat and will use natural gas as a fuel for general space heating. This study is designed to provide a preliminary assessment of the potential impacts that the SNS may have in the quality of the data from the NOAA research tower. The overall study is designed to provide information on the impacts associated with water vapor in the cooling plume, and CO_2 and NO_x released from the combustion of natural gas.

2.0 AIR QUALITY MODEL

EPA's backbone air quality model, the Industrial Source Complex Short Term (ISCST3, version 97363) model, was chosen to assess the effects from the sources of concern at the SNS. The ISCST3 model is a complex, straight-line, steady-state Gaussian plume model that can be used to model a number of sources that might be present at a typical industrial facility.

The ISCST3 model accepts hourly meteorological data to define the conditions for plume rise, transport, diffusion, and deposition. Output from the model can take many forms; but, it generally consists of an echo of the input runstream, summary of all modeling inputs, and modeling results summarized in several requestable formats (U.S.E.P.A., 1995).

2.1 Model Input

Input to the ISCST3 model is of two basic types: (1) the input runstream file, and (2) the meteorological data file.

2.1.1 Input Runstream

This file contains the selected modeling options, as well as source location and parameter data, receptor locations, meteorological data file specifications, and output options.

For this "Phase I" study two groups of sources were modeled: (1) the cooling towers for water vapor emissions, and (2) a group of ten (4 MW scenario) small boiler stacks located on various SNS structures for CO_2 and NO_x emissions.

The 13 adjacent cooling towers (cells) present were modeled as a single combined source with an overall water vapor emission rate of 350 gallons/minute and other stack parameters as supplied by Conventional Facilities Team personnel. The 10 boiler stacks were modeled as discrete point sources. Stack diameters and heights were provided as indicated previously, while exit velocities and temperatures were based upon an average value taken from boiler manufacture literature. Existing boiler emission rates were taken from AP42 (U.S.E.P.A., 1995) and are summarized below:

Combustion Products from Natural Gas-Fired Boilers at SNS		
Combustion Products	**Rate (lbs/mmcf)[1]**	**Rate (lbs/hr)[2]**
NO_x	100	3.48
CO_2	1.2E+05	4184

[1] Emission factors from EPA AP42 for commercial boilers (rating 0.3 to 10 mmBtu/hr)
[2] Based on cumulative output of 10 boilers at SNS with total heat load of 34,870,000 Btu/hr (0.0349 mmcf/hr).

Universal Traverse Mercator (UTM) coordinates, defining the location of each source in meters, were also provided to the model as well as source elevations. These locations along with source elevations were provided to the model. Input of source elevation data allows the model to perform intermediate and complex terrain calculations (via the incorporated COMPLEX I model). Complex terrain is defined as those receptor locations with elevations greater than a modeled stack top release elevation. For this study, only one receptor location was used (the NOAA monitoring tower location). This receptor also had a "flagpole" elevation (36 m) input that requests that the model provide concentrations 36 m from the ground elevation (where the instruments are located on the tower).

Building parameters were also input to the model to implement building downwash procedures. Other pertinent information input to the model included the use of "rural" wind profile exponents, vertical temperature gradients and mixing heights, and selection of the regulatory default option that sets a number of specific options to a selected default value.

2.1.2 Meteorological Data

Surface meteorological data supplied to the model consisted of one year (1991) of 15 minute averages for wind direction, mean wind speed, ambient temperature, solar radiation, and sigma-theta collected at NOAA's Walker Branch monitoring tower. Missing data were filled using data from additional nearby towers or by averaging surrounding period data for short missing periods. Solar radiation and sigma-theta are not used directly by the ISCST3 model but used (by the method indicated in Sect. 6.4.4.4. of U.S.E.P.A., 1987) to calculate stability category. This procedure was modified to reflect a surface roughness of 1.2 m and effective anemometer height of 9.1 m as suggested for the Walker Branch site by NOAA personnel.

A Fortran code was prepared to read these data, convert to the correct units when necessary, and write the values out to a new file in the correct format for ISCST3 use. Upper air data (mixing heights) were also taken from a preprocessed file of Knoxville/Nashville, TN 1991 surface/upper air data compiled from data downloaded from EPA's SCRAM bulletin board. Linear -interpolation was used to provide a mixing height for each 15-minute average from the 1-hour averages provided in the preprocessed file. All wind speeds less than 0.7 m/sec were considered a calm and set to zero (not processed by the model).

2.2 Model Output

Output from the ISCST3 model runs was somewhat different than normally expected in that the meteorological data utilized were 15-minute average data rather than 1-hour data. For this reason, while the model indicates 1 hour averages are output, the averages are actually 15-minute averages. The dates shown for the output concentrations are incorrect because they were being advanced by a factor of four. Additionally, since four times as much meteorological data are present as normal to an annual model run, four separate runs (each quarter year or approximately three months) were preformed to cover the entire year of Walker Branch, 15-minute data.

Actual model output consisted of 15-minute averages (in micrograms/cubic meter) of water vapor for the cooling tower and CO_2 and NO_x concentrations for the ten boiler stacks output at the monitoring tower location. The printed output consisted of a set of tables summarizing the maximum 50 concentrations for each of the modeled releases and two additional files listing the concentrations for every 15-minute period and every non-zero concentration, respectively. Approximately 80 – 85 percent of all projected concentrations at the tower are zeros (due mainly to wind direction not blowing from the sources toward the tower during that time).

ISCST3-projected maximums were 1.04 g/m³ for water vapor, 27,569 μg/m³ for CO_2 and 23 μg/m³ for NO_x. A copy of the ISCST3 output for the third quarter modeled is included in this appendix.

One important factor in considering the concentrations obtained is that these are conservative, probably worst-case, projections. The emission rates assume continuous, annual operation of all sources at full-rated capacity. The 350 gal/min emission rate for the cooling towers is for "droplet and vapor drag out." For modeling purposes, the assumption was made that this water is all vapor or aerosol. In reality, some larger droplets may be present and more may form as the plume travels downwind. These particles may condense or drop out before ever reaching the monitoring tower. The extent of this phenomena would probably be highly dependent upon local ambient meteorological conditions at any given time.

3.0 REFERENCES

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U.S.E.P.A. 1987. *On-Site* Meteorological *Program Guidance for Regulatory Modeling Applications*. OAQPS. Research Triangle Park, North Carolina.

U.S.E.P.A. 1995. *User's Guide for the Industrial Source Complex Dispersion Models*. OAQPS. Research Triangle Park, North Carolina.

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CO STARTING
CO TITLEONE CT & 10 STACKS @ MON. TOWER*4MW*1991 JUL-SEP WB MET
CO MODELOPT DFAULT CONC   RURAL
*** ave time is really 15 min per met data
CO AVERTIME 1
CO POLLUTID OTHER
CO TERRHGTS ELEV
CO FLAGPOLE
CO DCAYCOEF   0.000000E+00
CO RUNORNOT RUN
CO ERRORFIL ERRORS.OUT
CO FINISHED


SO STARTING
SO ELEVUNIT FEET

*** Source Location Cards:
***         SRCID SRCTYP        XS            YS            ZS

SO LOCATION CT1    POINT       743267.       3981595.      1040.0
*** COOLING TOWER
SO LOCATION S1C    POINT       742933.       3981537.      1039.5
***  FRONT END BLDG.
SO LOCATION S2C    POINT       743170.       3981701.      1054.0
*** KLYSTRON HALL
SO LOCATION S3C    POINT       743471.       3981795.      1088.0
*** RING SERVICE BLDG.
SO LOCATION S4C    POINT       743552.       3981865.      1041.0
*** RTBT SERVICE BLDG.
SO LOCATION S5C    POINT       743645.       3981965.      1038.5
*** TARGET BLDG.
SO LOCATION S6C    POINT       743239.       3981635.      1050.0
*** UTILITY BLDG.
SO LOCATION S7C    POINT       743347.       3981717.      1050.0
*** OFFICE BLDG.
SO LOCATION S8C    POINT       743567.       3982073.      1038.5
*** TARGET BLDG.
SO LOCATION S9C    POINT       743339.       3981977.      1088.0
*** RING SERVICE BLDG.
SO LOCATION S10C   POINT       743447.       3982027.      1041.0
*** RTBT SERVICE BLDG.
*** Source Parameter Cards:
*** POINT:   SRCID       QS            HS        TS          VS          DS
*** VOLUME:  SRCID       QS            HS      SYINIT      SZINIT
*** AREA:    SRCID       QS            HS       XINIT

*** WATER VAPOR EMISSIONS (350GPM) FROM COOLING TOWERS (13 COMBINED)
```

```
SO SRCPARAM   CT1        22015.          7.52       304.80        9.8000       4.8800
*** CO2 EMISSIONS FROM 10 BOILER STACKS
SO SRCPARAM   S1C        55.2300        13.5600   480.0000       7.1800        .4064
SO SRCPARAM   S2C        43.1500         9.1400   480.0000       7.1800        .3048
SO SRCPARAM   S3C        55.2300         8.5300   480.0000       7.1800        .4064
SO SRCPARAM   S4C        28.2900        14.9300   480.0000       7.1800        .2540
SO SRCPARAM   S5C       102.73000       20.4200   480.0000       7.1800        .4064
SO SRCPARAM   S6C        37.4200         7.9200   480.0000       7.1800        .3048
SO SRCPARAM   S7C        19.6600        11.5800   480.0000       7.1800        .2040
SO SRCPARAM   S8C       102.73000       20.4200   480.0000       7.1800        .4064
SO SRCPARAM   S9C        55.2300         8.5300   480.0000       7.1800        .4064
SO SRCPARAM   S10C       28.2900         14.930   480.0000       7.1800        .2540

SO BUILDHGT CT1          7.52     7.52     7.52     7.52     7.52     7.52
SO BUILDHGT CT1          7.52     7.52     7.52     7.52     7.52     7.52
SO BUILDHGT CT1          7.52     7.52     7.52     7.52     7.52     7.52
SO BUILDHGT CT1          7.52     7.52     7.52     7.52     7.52     7.52
SO BUILDHGT CT1          7.52     7.52     7.52     7.52     7.52     7.52
SO BUILDHGT CT1          7.52     7.52     7.52     7.52     7.52     7.52
SO BUILDWID CT1         79.02    67.64    54.21    39.13    22.86    20.43
SO BUILDWID CT1         36.20    50.87    64.00    75.18    84.08    90.43
SO BUILDWID CT1         94.02    96.76    98.21    97.74    94.30    88.00
SO BUILDWID CT1         79.02    67.64    54.21    39.13    22.86    20.43
SO BUILDWID CT1         36.20    50.87    64.00    75.18    84.08    90.43
SO BUILDWID CT1         94.02    96.76    98.21    97.74    94.30    88.00

SO BUILDHGT S1C         10.52    10.52    10.52    10.52    10.52    10.52
SO BUILDHGT S1C         10.52    10.52    10.52    10.52    10.52    10.52
SO BUILDHGT S1C         10.52    10.52    10.52    10.52    10.52    10.52
SO BUILDHGT S1C         10.52    10.52    10.52    10.52    10.52    10.52
SO BUILDHGT S1C         10.52    10.52    10.52    10.52    10.52    10.52
SO BUILDHGT S1C         10.52    10.52    10.52    10.52    10.52    10.52
SO BUILDWID S1C         39.57    37.93    35.14    31.28    26.48    26.48
SO BUILDWID S1C         28.53    29.72    30.00    31.69    33.41    34.11
SO BUILDWID S1C         33.79    32.43    34.14    37.25    39.22    40.00
SO BUILDWID S1C         39.57    37.93    35.14    31.28    26.48    26.48
SO BUILDWID S1C         28.53    29.72    30.00    31.69    33.41    34.11
SO BUILDWID S1C         33.79    32.43    34.14    37.25    39.22    40.00

SO BUILDHGT S2C          6.10     6.10     6.10     6.10     6.10     6.10
SO BUILDHGT S2C          6.10     6.10     6.10     6.10     6.10     6.10
SO BUILDHGT S2C          6.10     6.10     6.10     6.10     6.10     6.10
SO BUILDHGT S2C          6.10     6.10     6.10     6.10     6.10     6.10
SO BUILDHGT S2C          6.10     6.10     6.10     6.10     6.10     6.10
SO BUILDHGT S2C          6.10     6.10     6.10     6.10     6.10     6.10
SO BUILDWID S2C        394.37   329.75   255.11   172.73    85.09    70.76
SO BUILDWID S2C        159.19   242.78   319.00   385.52   440.33   481.76
SO BUILDWID S2C        508.55   519.89   519.11   510.34   486.05   447.00
SO BUILDWID S2C        394.37   329.75   255.11   172.73    85.09    70.76
SO BUILDWID S2C        159.19   242.78   319.00   385.52   440.33   481.76
SO BUILDWID S2C        508.55   519.89   519.11   510.34   486.05   447.00
```

SO	BUILDHGT S3C	5.49	5.49	5.49	5.49	5.49	5.49
SO	BUILDHGT S3C	5.49	5.49	5.49	5.49	5.49	5.49
SO	BUILDHGT S3C	5.49	5.49	5.49	5.49	5.49	5.49
SO	BUILDHGT S3C	5.49	5.49	5.49	5.49	5.49	5.49
SO	BUILDHGT S3C	5.49	5.49	5.49	5.49	5.49	5.49
SO	BUILDHGT S3C	5.49	5.49	5.49	5.49	5.49	5.49
SO	BUILDWID S3C	33.19	32.38	30.58	27.85	26.25	29.31
SO	BUILDWID S3C	32.21	34.12	35.00	34.82	33.57	31.31
SO	BUILDWID S3C	28.10	24.20	26.58	29.64	31.80	33.00
SO	BUILDWID S3C	33.19	32.38	30.58	27.85	26.25	29.31
SO	BUILDWID S3C	32.21	34.12	35.00	34.82	33.57	31.31
SO	BUILDWID S3C	28.10	24.20	26.58	29.64	31.80	33.00
SO	BUILDHGT S4C	17.37	17.37	17.37	5.49	5.49	5.49
SO	BUILDHGT S4C	17.37	5.49	5.49	5.49	5.49	5.49
SO	BUILDHGT S4C	5.49	5.49	5.49	5.49	5.49	17.37
SO	BUILDHGT S4C	17.37	17.37	17.37	17.37	17.37	17.37
SO	BUILDHGT S4C	17.37	5.49	5.49	5.49	5.49	5.49
SO	BUILDHGT S4C	5.49	5.49	5.49	5.49	5.49	17.37
SO	BUILDWID S4C	115.69	109.86	100.69	14.41	10.95	10.69
SO	BUILDWID S4C	83.96	18.08	21.00	23.29	24.86	25.69
SO	BUILDWID S4C	25.73	24.99	23.49	23.32	23.52	118.00
SO	BUILDWID S4C	115.69	109.86	100.69	88.46	73.55	67.40
SO	BUILDWID S4C	83.96	18.08	21.00	23.29	24.86	25.69
SO	BUILDWID S4C	25.73	24.99	23.49	23.32	23.52	118.00
SO	BUILDHGT S5C	17.37	17.37	17.37	17.37	17.37	17.37
SO	BUILDHGT S5C	17.37	17.37	17.37	17.37	17.37	17.37
SO	BUILDHGT S5C	17.37	17.37	17.37	17.37	17.37	17.37
SO	BUILDHGT S5C	17.37	17.37	17.37	17.37	17.37	17.37
SO	BUILDHGT S5C	17.37	17.37	17.37	17.37	17.37	17.37
SO	BUILDHGT S5C	17.37	17.37	17.37	17.37	17.37	17.37
SO	BUILDWID S5C	115.69	109.86	100.69	88.46	73.55	67.40
SO	BUILDWID S5C	83.96	97.97	109.00	116.72	120.90	121.40
SO	BUILDWID S5C	118.21	111.43	104.84	111.91	116.73	118.00
SO	BUILDWID S5C	115.69	109.86	100.69	88.46	73.55	67.40
SO	BUILDWID S5C	83.96	97.97	109.00	116.72	120.90	121.40
SO	BUILDWID S5C	118.21	111.43	104.84	111.91	116.73	118.00
SO	BUILDHGT S6C	4.88	4.88	4.88	4.88	4.88	4.88
SO	BUILDHGT S6C	4.88	4.88	4.88	4.88	4.88	4.88
SO	BUILDHGT S6C	4.88	4.88	4.88	4.88	4.88	4.88
SO	BUILDHGT S6C	4.88	4.88	4.88	4.88	4.88	4.88
SO	BUILDHGT S6C	4.88	4.88	4.88	4.88	4.88	4.88
SO	BUILDHGT S6C	4.88	4.88	4.88	4.88	4.88	4.88
SO	BUILDWID S6C	47.16	42.88	37.30	30.59	22.95	23.11

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SO BUILDWID S6C        31.09   38.12   44.00   48.54   51.61   53.11
SO BUILDWID S6C        52.99   51.26   49.30   51.09   51.32   50.00
SO BUILDWID S6C        47.16   42.88   37.30   30.59   22.95   23.11
SO BUILDWID S6C        31.09   38.12   44.00   48.54   51.61   53.11
SO BUILDWID S6C        52.99   51.26   49.30   51.09   51.32   50.00

SO BUILDHGT S7C         8.53    8.53    8.53    8.53    8.53    8.53
SO BUILDHGT S7C         8.53    8.53    8.53    8.53    8.53    8.53
SO BUILDHGT S7C         8.53    8.53    8.53    8.53    8.53    8.53
SO BUILDHGT S7C         8.53    8.53    8.53    8.53    8.53    8.53
SO BUILDHGT S7C         8.53    8.53    8.53    8.53    8.53    8.53
SO BUILDHGT S7C         8.53    8.53    8.53    8.53    8.53    8.53
SO BUILDWID S7C        51.21   54.85   56.84   57.09   55.61   55.50
SO BUILDWID S7C        58.94   61.41   62.00   60.71   57.58   52.69
SO BUILDWID S7C        46.26   41.42   44.11   45.45   45.42   46.00
SO BUILDWID S7C        51.21   54.85   56.84   57.09   55.61   55.50
SO BUILDWID S7C        58.94   61.41   62.00   60.71   57.58   52.69
SO BUILDWID S7C        46.26   41.42   44.11   45.45   45.42   46.00

SO BUILDHGT S8C        17.37   17.37   17.37   17.37   17.37   17.37
SO BUILDHGT S8C        17.37   17.37   17.37   17.37   17.37   17.37
SO BUILDHGT S8C        17.37   17.37   17.37   17.37   17.37   17.37
SO BUILDHGT S8C        17.37   17.37   17.37   17.37   17.37   17.37
SO BUILDHGT S8C        17.37   17.37   17.37   17.37   17.37   17.37
SO BUILDHGT S8C        17.37   17.37   17.37   17.37   17.37   17.37
SO BUILDWID S8C       113.02  106.61   96.96   84.36   69.20   68.80
SO BUILDWID S8C        83.87   96.40  106.00  112.38  115.34  114.80
SO BUILDWID S8C       110.77  103.37  103.96  111.40  115.45  116.00
SO BUILDWID S8C       113.02  106.61   96.96   84.36   69.20   68.80
SO BUILDWID S8C        83.87   96.40  106.00  112.38  115.34  114.80
SO BUILDWID S8C       110.77  103.37  103.96  111.40  115.45  116.00

SO BUILDHGT S9C         5.49    5.49    5.49    5.49    5.49    5.49
SO BUILDHGT S9C         5.49    5.49    5.49    5.49    5.49    5.49
SO BUILDHGT S9C         5.49    5.49    5.49    5.49    5.49    5.49
SO BUILDHGT S9C         5.49    5.49    5.49    5.49    5.49    5.49
SO BUILDHGT S9C         5.49    5.49    5.49    5.49    5.49    5.49
SO BUILDHGT S9C         5.49    5.49    5.49    5.49    5.49    5.49
SO BUILDWID S9C        34.35   33.66   31.94   29.26   25.69   26.31
SO BUILDWID S9C        30.15   33.08   35.00   35.86   35.63   34.31
SO BUILDWID S9C        31.95   28.63   26.94   30.24   32.62   34.00
SO BUILDWID S9C        34.35   33.66   31.94   29.26   25.68   26.31
SO BUILDWID S9C        30.15   33.08   35.00   35.86   35.63   34.31
SO BUILDWID S9C        31.95   28.63   26.94   30.24   32.62   34.00

SO BUILDHGT S10C        5.49    5.49    5.49   17.37   17.37   17.37
SO BUILDHGT S10C       17.37   17.37   17.37   17.37   17.37   17.37
SO BUILDHGT S10C        5.49    5.49    5.49    5.49    5.49    5.49
```

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SO BUILDHGT S10C        5.49     5.49     5.49    17.37    17.37    17.37
SO BUILDHGT S10C       17.37    17.37    17.37    17.37    17.37    17.37
SO BUILDHGT S10C        5.49     5.49     5.49     5.49     5.49     5.49
SO BUILDWID S10C       20.80    18.96    16.55    84.36    69.20    68.80
SO BUILDWID S10C       83.87    96.40   106.00   112.38   115.34   114.80
SO BUILDWID S10C       23.55    22.94    22.95    22.38    22.53    22.00
SO BUILDWID S10C       20.80    18.96    16.55    84.36    69.20    68.80
SO BUILDWID S10C       83.87    96.40   106.00   112.38   115.34   114.80
SO BUILDWID S10C       23.55    22.94    22.95    22.38    22.53    22.00

SO SRCGROUP   CT CT1
SO SRCGROUP   CO2 S1C-S10C
SO FINISHED


RE STARTING
RE ELEVUNIT FEET
RE DISCCART  744522.  3982825.  1120.  36.0
RE FINISHED


ME STARTING
*** all windspeeds <.7 m/sec set equal zero (calm)
ME INPUTFIL  ORNA8.ASC
ME ANEMHGHT    9.100 METERS
ME SURFDATA  13891  1991            ORTN
ME UAIRDATA  13897  1991            NATN
ME WINDCATS    1.54    3.09    5.14    8.23   10.80
ME FINISHED


OU STARTING
OU MAXTABLE ALLAVE 50
OU MAXIFILE 1 CT  .1 WB12CT.SUM
OU MAXIFILE 1 CO2 .1 WB12CO2.SUM
OU FINISHED


 *** Message Summary For ISC3 Model Setup ***

 --------- Summary of Total Messages --------

A Total of           0 Fatal Error Message(s)
A Total of           1 Warning Message(s)
A Total of           0 Informational Message(s)


   ******** FATAL ERROR MESSAGES ********
              ***  NONE  ***
```

```
   ********   WARNING MESSAGES   ********
CO W205     9 FLAGDF:No Option Parameter Setting.  Forced by Default to ZFLAG=0.

***********************************
*** SETUP Finishes Successfully ***
***********************************
```

```
 *** ISCST3 - VERSION 97363 ***    *** CT & 10 STACKS @ MON. TOWER*4MW*1991 JUL-SEP WB MET          ***       06/15/98
                                   ***                                                              ***       19:41:09
                                                                                                              PAGE   1
**MODELOPTs: CONC                          RURAL  ELEV   FLGPOL DFAULT

                                               ***     MODEL SETUP OPTIONS SUMMARY       ***
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

**Intermediate Terrain Processing is Selected

**Model Is Setup For Calculation of Average CONCentration Values.

  --  SCAVENGING/DEPOSITION LOGIC --
**Model Uses NO DRY DEPLETION.  DDPLETE =  F
**Model Uses NO WET DEPLETION.  WDPLETE =  F
**NO WET SCAVENGING Data Provided.
**Model Does NOT Use GRIDDED TERRAIN Data for Depletion Calculations

**Model Uses RURAL Dispersion.

**Model Uses Regulatory DEFAULT Options:
           1. Final Plume Rise.
           2. Stack-tip Downwash.
           3. Buoyancy-induced Dispersion.
           4. Use Calms Processing Routine.
           5. Not Use Missing Data Processing Routine.
           6. Default Wind Profile Exponents.
           7. Default Vertical Potential Temperature Gradients.
           8. "Upper Bound" Values for Supersquat Buildings.
           9. No Exponential Decay for RURAL Mode

**Model Accepts Receptors on ELEV Terrain.

**Model Accepts FLAGPOLE Receptor Heights.

**Model Calculates  1 Short Term Average(s) of:   1-HR

**This Run Includes:    11 Source(s);       2 Source Group(s); and       1 Receptor(s)

**The Model Assumes A Pollutant Type of:  OTHER

**Model Set To Continue RUNning After the Setup Testing.

**Output Options Selected:
         Model Outputs Tables of Overall Maximum Short Term Values (MAXTABLE Keyword)
         Model Outputs External File(s) of Threshold Violations (MAXIFILE Keyword)

**NOTE:  The Following Flags May Appear Following CONC Values:  c for Calm Hours
                                                                m for Missing Hours
                                                                b for Both Calm and Missing Hours
```

```
**Misc. Inputs:  Anem. Hgt. (m) =     9.10 ;    Decay Coef. =   0.0000     ;    Rot. Angle =     0.0
                 Emission Units = GRAMS/SEC                                 ;  Emission Rate Unit Factor =   0.10000E+07
                 Output Units   = MICROGRAMS/M**3

**Input Runstream File: wb12.inp                                      ;  **Output Print File: wb12.out
**Detailed Error/Message File:   ERRORS.OUT
```

*** ISCST3 - VERSION 97363 ***   *** CT & 10 STACKS @ MON. TOWER*4MW*1991 JUL-SEP WB MET   ***   06/15/98
***   ***   19:41:09
PAGE 2

**MODELOPTs: CONC   RURAL ELEV FLGPOL DFAULT

*** POINT SOURCE DATA ***

SOURCE ID	NUMBER PART. CATS.	EMISSION RATE (GRAMS/SEC)	X (METERS)	Y (METERS)	BASE ELEV. (METERS)	STACK HEIGHT (METERS)	STACK TEMP. (DEG.K)	STACK EXIT VEL. (M/SEC)	STACK DIAMETER (METERS)	BUILDING EXISTS	EMISSION RATE SCALAR VARY BY
CT1	0	0.22015E+05	743267.0	3981595.0	317.0	7.52	304.80	9.80	4.88	YES	
S1C	0	0.55230E+02	742933.0	3981537.0	316.8	13.56	480.00	7.18	0.41	YES	
S2C	0	0.43150E+02	743170.0	3981701.0	321.3	9.14	480.00	7.18	0.30	YES	
S3C	0	0.55230E+02	743471.0	3981795.0	331.6	8.53	480.00	7.18	0.41	YES	
S4C	0	0.28290E+02	743552.0	3981865.0	317.3	14.93	480.00	7.18	0.25	YES	
S5C	0	0.10273E+03	743645.0	3981965.0	316.5	20.42	480.00	7.18	0.41	YES	
S6C	0	0.37420E+02	743239.0	3981635.0	320.0	7.92	480.00	7.18	0.30	YES	
S7C	0	0.19660E+02	743347.0	3981717.0	320.0	11.58	480.00	7.18	0.20	YES	
S8C	0	0.10273E+03	743567.0	3982073.0	316.5	20.42	480.00	7.18	0.41	YES	
S9C	0	0.55230E+02	743339.0	3981977.0	331.6	8.53	480.00	7.18	0.41	YES	
S10C	0	0.28290E+02	743447.0	3982027.0	317.3	14.93	480.00	7.18	0.25	YES	

```
 *** ISCST3 - VERSION 97363 ***     *** CT & 10 STACKS @ MON. TOWER*4MW*1991 JUL-SEP WB MET                    ***        06/15/98
                                    ***                                                                        ***        19:41:09
                                                                                                                          PAGE   3
**MODELOPTs: CONC                            RURAL  ELEV   FLGPOL DFAULT


                                         *** SOURCE IDs DEFINING SOURCE GROUPS ***

GROUP ID                                                     SOURCE IDs


 CT         CT1      ,

 CO2        S1C      , S2C      , S3C      , S4C      , S5C      , S6C      , S7C      , S8C      , S9C      , S10C     ,
```

*** ISCST3 - VERSION 97363 ***   *** CT & 10 STACKS @ MON. TOWER*4MW*1991 JUL-SEP WB MET   ***   06/15/98
***   ***   19:41:09
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**MODELOPTs: CONC   RURAL ELEV FLGPOL DFAULT

*** DIRECTION SPECIFIC BUILDING DIMENSIONS ***

SOURCE ID: CT1

IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK
1	7.5,	79.0,	0	2	7.5,	67.6,	0	3	7.5,	54.2,	0	4	7.5,	39.1,	0	5	7.5,	22.9,	0	6	7.5,	20.4,	0
7	7.5,	36.2,	0	8	7.5,	50.9,	0	9	7.5,	64.0,	0	10	7.5,	75.2,	0	11	7.5,	84.1,	0	12	7.5,	90.4,	0
13	7.5,	94.0,	0	14	7.5,	96.8,	0	15	7.5,	98.2,	0	16	7.5,	97.7,	0	17	7.5,	94.3,	0	18	7.5,	88.0,	0
19	7.5,	79.0,	0	20	7.5,	67.6,	0	21	7.5,	54.2,	0	22	7.5,	39.1,	0	23	7.5,	22.9,	0	24	7.5,	20.4,	0
25	7.5,	36.2,	0	26	7.5,	50.9,	0	27	7.5,	64.0,	0	28	7.5,	75.2,	0	29	7.5,	84.1,	0	30	7.5,	90.4,	0
31	7.5,	94.0,	0	32	7.5,	96.8,	0	33	7.5,	98.2,	0	34	7.5,	97.7,	0	35	7.5,	94.3,	0	36	7.5,	88.0,	0

SOURCE ID: S1C

IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK
1	10.5,	39.6,	0	2	10.5,	37.9,	0	3	10.5,	35.1,	0	4	10.5,	31.3,	0	5	10.5,	26.5,	0	6	10.5,	26.5,	0
7	10.5,	28.5,	0	8	10.5,	29.7,	0	9	10.5,	30.0,	0	10	10.5,	31.7,	0	11	10.5,	33.4,	0	12	10.5,	34.1,	0
13	10.5,	33.8,	0	14	10.5,	32.4,	0	15	10.5,	34.1,	0	16	10.5,	37.3,	0	17	10.5,	39.2,	0	18	10.5,	40.0,	0
19	10.5,	39.6,	0	20	10.5,	37.9,	0	21	10.5,	35.1,	0	22	10.5,	31.3,	0	23	10.5,	26.5,	0	24	10.5,	26.5,	0
25	10.5,	28.5,	0	26	10.5,	29.7,	0	27	10.5,	30.0,	0	28	10.5,	31.7,	0	29	10.5,	33.4,	0	30	10.5,	34.1,	0
31	10.5,	33.8,	0	32	10.5,	32.4,	0	33	10.5,	34.1,	0	34	10.5,	37.3,	0	35	10.5,	39.2,	0	36	10.5,	40.0,	0

SOURCE ID: S2C

IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK
1	6.1,	394.4,	0	2	6.1,	329.8,	0	3	6.1,	255.1,	0	4	6.1,	172.7,	0	5	6.1,	85.1,	0	6	6.1,	70.8,	0
7	6.1,	159.2,	0	8	6.1,	242.8,	0	9	6.1,	319.0,	0	10	6.1,	385.5,	0	11	6.1,	440.3,	0	12	6.1,	481.8,	0
13	6.1,	508.5,	0	14	6.1,	519.9,	0	15	6.1,	519.1,	0	16	6.1,	510.3,	0	17	6.1,	486.0,	0	18	6.1,	447.0,	0
19	6.1,	394.4,	0	20	6.1,	329.8,	0	21	6.1,	255.1,	0	22	6.1,	172.7,	0	23	6.1,	85.1,	0	24	6.1,	70.8,	0
25	6.1,	159.2,	0	26	6.1,	242.8,	0	27	6.1,	319.0,	0	28	6.1,	385.5,	0	29	6.1,	440.3,	0	30	6.1,	481.8,	0
31	6.1,	508.5,	0	32	6.1,	519.9,	0	33	6.1,	519.1,	0	34	6.1,	510.3,	0	35	6.1,	486.0,	0	36	6.1,	447.0,	0

SOURCE ID: S3C

IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK
1	5.5,	33.2,	0	2	5.5,	32.4,	0	3	5.5,	30.6,	0	4	5.5,	27.8,	0	5	5.5,	26.3,	0	6	5.5,	29.3,	0
7	5.5,	32.2,	0	8	5.5,	34.1,	0	9	5.5,	35.0,	0	10	5.5,	34.8,	0	11	5.5,	33.6,	0	12	5.5,	31.3,	0
13	5.5,	28.1,	0	14	5.5,	24.2,	0	15	5.5,	26.6,	0	16	5.5,	29.6,	0	17	5.5,	31.8,	0	18	5.5,	33.0,	0
19	5.5,	33.2,	0	20	5.5,	32.4,	0	21	5.5,	30.6,	0	22	5.5,	27.8,	0	23	5.5,	26.3,	0	24	5.5,	29.3,	0
25	5.5,	32.2,	0	26	5.5,	34.1,	0	27	5.5,	35.0,	0	28	5.5,	34.8,	0	29	5.5,	33.6,	0	30	5.5,	31.3,	0
31	5.5,	28.1,	0	32	5.5,	24.2,	0	33	5.5,	26.6,	0	34	5.5,	29.6,	0	35	5.5,	31.8,	0	36	5.5,	33.0,	0

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*** ISCST3 - VERSION 97363 ***     *** CT & 10 STACKS @ MON. TOWER*4MW*1991 JUL-SEP WB MET              ***        06/15/98
                                   ***                                                                  ***        19:41:09
                                                                                                                   PAGE   5
**MODELOPTs: CONC                            RURAL  ELEV   FLGPOL DFAULT

                                             *** DIRECTION SPECIFIC BUILDING DIMENSIONS ***


SOURCE ID: S4C
 IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK
   1  17.4, 115.7, 0       2  17.4, 109.9, 0       3  17.4, 100.7, 0       4   5.5,  14.4, 0       5   5.5,  10.9, 0       6   5.5,  10.7, 0
   7  17.4,  84.0, 0       8   5.5,  18.1, 0       9   5.5,  21.0, 0      10   5.5,  23.3, 0      11   5.5,  24.9, 0      12   5.5,  25.7, 0
  13   5.5,  25.7, 0      14   5.5,  25.0, 0      15   5.5,  23.5, 0      16   5.5,  23.3, 0      17   5.5,  23.5, 0      18  17.4, 118.0, 0
  19  17.4, 115.7, 0      20  17.4, 109.9, 0      21  17.4, 100.7, 0      22  17.4,  88.5, 0      23  17.4,  73.6, 0      24  17.4,  67.4, 0
  25  17.4,  84.0, 0      26   5.5,  18.1, 0      27   5.5,  21.0, 0      28   5.5,  23.3, 0      29   5.5,  24.9, 0      30   5.5,  25.7, 0
  31   5.5,  25.7, 0      32   5.5,  25.0, 0      33   5.5,  23.5, 0      34   5.5,  23.3, 0      35   5.5,  23.5, 0      36  17.4, 118.0, 0


SOURCE ID: S5C
 IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK
   1  17.4, 115.7, 0       2  17.4, 109.9, 0       3  17.4, 100.7, 0       4  17.4,  88.5, 0       5  17.4,  73.6, 0       6  17.4,  67.4, 0
   7  17.4,  84.0, 0       8  17.4,  98.0, 0       9  17.4, 109.0, 0      10  17.4, 116.7, 0      11  17.4, 120.9, 0      12  17.4, 121.4, 0
  13  17.4, 118.2, 0      14  17.4, 111.4, 0      15  17.4, 104.8, 0      16  17.4, 111.9, 0      17  17.4, 116.7, 0      18  17.4, 118.0, 0
  19  17.4, 115.7, 0      20  17.4, 109.9, 0      21  17.4, 100.7, 0      22  17.4,  88.5, 0      23  17.4,  73.6, 0      24  17.4,  67.4, 0
  25  17.4,  84.0, 0      26  17.4,  98.0, 0      27  17.4, 109.0, 0      28  17.4, 116.7, 0      29  17.4, 120.9, 0      30  17.4, 121.4, 0
  31  17.4, 118.2, 0      32  17.4, 111.4, 0      33  17.4, 104.8, 0      34  17.4, 111.9, 0      35  17.4, 116.7, 0      36  17.4, 118.0, 0


SOURCE ID: S6C
 IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK
   1   4.9,  47.2, 0       2   4.9,  42.9, 0       3   4.9,  37.3, 0       4   4.9,  30.6, 0       5   4.9,  22.9, 0       6   4.9,  23.1, 0
   7   4.9,  31.1, 0       8   4.9,  38.1, 0       9   4.9,  44.0, 0      10   4.9,  48.5, 0      11   4.9,  51.6, 0      12   4.9,  53.1, 0
  13   4.9,  53.0, 0      14   4.9,  51.3, 0      15   4.9,  49.3, 0      16   4.9,  51.1, 0      17   4.9,  51.3, 0      18   4.9,  50.0, 0
  19   4.9,  47.2, 0      20   4.9,  42.9, 0      21   4.9,  37.3, 0      22   4.9,  30.6, 0      23   4.9,  22.9, 0      24   4.9,  23.1, 0
  25   4.9,  31.1, 0      26   4.9,  38.1, 0      27   4.9,  44.0, 0      28   4.9,  48.5, 0      29   4.9,  51.6, 0      30   4.9,  53.1, 0
  31   4.9,  53.0, 0      32   4.9,  51.3, 0      33   4.9,  49.3, 0      34   4.9,  51.1, 0      35   4.9,  51.3, 0      36   4.9,  50.0, 0


SOURCE ID: S7C
 IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK  IFV    BH      BW  WAK
   1   8.5,  51.2, 0       2   8.5,  54.8, 0       3   8.5,  56.8, 0       4   8.5,  57.1, 0       5   8.5,  55.6, 0       6   8.5,  55.5, 0
   7   8.5,  58.9, 0       8   8.5,  61.4, 0       9   8.5,  62.0, 0      10   8.5,  60.7, 0      11   8.5,  57.6, 0      12   8.5,  52.7, 0
  13   8.5,  46.3, 0      14   8.5,  41.4, 0      15   8.5,  44.1, 0      16   8.5,  45.5, 0      17   8.5,  45.4, 0      18   8.5,  46.0, 0
  19   8.5,  51.2, 0      20   8.5,  54.8, 0      21   8.5,  56.8, 0      22   8.5,  57.1, 0      23   8.5,  55.6, 0      24   8.5,  55.5, 0
  25   8.5,  58.9, 0      26   8.5,  61.4, 0      27   8.5,  62.0, 0      28   8.5,  60.7, 0      29   8.5,  57.6, 0      30   8.5,  52.7, 0
  31   8.5,  46.3, 0      32   8.5,  41.4, 0      33   8.5,  44.1, 0      34   8.5,  45.5, 0      35   8.5,  45.4, 0      36   8.5,  46.0, 0
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*** ISCST3 - VERSION 97363 *** *** CT & 10 STACKS @ MON. TOWER*4MW*1991 JUL-SEP WB MET *** 06/15/98
*** *** 19:41:09
PAGE 6

**MODELOPTs: CONC RURAL ELEV FLGPOL DFAULT

*** DIRECTION SPECIFIC BUILDING DIMENSIONS ***

SOURCE ID: S8C

IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK
1	17.4,	113.0,	0	2	17.4,	106.6,	0	3	17.4,	97.0,	0	4	17.4,	84.4,	0	5	17.4,	69.2,	0	6	17.4,	68.8,	0
7	17.4,	83.9,	0	8	17.4,	96.4,	0	9	17.4,	106.0,	0	10	17.4,	112.4,	0	11	17.4,	115.3,	0	12	17.4,	114.8,	0
13	17.4,	110.8,	0	14	17.4,	103.4,	0	15	17.4,	104.0,	0	16	17.4,	111.4,	0	17	17.4,	115.5,	0	18	17.4,	116.0,	0
19	17.4,	113.0,	0	20	17.4,	106.6,	0	21	17.4,	97.0,	0	22	17.4,	84.4,	0	23	17.4,	69.2,	0	24	17.4,	68.8,	0
25	17.4,	83.9,	0	26	17.4,	96.4,	0	27	17.4,	106.0,	0	28	17.4,	112.4,	0	29	17.4,	115.3,	0	30	17.4,	114.8,	0
31	17.4,	110.8,	0	32	17.4,	103.4,	0	33	17.4,	104.0,	0	34	17.4,	111.4,	0	35	17.4,	115.5,	0	36	17.4,	116.0,	0

SOURCE ID: S9C

IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK
1	5.5,	34.3,	0	2	5.5,	33.7,	0	3	5.5,	31.9,	0	4	5.5,	29.3,	0	5	5.5,	25.7,	0	6	5.5,	26.3,	0
7	5.5,	30.1,	0	8	5.5,	33.1,	0	9	5.5,	35.0,	0	10	5.5,	35.9,	0	11	5.5,	35.6,	0	12	5.5,	34.3,	0
13	5.5,	31.9,	0	14	5.5,	28.6,	0	15	5.5,	26.9,	0	16	5.5,	30.2,	0	17	5.5,	32.6,	0	18	5.5,	34.0,	0
19	5.5,	34.3,	0	20	5.5,	33.7,	0	21	5.5,	31.9,	0	22	5.5,	29.3,	0	23	5.5,	25.7,	0	24	5.5,	26.3,	0
25	5.5,	30.1,	0	26	5.5,	33.1,	0	27	5.5,	35.0,	0	28	5.5,	35.9,	0	29	5.5,	35.6,	0	30	5.5,	34.3,	0
31	5.5,	31.9,	0	32	5.5,	28.6,	0	33	5.5,	26.9,	0	34	5.5,	30.2,	0	35	5.5,	32.6,	0	36	5.5,	34.0,	0

SOURCE ID: S10C

IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK	IFV	BH	BW	WAK
1	5.5,	20.8,	0	2	5.5,	19.0,	0	3	5.5,	16.5,	0	4	17.4,	84.4,	0	5	17.4,	69.2,	0	6	17.4,	68.8,	0
7	17.4,	83.9,	0	8	17.4,	96.4,	0	9	17.4,	106.0,	0	10	17.4,	112.4,	0	11	17.4,	115.3,	0	12	17.4,	114.8,	0
13	5.5,	23.5,	0	14	5.5,	22.9,	0	15	5.5,	22.9,	0	16	5.5,	22.4,	0	17	5.5,	22.5,	0	18	5.5,	22.0,	0
19	5.5,	20.8,	0	20	5.5,	19.0,	0	21	5.5,	16.5,	0	22	17.4,	84.4,	0	23	17.4,	69.2,	0	24	17.4,	68.8,	0
25	17.4,	83.9,	0	26	17.4,	96.4,	0	27	17.4,	106.0,	0	28	17.4,	112.4,	0	29	17.4,	115.3,	0	30	17.4,	114.8,	0
31	5.5,	23.5,	0	32	5.5,	22.9,	0	33	5.5,	22.9,	0	34	5.5,	22.4,	0	35	5.5,	22.5,	0	36	5.5,	22.0,	0

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 *** ISCST3 - VERSION 97363 ***    *** CT & 10 STACKS @ MON. TOWER*4MW*1991 JUL-SEP WB MET                 ***        06/15/98
                                   ***                                                                       ***        19:41:09
                                                                                                                        PAGE   7
**MODELOPTs: CONC                          RURAL  ELEV   FLGPOL DFAULT


                                              *** DISCRETE CARTESIAN RECEPTORS ***
                                                (X-COORD, Y-COORD, ZELEV, ZFLAG)
                                                             (METERS)

    ( 744522.0, 3982825.0,     341.4,      36.0);
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*** ISCST3 - VERSION 97363 ***    *** CT & 10 STACKS @ MON. TOWER*4MW*1991 JUL-SEP WB MET          ***     06/15/98
                                  ***                                                              ***     19:41:09
                                                                                                           PAGE   8
**MODELOPTs: CONC                          RURAL  ELEV   FLGPOL DFAULT

                         *** METEOROLOGICAL DAYS SELECTED FOR PROCESSING ***
                                        (1=YES; 0=NO)

    1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
    1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
    1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
    1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
    1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
    1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
    1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1 1 1 1 1
    1 1 1 1 1 1 1 1 1 1  1 1 1 1 1 1

      NOTE:  METEOROLOGICAL DATA ACTUALLY PROCESSED WILL ALSO DEPEND ON WHAT IS INCLUDED IN THE DATA FILE.


                   *** UPPER BOUND OF FIRST THROUGH FIFTH WIND SPEED CATEGORIES ***
                                          (METERS/SEC)

                              1.54,    3.09,    5.14,    8.23,   10.80,
```

*** WIND PROFILE EXPONENTS ***

STABILITY CATEGORY	WIND SPEED CATEGORY 1	2	3	4	5	6
A	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01
B	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01
C	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00
D	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00
E	.35000E+00	.35000E+00	.35000E+00	.35000E+00	.35000E+00	.35000E+00
F	.55000E+00	.55000E+00	.55000E+00	.55000E+00	.55000E+00	.55000E+00

*** VERTICAL POTENTIAL TEMPERATURE GRADIENTS ***
(DEGREES KELVIN PER METER)

STABILITY CATEGORY	WIND SPEED CATEGORY 1	2	3	4	5	6
A	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
B	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
C	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
D	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
E	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01
F	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01

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*** ISCST3 - VERSION 97363 ***     *** CT & 10 STACKS @ MON. TOWER*4MW*1991 JUL-SEP WB MET          ***          06/15/98
                                   ***                                                              ***          19:41:09
                                                                                                                 PAGE   9
**MODELOPTs: CONC                             RURAL   ELEV    FLGPOL DFAULT

                      *** THE FIRST  24 HOURS OF METEOROLOGICAL DATA ***

     FILE: ORNA8.ASC                                    FORMAT: (4I2,2F9.4,F6.1,I2,2F7.1,f9.4,f10.1,f8.4,i4,f7.2)
     SURFACE STATION NO.:  13891                        UPPER AIR STATION NO.:  13897
                     NAME: ORTN                                           NAME: NATN
                     YEAR:    1991                                        YEAR:    1991
```

YR	MN	DY	HR	FLOW VECTOR	SPEED (M/S)	TEMP (K)	STAB CLASS	MIXING HEIGHT (M) RURAL	MIXING HEIGHT (M) URBAN	USTAR (M/S)	M-O LENGTH (M)	Z-0 (M)	IPCODE	PRATE (mm/HR)
91	1	1	1	32.0	1.82	303.1	2	2125.8	2161.9	0.0000	0.0	0.0000	0	0.00
91	1	1	2	52.1	2.30	303.2	3	2196.4	2223.4	0.0000	0.0	0.0000	0	0.00
91	1	1	3	97.4	3.72	302.8	2	2266.9	2284.9	0.0000	0.0	0.0000	0	0.00
91	1	1	4	119.5	3.90	300.0	3	2337.4	2346.5	0.0000	0.0	0.0000	0	0.00
91	1	1	5	104.3	3.39	298.1	3	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	6	122.6	2.57	297.3	4	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	7	108.5	2.71	297.2	3	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	8	120.6	2.76	297.4	4	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	9	134.4	2.15	298.5	4	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	10	99.4	1.20	300.6	1	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	11	106.0	1.38	301.9	2	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	12	113.0	1.24	302.7	2	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	13	98.5	1.38	303.1	4	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	14	120.9	1.13	303.6	4	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	15	123.5	0.00	304.4	3	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	16	9.2	0.78	304.0	1	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	17	11.2	0.98	302.5	4	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	18	312.1	0.78	302.1	4	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	19	250.0	0.00	301.9	3	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	20	144.0	1.88	301.4	3	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	21	128.3	4.62	299.7	4	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	22	114.9	5.02	298.3	4	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	23	88.2	7.96	296.5	4	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00
91	1	1	24	81.5	5.35	293.9	4	2408.0	2408.0	0.0000	0.0	0.0000	0	0.00

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*** NOTES:  STABILITY CLASS 1=A, 2=B, 3=C, 4=D, 5=E AND 6=F.
            FLOW VECTOR IS DIRECTION TOWARD WHICH WIND IS BLOWING.
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*** ISCST3 - VERSION 97363 ***    *** CT & 10 STACKS @ MON. TOWER*4MW*1991 JUL-SEP WB MET       ***     06/15/98
                                  ***                                                            ***     19:41:09
**MODELOPTs: CONC                           RURAL  ELEV   FLGPOL DFAULT                                  PAGE  10

                            *** THE MAXIMUM   50   1-HR AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP:  CT        ***
                                INCLUDING SOURCE(S):     CT1     ,

                                  ** CONC OF OTHER     IN MICROGRAMS/M**3                          **
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RANK	CONC	(YYMMDDHH)	AT	RECEPTOR (XR,YR)	OF TYPE	RANK	CONC	(YYMMDDHH)	AT	RECEPTOR (XR,YR)	OF TYPE
1.	1040519.44000	(91052301)	AT	(744522.00, 3982825.00)	DC	26.	408944.15600	(91103013)	AT	(744522.00, 3982825.00)	DC
2.	860371.37500	(91071318)	AT	(744522.00, 3982825.00)	DC	27.	407653.59400	(91041610)	AT	(744522.00, 3982825.00)	DC
3.	852523.31300	(91021122)	AT	(744522.00, 3982825.00)	DC	28.	407477.68800	(91071319)	AT	(744522.00, 3982825.00)	DC
4.	730122.50000	(91062409)	AT	(744522.00, 3982825.00)	DC	29.	406411.00000	(91053015)	AT	(744522.00, 3982825.00)	DC
5.	715342.68800	(91032316)	AT	(744522.00, 3982825.00)	DC	30.	406308.28100	(91012307)	AT	(744522.00, 3982825.00)	DC
6.	661015.50000	(91122008)	AT	(744522.00, 3982825.00)	DC	31.	403909.93800	(91011924)	AT	(744522.00, 3982825.00)	DC
7.	588806.12500	(91122006)	AT	(744522.00, 3982825.00)	DC	32.	401106.93800	(91051419)	AT	(744522.00, 3982825.00)	DC
8.	566632.50000	(91031924)	AT	(744522.00, 3982825.00)	DC	33.	398889.31300	(91051006)	AT	(744522.00, 3982825.00)	DC
9.	528942.06300	(91090713)	AT	(744522.00, 3982825.00)	DC	34.	390928.28100	(91082716)	AT	(744522.00, 3982825.00)	DC
10.	522100.75000	(91031210)	AT	(744522.00, 3982825.00)	DC	35.	387549.31300	(91051422)	AT	(744522.00, 3982825.00)	DC
11.	505200.96900	(91050223)	AT	(744522.00, 3982825.00)	DC	36.	384416.31300	(91120224)	AT	(744522.00, 3982825.00)	DC
12.	495518.90600	(91081406)	AT	(744522.00, 3982825.00)	DC	37.	376056.21900	(91030411)	AT	(744522.00, 3982825.00)	DC
13.	484229.78100	(91051024)	AT	(744522.00, 3982825.00)	DC	38.	374980.28100	(91100124)	AT	(744522.00, 3982825.00)	DC
14.	484089.75000	(91051012)	AT	(744522.00, 3982825.00)	DC	39.	374238.78100	(91041723)	AT	(744522.00, 3982825.00)	DC
15.	458267.34400	(91091508)	AT	(744522.00, 3982825.00)	DC	40.	370532.78100	(91100202)	AT	(744522.00, 3982825.00)	DC
16.	452520.68800	(91101006)	AT	(744522.00, 3982825.00)	DC	41.	368265.96900	(91051414)	AT	(744522.00, 3982825.00)	DC
17.	451771.87500	(91042012)	AT	(744522.00, 3982825.00)	DC	42.	367364.46900	(91122813)	AT	(744522.00, 3982825.00)	DC
18.	447626.53100	(91110306)	AT	(744522.00, 3982825.00)	DC	43.	359781.78100	(91110402)	AT	(744522.00, 3982825.00)	DC
19.	436331.84400	(91070504)	AT	(744522.00, 3982825.00)	DC	44.	352743.71900	(91021209)	AT	(744522.00, 3982825.00)	DC
20.	434912.84400	(91013015)	AT	(744522.00, 3982825.00)	DC	45.	351305.65600	(91011914)	AT	(744522.00, 3982825.00)	DC
21.	431920.71900	(91082706)	AT	(744522.00, 3982825.00)	DC	46.	349772.53100	(91032315)	AT	(744522.00, 3982825.00)	DC
22.	414508.93800	(91012304)	AT	(744522.00, 3982825.00)	DC	47.	344577.96900	(91122005)	AT	(744522.00, 3982825.00)	DC
23.	413562.81300	(91050716)	AT	(744522.00, 3982825.00)	DC	48.	343476.03100	(91122814)	AT	(744522.00, 3982825.00)	DC
24.	411230.18800	(91081509)	AT	(744522.00, 3982825.00)	DC	49.	337569.43800	(91052401)	AT	(744522.00, 3982825.00)	DC
25.	410081.40600	(91042020)	AT	(744522.00, 3982825.00)	DC	50.	334396.34400	(91101824)	AT	(744522.00, 3982825.00)	DC

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*** RECEPTOR TYPES:  GC = GRIDCART
                     GP = GRIDPOLR
                     DC = DISCCART
                     DP = DISCPOLR
                     BD = BOUNDARY
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*** ISCST3 - VERSION 97363 ***     *** CT & 10 STACKS @ MON. TOWER*4MW*1991 JUL-SEP WB MET               ***       06/15/98
                                   ***                                                                    ***       19:41:09
                                                                                                                    PAGE  11
**MODELOPTs: CONC                             RURAL   ELEV    FLGPOL DFAULT

                                *** THE MAXIMUM    50   1-HR AVERAGE CONCENTRATION   VALUES FOR SOURCE GROUP:  CO2        ***
                                    INCLUDING SOURCE(S):    S1C      , S2C      , S3C      , S4C      , S5C      , S6C      , S7C      ,
        S8C      , S9C      , S10C     ,

                                         ** CONC OF OTHER    IN MICROGRAMS/M**3                         **
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RANK	CONC	(YYMMDDHH)	AT	RECEPTOR (XR,YR)	OF TYPE	RANK	CONC	(YYMMDDHH)	AT	RECEPTOR (XR,YR)	OF TYPE
1.	23410.70120	(91071812)	AT	(744522.00, 3982825.00)	DC	26.	17071.55470	(91062409)	AT	(744522.00, 3982825.00)	DC
2.	21986.40040	(91032316)	AT	(744522.00, 3982825.00)	DC	27.	16991.44140	(91032418)	AT	(744522.00, 3982825.00)	DC
3.	21535.64450	(91120224)	AT	(744522.00, 3982825.00)	DC	28.	16965.68750	(91020413)	AT	(744522.00, 3982825.00)	DC
4.	20892.60940	(91081509)	AT	(744522.00, 3982825.00)	DC	29.	16848.01560	(91082716)	AT	(744522.00, 3982825.00)	DC
5.	20041.11330	(91051421)	AT	(744522.00, 3982825.00)	DC	30.	16829.27340	(91112409)	AT	(744522.00, 3982825.00)	DC
6.	20030.30660	(91040123)	AT	(744522.00, 3982825.00)	DC	31.	16754.21090	(91082516)	AT	(744522.00, 3982825.00)	DC
7.	19808.75980	(91020822)	AT	(744522.00, 3982825.00)	DC	32.	16634.74020	(91100218)	AT	(744522.00, 3982825.00)	DC
8.	19677.09960	(91011924)	AT	(744522.00, 3982825.00)	DC	33.	16623.85740	(91012001)	AT	(744522.00, 3982825.00)	DC
9.	19644.17970	(91010308)	AT	(744522.00, 3982825.00)	DC	34.	16616.91020	(91123123)	AT	(744522.00, 3982825.00)	DC
10.	19468.10550	(91082621)	AT	(744522.00, 3982825.00)	DC	35.	16578.47850	(91071318)	AT	(744522.00, 3982825.00)	DC
11.	19457.75000	(91090713)	AT	(744522.00, 3982825.00)	DC	36.	16355.34860	(91110402)	AT	(744522.00, 3982825.00)	DC
12.	19398.85160	(91071507)	AT	(744522.00, 3982825.00)	DC	37.	16330.78220	(91100423)	AT	(744522.00, 3982825.00)	DC
13.	18869.52930	(91071319)	AT	(744522.00, 3982825.00)	DC	38.	16329.21580	(91050711)	AT	(744522.00, 3982825.00)	DC
14.	18642.33980	(91032315)	AT	(744522.00, 3982825.00)	DC	39.	16133.59860	(91120405)	AT	(744522.00, 3982825.00)	DC
15.	18337.98050	(91103013)	AT	(744522.00, 3982825.00)	DC	40.	16127.61620	(91031210)	AT	(744522.00, 3982825.00)	DC
16.	18333.78710	(91050716)	AT	(744522.00, 3982825.00)	DC	41.	15932.03130	(91091421)	AT	(744522.00, 3982825.00)	DC
17.	18156.91020	(91100422)	AT	(744522.00, 3982825.00)	DC	42.	15881.87790	(91112318)	AT	(744522.00, 3982825.00)	DC
18.	17871.23240	(91030411)	AT	(744522.00, 3982825.00)	DC	43.	15826.50290	(91122009)	AT	(744522.00, 3982825.00)	DC
19.	17843.57420	(91040321)	AT	(744522.00, 3982825.00)	DC	44.	15798.71290	(91062103)	AT	(744522.00, 3982825.00)	DC
20.	17636.11520	(91052301)	AT	(744522.00, 3982825.00)	DC	45.	15557.46880	(91112315)	AT	(744522.00, 3982825.00)	DC
21.	17512.26170	(91091619)	AT	(744522.00, 3982825.00)	DC	46.	15491.74800	(91031905)	AT	(744522.00, 3982825.00)	DC
22.	17505.71290	(91091610)	AT	(744522.00, 3982825.00)	DC	47.	15443.38180	(91041616)	AT	(744522.00, 3982825.00)	DC
23.	17472.12110	(91100420)	AT	(744522.00, 3982825.00)	DC	48.	15405.26950	(91031924)	AT	(744522.00, 3982825.00)	DC
24.	17386.54490	(91110307)	AT	(744522.00, 3982825.00)	DC	49.	15323.43360	(91051419)	AT	(744522.00, 3982825.00)	DC
25.	17223.24020	(91121006)	AT	(744522.00, 3982825.00)	DC	50.	14943.97560	(91101006)	AT	(744522.00, 3982825.00)	DC

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*** RECEPTOR TYPES:  GC = GRIDCART
                     GP = GRIDPOLR
                     DC = DISCCART
                     DP = DISCPOLR
                     BD = BOUNDARY
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 *** ISCST3 - VERSION 97363 ***     *** CT & 10 STACKS @ MON. TOWER*4MW*1991 JUL-SEP WB MET                  ***        06/15/98
                                    ***                                                                      ***        19:41:09
                                                                                                                        PAGE  12
**MODELOPTs: CONC                           RURAL  ELEV   FLGPOL DFAULT


*** Message Summary : ISCST3 Model Execution ***

 --------- Summary of Total Messages --------

A Total of           0 Fatal Error Message(s)
A Total of           1 Warning Message(s)
A Total of         666 Informational Message(s)

A Total of         666 Calm Hours Identified


   ******** FATAL ERROR MESSAGES ********
              ***  NONE  ***


   ********   WARNING MESSAGES   ********
CO W205     9 FLAGDF:No Option Parameter Setting.  Forced by Default to ZFLAG=0.

   ************************************
   *** ISCST3 Finishes Successfully ***
   ************************************
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