DOE/EIS-0203-F

Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement

Volume 1

April 1995

U.S. Department of Energy
Office of Environmental Management
Idaho Operations Office

COVER SHEET

RESPONSIBLE AGENCIES: Lead Federal Agency: U.S. Department of Energy
Cooperating Federal Agency: U.S. Department of the Navy

TITLE: Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement.

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ABSTRACT: This document analyzes at a programmatic level the potential environmental consequences over the next 40 years of alternatives related to the transportation, receipt, processing, and storage of spent nuclear fuel under the responsibility of the U.S. Department of Energy. It also analyzes the site-specific consequences of the Idaho National Engineering Laboratory sitewide actions anticipated over the next 10 years for waste and spent nuclear fuel management and environmental restoration. For programmatic spent nuclear fuel management, this document analyzes alternatives of no action, decentralization, regionalization, centralization and the use of the plans that existed in 1992/1993 for the management of these materials. For the Idaho National Engineering Laboratory, this document analyzes alternatives of no action, ten-year plan, and minimum and maximum treatment, storage, and disposal of U.S. Department of Energy wastes.

Reader's Guide

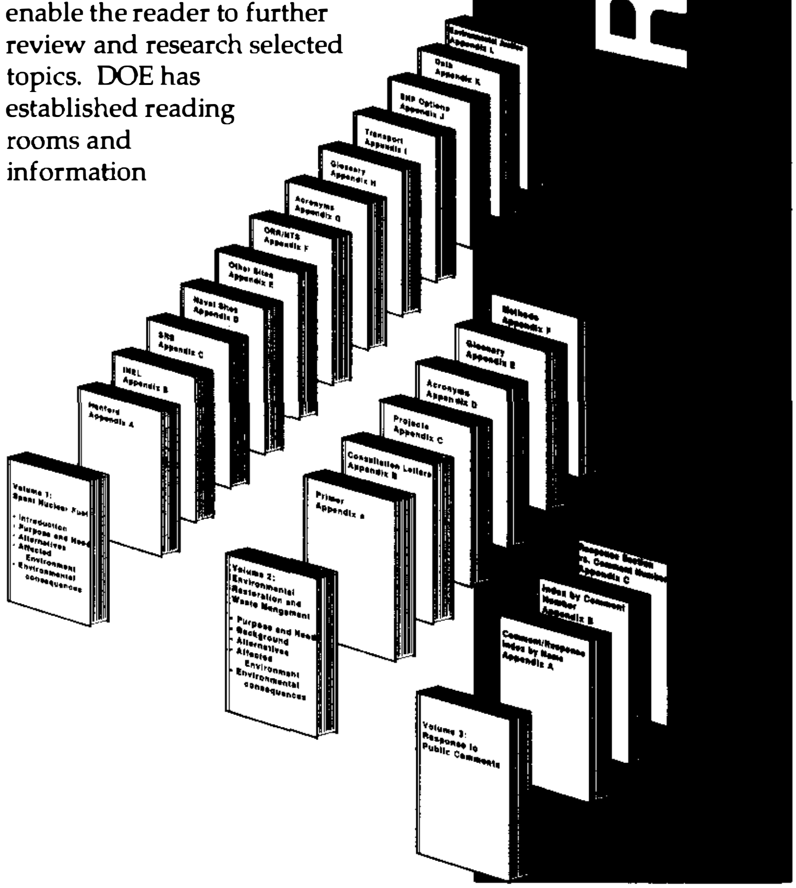
The U.S. Department of Energy's (DOE's) Environmental Impact Statement (EIS) for Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs [DOE/EIS-0203-F] is divided into three volumes:

- Volume 1, DOE Programmatic Spent Nuclear Fuel Management
- Volume 2, Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs (including site-specific spent nuclear fuel management)
- Volume 3, Comment Response Document.

Volume 1 comprises five primary sections and ten key appendices. The five primary sections provide (a) an introduction and overview to DOE's spent nuclear fuel management program throughout the nation, (b) the purpose and need for action to manage spent nuclear fuel, (c) management alternatives that are under consideration, (d) the affected environment, and (e) potential environmental consequences that may be caused by the implementation of each alternative. The information contained in these sections relies, in part, upon more detailed information and analyses in the ten key appendices. These appendices describe and assess the site-specific spent nuclear fuel management programs at three primary DOE facilities and several alternative sites, the naval spent nuclear fuel management program, offsite transportation of spent nuclear fuel, environmental consequences data, and environmental justice considerations. Two additional appendices include a glossary and a list of acronyms and abbreviations.

Volume 2 is similarly constructed. Five primary sections are presented that provide (a) the purpose and need for an integrated 10-year environmental restoration, waste management, and spent nuclear fuel management program at the Idaho National Engineering Laboratory, (b) background, (c) management alternatives under consideration, (d) the affected environment, and (e) potential environmental consequences that may be associated with the implementation of each alternative. The information presented in these sections relies, in part, upon four key appendices, which include a basic description of radioactivity and toxicology (chemical effects), agency consultation letters, detailed project summaries, and technical methodologies and key data. Two additional appendices include a glossary and a list of acronyms and abbreviations.

Volumes 1 and 2 provide an index as well as a list of references to enable the reader to further review and research selected topics. DOE has established reading rooms and information



locations across the United States where these references may either be reviewed or obtained for review through interlibrary loan. The addresses, phone numbers, and hours of operation for these reading rooms and information locations are provided at the end of this EIS Summary.

A line in the margin in Volumes 1 and 2 indicates a change since the Draft EIS.

Volume 3 comprises a primary section, called Comment Summaries and Responses, and three appendices. In the primary section individual public comments are summarized, grouped with others that are similar and organized into topical sections, called Response Sections. The appendices are designed to aid the reader in locating specific comment summaries and responses. Appendix A is an alphabetical list of commentors, showing for each the associated comment document number and response section number(s). Appendix B is a numerically ordered list of comment document numbers, showing associated commentors and response section numbers, and Appendix C provides a correlation of response section numbers to comment document numbers.

To find a response to comment(s), the reader should:

1. Turn to Appendix A in Volume 3 and find the name (or organization or agency), and note the comment document number(s) assigned to his/her comments.

2. In the same entry, find the response section number(s) where the responses to the comments are located.

3. Turn to the Table of Contents in Volume 3 under the heading Comment Summaries and Responses, where response section numbers are listed in numerical order, to find the page on which the response section number(s) that apply to the comment(s) appear.

4. Turn to the appropriate page(s) to find a response to a summary of the comment.

A copy of the actual comments (rather than the comment summaries found in Volume 3 of the EIS) can be found along with the EIS in the public reading rooms listed at the end of this summary.

Example:

1. The first alphabetical entrant, Dinah Abbott, has been assigned comment document number 615.

2. Ms. Abbott's first entry is for response number 01.01.01.01(005); four other response numbers are applicable to her comments.

3. That first entry is in Section 1.1.1.1, entitled "Action alternatives" under Specific Preferences for SNF Management Alternatives.

4. Section 1.1.1.1 begins on page 1-1. The selected entry for Ms. Abbott is Response 005 in that section and is located on page 1-2.

Contents

Introduction

National Environmental Policy Act Process

The U.S. Department of Energy (DOE) is currently evaluating its options for two separate, but related, sets of decisions. The first involves programmatic (DOE-wide) approaches to DOE's management of spent nuclear fuel. The second involves site-specific approaches regarding the future direction of environmental restoration and waste management programs (including spent nuclear fuel) at the Idaho National Engineering Laboratory.

A key element of DOE's decisionmaking is a thorough understanding of the environmental impacts that may occur during the implementation of the proposed action. The National Environmental Policy Act of 1969, as amended, provides federal agency decisionmakers with a process to consider potential environmental consequences (both positive and negative) of proposed actions before agencies make decisions. In following this process, DOE has prepared this final Environmental Impact Statement (EIS) to assess various management alternatives and to provide the necessary background, data, and analyses to help decisionmakers and the public understand the potential environmental impacts of each alternative. DOE's decisions will be discussed in a Record of Decision to be issued by June 1995.

National Environmental Policy Act

National Environmental Policy Act of 1969: A law that requires Federal agencies to consider in their decisionmaking processes the potential environmental effects of proposed actions and analyses of alternatives and measures to avoid or minimize the adverse effects of a proposed action.

Alternatives: A range of reasonable options considered in selecting an a roach to meeting the proposed objectives. In accordance with other applicable requirements, the No-Action alternative is also considered.

Environmental Impact Statement: A detailed environmental analysis for a proposed major Federal action that could significantly affect the quality of the human environment. A tool to assist in decisionmaking, it describes the positive and negative environmental effects of the proposed undertaking and alternatives.

Record of Decision: A concise public record of DOE's decision, which discusses the decision, identifies the alternatives (specifying which ones were considered environmentally preferable), and indicates whether all practicable means to avoid or minimize environmental harm from the selected alternative were adopted (and if not, why not).

General Scope of the Environmental Impact Statement

Volume 1 of this EIS considers programmatic (DOE-wide) alternative approaches to safely, efficiently, and responsibly manage existing and projected quantities of spent nuclear fuel until the year 2035. This amount of time may be required to make and implement a decision on the ultimate disposition of spent nuclear fuel. DOE's spent nuclear fuel responsibilities include fuel generated by DOE production, research, and development reactors; naval reactors; university and foreign research reactors; domestic non-DOE reactors such as those at the National Institute of Standards and Technology and the Armed Forces Radiobiology Research Institute; and special-case commercial reactors such as Fort St. Vrain and the Lynchburg Technology Center. Volume 1 focuses on the following:

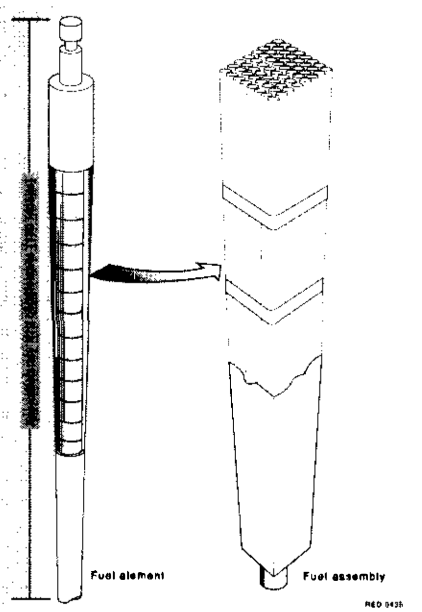
- Impacts to worker safety, public health, the environment, and socioeconomic factors related to transporting, receiving, stabilizing, and storing DOE and naval spent nuclear fuel, as well as special-case commercial fuels under DOE responsibility.

- Siting locations for spent nuclear fuel management operations, which may

What Is Spent Nuclear Fuel?

Spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated. For purposes of this EIS, spent nuclear fuel inventory also includes uranium/neptunium target material, blanket subassemblies, pieces of fuel, and debris.

Fuel in a reactor consists of fuel assemblies that come in many configurations but generally consist of the fuel matrix, cladding, and structural hardware. The matrix, which contains the fissionable material (typically uranium oxide or uranium metal), is typically plates or cylindrical pellets. The cladding (typically zirconium, aluminum, or stainless steel) surrounds the fuel, confining and protecting it. For gas-cooled reactors, this may be a ceramic coating over fuel particles. Structural parts hold fuel rods or plates in the proper configuration and direct coolant flow (typically water) over the fuel. Structural hardware is generally nickel alloys, stainless steel, zirconium, or aluminum, or for gas-cooled reactors, graphite.



The radiation of most concern from spent nuclear fuel is gamma rays. Although the radiation levels can be very high, the gamma-ray intensities are readily reduced by shielding the fuel elements with such materials as concrete, lead, steel, and water. The shielding thicknesses are dependent on the energy of the radiation source, desired protection level, and density of the shielding material. Shielding thicknesses for concrete or lead are smaller than for water.

include storing, stabilizing, and continuing research and development. (Stabilizing reduces fuel deterioration.)

- Fuel stabilization activities required for safe interim storage such as canning of degraded fuels or processing, research and development of spent nuclear fuel management technologies, and pilot programs.

DOE will not analyze the ultimate disposition (final step in which material is disposed of) of spent nuclear fuel in this EIS. Decisions regarding the actual disposition of DOE's spent nuclear fuel will follow appropriate review under the National Environmental Policy Act and be subject to licensing by the Nuclear Regulatory Commission.

DOE will not select spent nuclear fuel stabilization technologies on the basis of this EIS. These technology-based decisions are more appropriately dealt with on a fuel-type basis. DOE will conduct additional National Environmental Policy Act reviews for research and development, and characterization activities that help select technologies for placing the fuel in a form suitable for ultimate disposition (this is commonly referred to as "tiering" within the National Environmental Policy Act process).

For example, the Waste Management Programmatic EIS complements decisions to be made in Volume 2. Other EISs being prepared complement decisions for the disposition of other nuclear materials, and these EISs and their relationships to this EIS are discussed in Section 1.2 of Volume 1. The Draft EIS on a Proposed Nuclear Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel will be distributed for public review and comment in April 1995. Decisions derived from that policy also complement this EIS.

Waste management activities at the Idaho National Engineering Laboratory.

Except for special-case commercial fuel, management of spent nuclear fuel from commercial nuclear power plants is not the subject of this EIS.

Volume 2 of this EIS addresses alternative approaches for the management of DOE's environmental restoration, waste management, and spent nuclear fuel activities over the next 10 years at the Idaho National Engineering Laboratory. This volume includes evaluations of potential environmental impacts associated with Idaho National Engineering Laboratory programs and site activities that contribute to waste streams requiring handling or disposal. Waste management activities are evaluated at both the site-wide and project-specific levels.

Environmental restoration activities are addressed only at the site-wide level. Volume 2 considers site-specific activities for spent nuclear fuel management, including fuel receipt, transportation, characterization, stabilization, storage, and technology development for ultimate disposition.

Volume 2 evaluates impacts of operations or programs associated with the spent nuclear fuel, environmental restoration, and waste management programs at the Idaho National Engineering Laboratory. Other activities are discussed when they are relevant to understanding the affected environment or are expected to occur during the next 10 years, and are included as part of the cumulative effects analysis.

This EIS does not evaluate the DOE-wide programmatic alternatives for waste management, which are being evaluated in a separate programmatic EIS to be issued in draft form in 1995. However, the alternatives presented in Volume 2 have been developed to be consistent with the programmatic objectives of the Waste Management Programmatic EIS (previously known as the Environmental Restoration and Waste Management Programmatic Environmental Impact Statement), which will not be completed before the Record of Decision is signed for the EIS summarized here. Any conflicts between these Records of Decision will be evaluated and, as appropriate, additional National Environmental Policy Act reviews will be conducted.

Comments and Responses

During the public comment period for the Draft EIS, more than 1,430 individuals, agencies, and organizations provided DOE with comments. Comments were received from all affected DOE and shipyard communities. Most citizens and organizations expressed broad opinions, especially on siting and transportation options, and recommended new or enhanced alternatives or additional sites, or commented on the National Environmental Policy Act process. Many commentors used this opportunity to comment on legislation, policies, or federal programs not specifically related to the EIS. Some questioned or commented on the laws and regulations applicable to DOE's mission, DOE interim spent nuclear fuel management, or environmental restoration and waste management at the Idaho National Engineering Laboratory.

Many commentors expressed strongly held opinions about the EIS, DOE, and the Navy and/or the alternatives. Some commentors expressed the opinion that DOE does not consider public comments and that some comments will be given more weight than others. Others stated that fear-driven commentors should be ignored, and decisions should be based on good science.

Recurring and controversial issues raised during the public comment period included comments on DOE and Navy credibility; the apparent lack of a clear path forward with respect to ultimate disposition of spent nuclear fuel and nuclear waste; continued generation of spent nuclear fuel; cost of implementation; safety of, and risk to, the public; transportation of spent nuclear fuel and waste; impacts of accidents and perceived risk on local economies and the quality of life; other issues of local interest; and U.S. nuclear, defense, energy, and foreign policies.

Public comments were considered by the DOE and Navy and resulted in changes to the Draft EIS and in the preparation of the Comment Response Document, Volume 3, of this Final EIS. In general, public comments, coupled with consultations with commenting agencies and state and tribal governments, resulted in additional analyses, clarifying or correcting facts, or expanded discussion in certain technical areas. Where appropriate, Volume 3 provides an explanation of why certain comments did not warrant further change to the EIS.

Both volumes of the Final EIS identify DOE's preferred alternatives—Regionalization by fuel type (Alternative 4A) for managing spent nuclear fuel, and a hybrid alternative that is the Ten-Year Plan (Alternative B) enhanced to include elements of other alternatives for the Idaho National Engineering Laboratory. The DOE's preferred alternatives are consistent with the Navy's preferred alternative identified in the draft EIS—to continue to conduct refueling and defueling of nuclear-powered vessels and prototypes, and to transport spent nuclear fuel to the Idaho National Engineering Laboratory for full examination and interim storage, using the same practices as in the past. Identification of the preferred alternatives was based on consideration of environmental impacts, public issues and concerns, regulatory compliance, the DOE's and Navy's spent nuclear fuel missions, national security and defense, cost, and DOE policy.

As committed to in the Draft EIS, the evaluation and discussion of environmental justice has been expanded to both Volumes 1 and 2 of the Final EIS. This approach is consistent with draft interagency definitions at the time of its preparation and reflects public comments received regarding environmental justice. Consultation with commenting Native American

Tribes is reflected in the environmental justice analysis, as well as in various sections of the EIS, as appropriate.

In response to concerns raised by public comments regarding the technical analysis, seismic and water resource discussions and analyses were reviewed, clarified, and enhanced for all alternative sites, and current data and analyses were added to Volumes 1 and 2, as appropriate.

In Volume 1, a discussion of potential accidents caused by a common initiator was added. The option of stabilizing some of DOE's spent nuclear fuel (specifically Hanford site production reactor fuel) by processing it at available facilities located overseas was added, thus expanding processing options discussed in the EIS. An analysis of barge transportation was added to the EIS, addressing the option of transporting production-reactor fuel to a shipping point for overseas processing and supporting the transport of Brookhaven National Laboratory spent nuclear fuel to another site, as appropriate. In addition, an analysis of shipboard fires was added, primarily in response to comments related to receiving spent nuclear fuel of U.S. origin from foreign research reactors.

In response to public comments, the results of a separate evaluation of the various alternatives' costs were summarized in the EIS. The cost evaluation was performed independently of the EIS for purposes broader than those analyzed in the EIS.

The discussion of the option of leaving Fort St. Vrain spent nuclear fuel in Colorado has been expanded, specifically with respect to contractual commitments versus programmatic benefits.

Other enhancements include clarification that potential shipment of spent nuclear fuel of U.S. origin from foreign research reactors consists of approximately 20 metric tons of heavy metal. As a result of public comments, Volume 1 was enhanced to include a description that clarifies the relationship between other DOE NEPA reviews related to spent nuclear fuel and this EIS. This description explains the interrelationship of these actions in response to comments about segmentation. In the same regard, the relationship between the EIS and *Spent Fuel Vulnerability Action Plans* was clarified.

With regard to naval spent nuclear fuel, enhancements to Appendix D (Naval Spent Nuclear Fuel Management) include providing additional information in the following areas: importance of naval spent nuclear fuel examination, impacts of not refueling or defueling nuclear-powered vessels, the reasons why storage and processing of naval spent nuclear fuel in foreign facilities were not evaluated in detail, environmental justice considerations, the transition period required to implement naval spent nuclear fuel alternatives, potential accident scenarios at naval shipyards, and uncertainties in calculating potential environmental impacts.

In Volume 2, the air quality analysis was revised to upgrade the information on existing baseline conditions. The analysis compared impacts of each alternative with Prevention of Significant Deterioration increment limits. The Waste Experimental Reduction Facility project summary was enhanced with respect to related operation and combustion strategy. The EIS was also revised to reflect employment projections resulting from the Idaho National Engineering Laboratory contractor consolidation.

Overview

The DOE Spent Nuclear Fuel Management Program is intended to (a) provide interim storage and management of fuel at specified locations until ultimate disposition, (b) stabilize the fuel as required for environmentally safe storage and protection of human health (for both workers and the public), (c) increase safe storage capacity by replacing facilities that cannot meet current standards and providing additional capacity for newly generated spent nuclear fuel, (d) conduct research and development initiatives to support safe storage and/or ultimate disposition, and (e) examine fuel generated by the Naval Nuclear Propulsion Program. DOE's spent nuclear fuel management responsibilities include fuel generated by DOE production and research and development reactors, naval reactors, university and foreign research reactors, other miscellaneous generators, and special-case commercial reactors. The primary goals of the management program are to reduce the risk of nuclear accidents during transportation and storage and to minimize the release of radionuclides to the environment where they can pose hazards to human health, plants, and animals.

History of Spent Nuclear Fuel Management

Most DOE spent nuclear fuel is currently stored at three primary locations: the Hanford Site (State of Washington), the Idaho National Engineering Laboratory (State of Idaho), and the Savannah River Site (State of South Carolina) (Figure 1). Much smaller quantities of spent nuclear fuel remain at other locations throughout the nation (see Figure 1). Historically, DOE has reprocessed spent nuclear fuel at the three primary locations to recover and recycle uranium and plutonium.

Much of the spent nuclear fuel at the three primary locations resulted from production reactors at the Hanford and Savannah River Sites. These reactors are no longer operating, but they previously produced material for DOE's defense programs and research and development programs. Smaller quantities of spent nuclear fuel at other locations have resulted from experimental reactor operations and from research conducted by approximately 55 university- and Government-owned test reactors. DOE proposes to adopt and implement a policy concerning management of spent nuclear fuel containing enriched uranium that originated in the United States and was used by foreign research reactors. DOE also would manage limited amounts of special-case commercial reactor spent nuclear fuel.

Since 1957, spent nuclear fuel from nuclear-powered naval vessels and naval reactor prototypes (operating reactors used for land-based training) has been transported from shipyards and prototype sites to the Naval Reactors Facility at the Idaho National Engineering Laboratory for testing and examination. A court order issued on June 28, 1993 prohibited the receipt of all spent nuclear fuel by Idaho; that order was amended on December 22, 1993 allowing only a limited number of shipments of spent nuclear fuel to Idaho, pending completion of this EIS and the Record of Decision.

Purpose and Need for Future Spent Nuclear Fuel Management

DOE is responsible for developing and maintaining a capability to safely manage its spent nuclear fuel. During the last four decades, DOE and its

Existing Spent Nuclear Fuel Locations

1995 Inventory (Metric Tons Heavy Metal)[a]	
Hanford	2,133
Idaho National Engineering Laboratory	261
Savannah River Site	206
Oak Ridge Reservation	1
Other DOE Facilities	27
Universities	2
Other	16
Total	2,646

Legend

Source	No. of locations
U.S. Department of Energy Facilities	8
Naval Sites	7
Foreign Returns (potential points of entry)	11
Special-Case Commercial	3
Domestic Non-DOE	9
Universities	29

Naval Sites[b]	State
Kesselring	New York
Newport News	Virginia
Norfolk	Virginia
Pearl Harbor	Hawaii
Portsmouth	Maine
Puget Sound	Washington
Windsor	Connecticut

DOE Facilities	State
Argonne National Laboratory-East	Illinois
Brookhaven National Laboratory	New York
Hanford	Washington
Idaho National Engineering Laboratory	Idaho
Los Alamos National Laboratory	New Mexico
Oak Ridge Reservation	Tennessee
Sandia National Laboratories	New Mexico
Savannah River Site	South Carolina

a. A metric ton of heavy metal is the unit used throughout this document to indicate the amount of spent nuclear fuel. It corresponds to 1,000 kilograms (2,200 pounds) of heavy metal (uranium, plutonium, thorium).

b. Name of shipyard or site.

RED 0674

Figure 1. *Locations of current spent nuclear fuel generators and storage sites.*

predecessor agencies have transported, received, stored, and reprocessed more than 100,000 metric tons of heavy metal[a] of spent nuclear fuel. Approximately 2,700 metric tons heavy metal of spent nuclear fuel stored at various locations in the United States and overseas have not been reprocessed. This spent nuclear fuel is in a wide range of enrichments (that is, percent uranium-235), types, and conditions. By the year 2035, this quantity may increase by approximately 100 metric tons of heavy metal.

The end of the Cold War led DOE to reevaluate the scale of its weapons production, nuclear propulsion, and research missions. In April 1992, DOE began to phase out reprocessing of spent nuclear fuel for recovery and recycling of highly enriched uranium. In November 1993, DOE documented current and potential environmental, safety, and health vulnerabilities regarding DOE spent nuclear fuel storage facilities. DOE also identified storage locations of fuel with degraded cladding (metal coverings to prevent fuel corrosion) and other problems that require action to ensure continued safe storage. This situation has also been identified by the independent Defense Nuclear Facilities Safety Board in Recommendation 94-1, issued May 26, 1994. The Board concluded that imminent hazards could arise within several years unless certain problems are corrected, including those related to spent nuclear fuel storage. Thus, DOE needs to establish an integrated complex-wide program that provides safe and effective management for present and reasonably foreseeable quantities of spent nuclear fuel, pending its ultimate disposition. Relevant decisions that must be made include the selection of:

What Spent Nuclear Fuel Management Decisions Will Be Made Based on this EIS?

Where should DOE locate specific spent nuclear fuel management activities?

What capabilities, facilities, and technologies are needed for spent nuclear fuel management?

What research and development activities are needed to support the spent nuclear fuel management program?

- Locations to conduct specific spent nuclear fuel management activities after evaluating existing and potential locations
- Appropriate capabilities, facilities, and technologies
- Research and development activities needed to support the DOE Spent Nuclear Fuel Management Program.

In other words, this EIS will provide the environmental information to support decisions that will facilitate a transition between DOE's current management practices and ultimate disposition of spent nuclear fuel.

Technologies for Spent Nuclear Fuel Management

Technologies for spent nuclear fuel management are required to ensure safe, environmentally sound, and economic management until ultimate disposition is implemented. Ultimate disposition of DOE's spent nuclear

a. A metric ton of heavy metal is the unit used throughout this document to indicate the amount of spent nuclear fuel. It corresponds to 1,000 kilograms (2,200 pounds) of heavy metal (uranium, plutonium, thorium).

fuel is a high priority. Two broad strategies may at this point be envisioned for the ultimate disposition of DOE spent nuclear fuel. The Department could (a) work toward direct disposal of spent fuel in a geologic repository or (b) chemically dissolve the fuel and produce a waste form (such as vitrified glass) for repository disposal. Variations on these broad strategies are also possible and both remain under consideration. It is possible that much of DOE's spent fuel could qualify for direct disposal. Aggressive characterization and, if appropriate, preparation programs would be necessary to support the first repository schedule.

Sufficient quantity and quality of information is still not available to determine at this time whether the Yucca mountain site is a suitable candidate for geologic disposal of spent nuclear fuel and high-level radioactive waste. The DOE, however, is in the early planning stages for a repository EIS, which will be prepared pursuant to the directives of the Nuclear Waste policy Act, as amended. The DOE plans to issue in mid-1995 a formal notice of its intent to prepare this analysis. The repository EIS is being prepared to evaluate potential environmental impacts, based on the best available information and data, that would be associated with the repository's development and operation, and to support the Secretary of Energy's final recommendation to the President, as required by the Nuclear Waste Policy Act, as amended. The repository EIS will examine the site specific environmental impacts from construction, operation, and eventual closure of the repository, including potential post-closure radiological effects to the environment. Until the repository EIS is complete, no final decision could be made concerning what DOE spent nuclear fuel would be accepted in a geologic repository.

As part of its spent nuclear fuel management program, DOE would (1) stabilize the spent nuclear fuel as needed to ensure safe interim storage, (2) characterize the existing spent nuclear fuel inventory to assess compliance with the repository acceptance criteria as they are developed, and (3) determine what processing, if any, is required to meet

Definition of Terms Related to Spent Nuclear Fuel

management (of spent nuclear fuel)—Emplacing, operating, and administering facilities, transportation systems, and procedures to ensure safe and environmentally responsible handling and storage of spent nuclear fuel pending (and in anticipation of) a decision on ultimate disposition.

stabilization (of spent nuclear fuel)—Actions taken to further confine or reduce the hazards associated with spent nuclear fuel, as necessary for safe management and environmentally responsible storage for extended periods of time. Activities that may be necessary to stabilize spent nuclear fuel include canning, processing, and passivation.

canning—The process of placing spent nuclear fuel in canisters to retard corrosion, contain radioactive releases, or control geometry.

processing (of spent nuclear fuel)—Applying a chemical or physical process designed to alter the characteristics of the spent nuclear fuel matrix.

passivation—The process of making metals inactive or less chemically reactive. For example, the surface of steel can be passivated by chemical treatment.

the criteria. Decisions regarding the actual disposition of DOE's spent nuclear fuel would follow appropriate review under the National Environmental Policy Act, and would be subject to licensing by the U.S. Nuclear Regulatory Commission. This "path forward" would be implemented so as to minimize impacts on the first repository schedule. The current planning assumption is that any DOE material (vitrified high-level waste and/or spent nuclear fuel) qualified and selected for emplacement in the first repository would be disposed beginning in the year 2015. Disposition of the remaining DOE spent nuclear fuel and vitrified high-level waste that is not emplaced in the first repository would not be decided until the DOE recommendation on the need for a second repository (which would consider such factors as the physical and statutory limits of the first repository). The Nuclear Waste Policy Act, as amended, requires DOE to make that recommendation between January 1, 2007 and January 1, 2010.

Several technology options are available to accomplish overall spent nuclear fuel management objectives. Their selection is dependent upon fuel design and its structural integrity, fuel enrichment, and the chemical stability of the cladding including the degree of corrosion, and of the fuel matrix. These options include direct storage (limited to high-integrity fuels) or stabilization in preparation for storage.

Direct storage means storing spent nuclear fuel in essentially the same physical form in which it is removed from the reactor (that is, little or limited stabilization of the fuel elements). Fuel that has high-integrity cladding, for example naval fuel, can be direct stored, indefinitely. Both wet storage in water pools and dry storage in casks and vaults provide effective cooling and shielding for the safe storage of such high-integrity spent nuclear fuel.

Some stabilization technologies provide additional containment for spent nuclear fuel with reduced integrity. These technologies include (a) direct canning, (b) passivation, and (c) coating.

Several processing technologies are available to stabilize spent nuclear fuel without separating uranium and/or plutonium from the highly radioactive constituents. These technologies involve changing the physical and chemical form to reduce fuel volume and reactivity, or make the fuel more homogenous. They include (a) oxidation, (b) chemical dissolution, and (c) mechanical steps, such as chopping or shredding.

Some processing technologies separate uranium and/or plutonium from degraded cladding. Available technologies include (a) aqueous extraction from the chemically dissolved fuel, and (b) electrometallurgical processing with an electrical current to create chemical reactions at high temperature to extract the chemical elements.

Processing facilities and capabilities exist at various DOE sites. For some fuel, such as Hanford Site production reactor fuel, existing foreign processing capabilities could be employed. Foreign processing would be on a pay-as-you-go basis, without a substantial investment in facility upgrades and maintenance. A viable scenario would have to consider proliferation concerns, safety of overseas transport of spent nuclear fuel and returned materials, and national security.

Alternatives

DOE must provide for safe, efficient management of its spent nuclear fuel during the next 40 years, pending ultimate disposition. The alternatives considered are: No Action, Decentralization, 1992/1993 Planning Basis, Regionalization, and Centralization. These alternatives include variations of several components: (a) number of storage locations, (b) amounts of spent nuclear fuel shipped, (c) fuel stabilization methods (ways to reduce deterioration) required, (d) number and types of storage facilities to be constructed, and (e) scope of technology research and development efforts for management technologies.

In addition to the three DOE sites that have conducted extensive spent nuclear fuel management activities, four naval shipyards (Norfolk, Portsmouth, Pearl Harbor, and Puget Sound) and one prototype reactor site (Kesselring Site) were selected as potential storage locations for naval spent nuclear fuel. In response to public comments raised during the scoping process, DOE undertook a process for identifying possible alternative sites. The end result of the selection process was the inclusion and evaluation of two additional sites, the Oak Ridge Reservation (State of Tennessee) and the Nevada Test Site (State of Nevada). DOE did not consider the Nevada Test Site to be a preferred site for the management of spent nuclear fuel in the Draft EIS because of the State's current role as the host site for the Yucca Mountain Site Characterization Project. DOE's identification of the preferred alternatives also indicates that DOE does not consider the Nevada Test Site as a preferred site for spent nuclear fuel management in the Final EIS. Figure 2 depicts the various alternatives, options, and locations that DOE is evaluating for spent nuclear fuel management.

The DOE's preferred alternative is Regionalization by fuel type (Alternative 4A). Under this alternative, spent nuclear fuel would be assigned to sites having the largest inventory of similar fuel types. The DOE's preferred alternative is consistent with the Navy's preferred alternative to continue to conduct refueling and defueling of nuclear-powered vessels and prototypes, and to transport spent nuclear fuel to the Idaho National Engineering Laboratory for full examination and interim storage, using the same practices as in the past.

Summary of Alternatives for the Management of DOE Spent Nuclear Fuel

No Action

Take *minimum* actions required for safe and secure management of spent nuclear fuel at or close to the generation site or current storage location.

Decentralization

Store most spent nuclear fuel at or close to the generation site or current storage location with limited shipments to DOE facilities.

1992/1993 Planning Basis

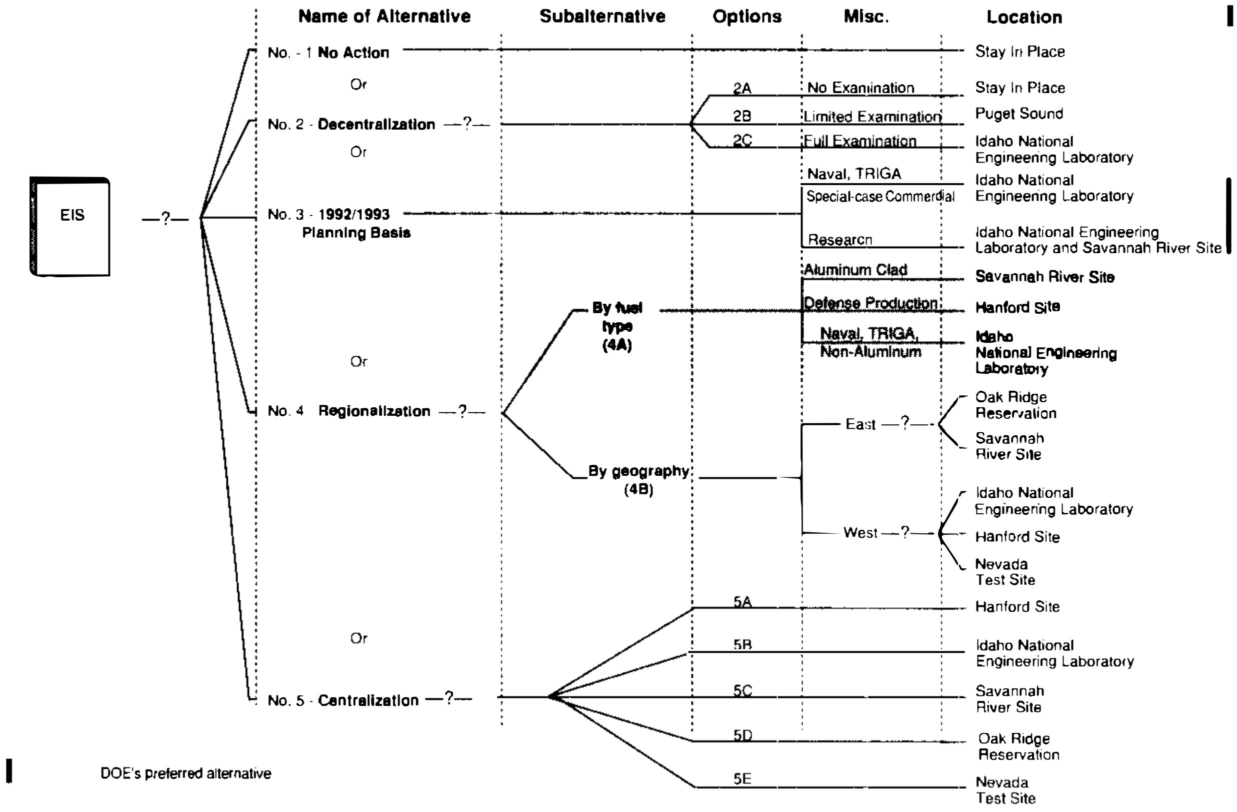
Transport to and store newly generated spent nuclear fuel at the Idaho National Engineering Laboratory or Savannah River Site. Consolidate some existing fuels at the Idaho National Engineering Laboratory or the Savannah River Site.

Regionalization

Distribute existing and projected spent nuclear fuel among DOE sites based primarily on fuel type (Preferred Alternative) or geography.

Centralization

Manage all existing and projected spent nuclear fuel inventories from DOE and the Navy at one site until ultimate disposition.



Note: Question marks note decisions to be made (an alternative or option will be chosen at these points).

RED 0650

Figure 2. *Alternatives for management of DOE spent nuclear fuel.*

The programmatic (DOE-wide) decisions will not select all site-specific spent nuclear fuel management options. Such decisions will be made following additional site-specific National Environmental Policy Act evaluations.

No Action Alternative

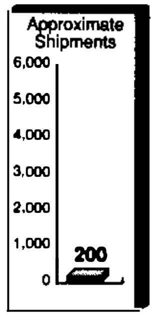
In the No Action alternative, which provides a baseline for comparison, DOE would limit actions to the minimum necessary for safe and secure management of spent nuclear fuel at or near the point where it is generated or currently located (Figure 3). Under this

No Action Alternative

Take minimum actions required for safe and secure management of spent nuclear fuel at or close to the generation site or current storage location.

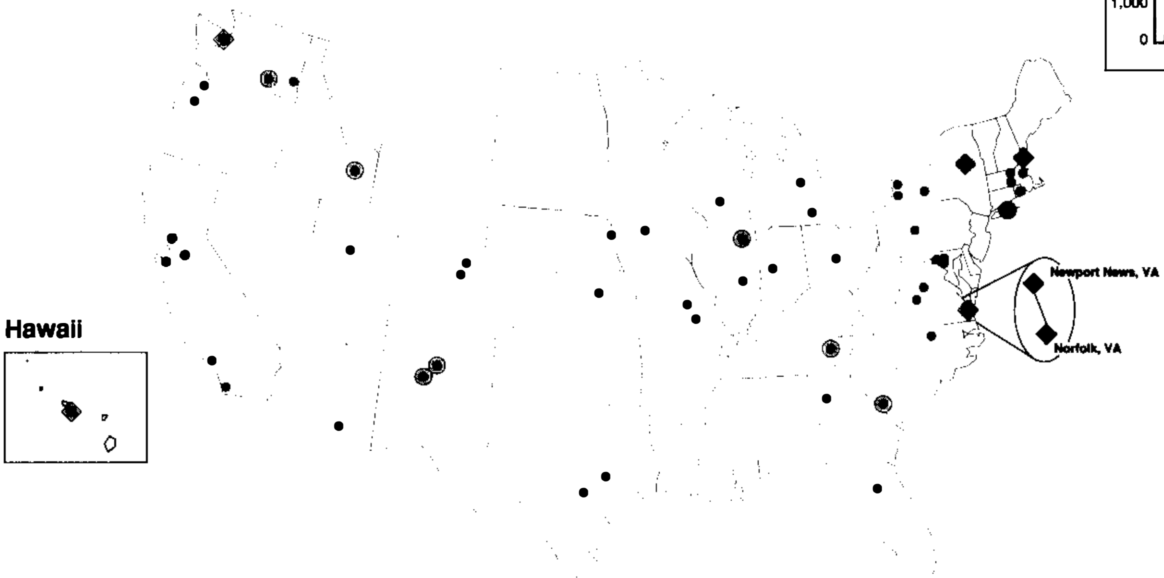
- **After an approximate three-year transition period, no shipment of spent nuclear fuel to or from DOE facilities would occur.**
- **Stabilization activities would be limited to the minimum actions required to safely store spent nuclear fuel.**
- **Naval reactor spent nuclear fuel would be stored at naval sites.**
- **Facility upgrade/replacement and onsite fuel transfers would be limited to those necessary for safe interim storage.**
- **Existing research and development activities would continue.**

1. No Action Alternative



Radiation Risk

Estimated latent cancer fatalities less than 1 over 40-year period for normal operations.



Approximate No Action Shipments Over 40 Years[a]

To: Norfolk, VA	200
From: Newport News, VA	

Approximate 2035 Inventory (Metric Tons Heavy Metal)

Hanford	2,132
Idaho National Engineering Laboratory	274
Savannah River Site	206
Naval Sites	55
Oak Ridge Reservation	2
Other	73
Total	2,742

Legend

Source	No. of locations
U.S. Department of Energy Facilities	8
Naval Sites	6
Special-Case Commercial	3
Domestic Non-DOE	9
Universities	29

Naval Sites[b]	State
Kesselring	New York
Norfolk	Virginia
Newport News	Virginia
Pearl Harbor	Hawaii
Portsmouth	Maine
Puget Sound	Washington

DOE Facilities	State
Argonne National Laboratory-East	Illinois
Brookhaven National Laboratory	New York
Hanford	Washington
Idaho National Engineering Laboratory	Idaho
Los Alamos National Laboratory	New Mexico
Oak Ridge Reservation	Tennessee
Sandia National Laboratories	New Mexico
Savannah River Site	South Carolina

a. Shipment numbers exclude shipments that would be made during transition period (see text).

b. Name of shipyard or site.

RED 0668

Figure 3. *Spent nuclear fuel distribution for the No Action alternative.*

alternative, both small and large DOE sites, naval shipyards and prototypes, university and other non-DOE domestic research reactors, and foreign research reactors would independently manage their fuel onsite. No spent nuclear fuel would be transported between DOE sites. Naval spent nuclear fuel at the Newport News Shipyard would be transferred to Norfolk Naval Shipyard for retention.

Naval reactors would be refueled and defueled as planned. Naval spent nuclear fuel would be stored in shipping containers at the naval or DOE facility where refueling and defueling are conducted. This alternative would require about a three-year transition period to obtain additional shipping containers for storage. During the transition period, fuel would be transported to the Idaho National Engineering Laboratory for examination at the Expended Core Facility. The shipping containers would be unloaded and reused for additional refueling and defuelings. However, after the transition period, the fuel removed from naval reactors would remain in storage at the naval sites and the Expended Core Facility at the Idaho National Engineering Laboratory would be shut down. Examinations of naval spent nuclear fuel would also cease. Current technology development activities related to spent nuclear fuel management would continue within DOE.

Decentralization Alternative

Under this alternative, DOE would maintain existing spent nuclear fuel in storage at current locations and store newly generated fuel at or near the site of generation (Figure 4). This

Decentralization Alternative

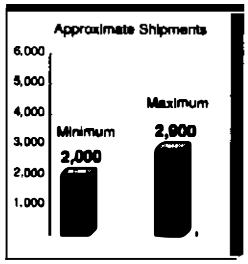
Store most spent nuclear fuel at or close to the generation site or current storage location with limited shipments to DOE facilities.

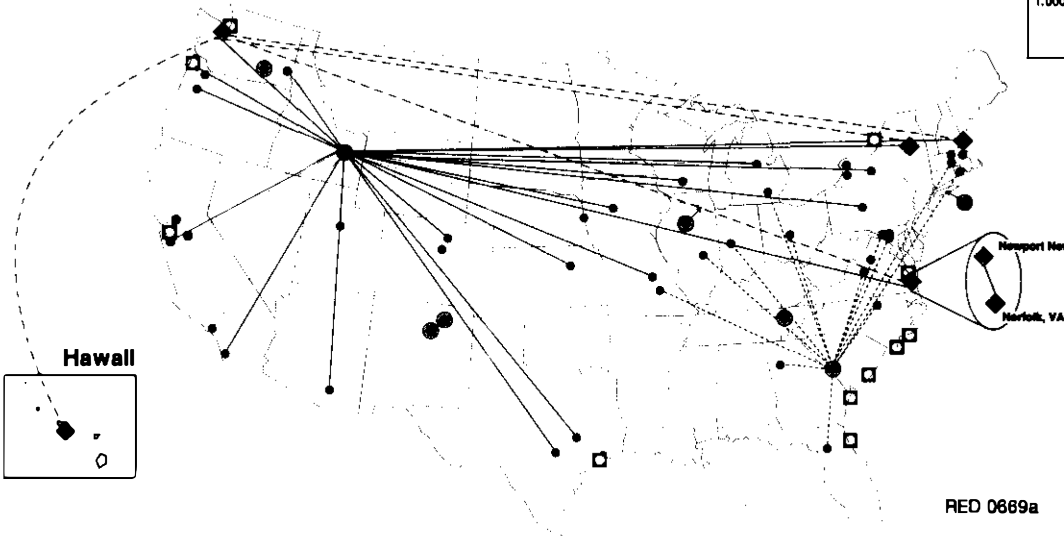
- **DOE spent nuclear fuel shipments would be limited to the following:**
  - **Spent nuclear fuel stored or generated at universities and non-DOE facilities**
  - **Potential foreign research reactor fuel.**
- **Spent nuclear fuel processing might need to be conducted. Other forms of stabilization might occur to provide for safe storage and/or transport.**
- **Some facilities would be upgraded/replaced and additional storage capacity required by the alternative would be constructed.**
- **Onsite fuel transfers would occur for improved safe storage.**
- **Research and development activities would be undertaken for spent nuclear fuel management, including stabilization technology.**
- **Three options for naval spent nuclear fuel**
  - **No inspection—fuel remains close to refueling/defueling site**
  - **Limited inspection at Puget Sound Naval Shipyard**
  - **Full inspection at the Idaho National Engineering Laboratory followed by storage close to refueling/defueling site.**

2. Decentralization

Radiation Risk

Estimated latent cancer fatalities less than 1 over 40-year period for normal operations.





● U.S. Department of Energy Facilities
············ Shipments going to Savannah River Site
——— Shipments going to Idaho National Engineering Laboratory
- - - - - - Shipments going to Puget Sound Naval Shipyard

• Domestic Non-DOE

Approximate Shipments

To: Idaho National Engineering Laboratory	30
To: Savannah River Site	190

Fuel Source

Savannah River Site Destination:
- Armed Forces Radiobiology Research Institute
- National Institute of Standards and Technology

Idaho National Engineering Laboratory Destination:
- Aerotest
- Dow
- General Atomic
- General Electric
- U.S. Geological Survey
- U.S. Air Force
- Veterans Administration Medical Center

• University

Approximate Shipments

To: Idaho National Engineering Laboratory	260
To: Savannah River Site	260

◻ Foreign Fuel [a] (potential points of entry)

Approximate Shipments

To: Idaho National Engineering Laboratory	460
To: Savannah River Site	550

◆ Naval Fuel Shipments

2A. No Exam [b]

Approximate Shipments

To: Norfolk, VA	200
From: Newport News, VA	

2B. Limited Exam [b]

Approximate Shipments

To: Puget Sound, WA	50
To: Norfolk, VA	180

2C. Full Exam [c]

Approximate Shipments

To: Idaho National Engineering Laboratory	580
From: Idaho National Engineering Laboratory	580

a. Foreign fuel could enter the US at any one of the identified points of entry for transport to the INEL or SRS.
b. Shipment numbers exclude shipments that would be made during transition period (see text).
c. All shipments to the Idaho National Engineering Laboratory for examination and then back to shipyards for storage.

RED 0669

Figure 4. *Spent nuclear fuel distribution for the Decentralization alternative.*

alternative differs from the No Action alternative by allowing fuel shipments from universities, non-DOE facilities, and foreign research reactors to DOE sites, which requires developing and upgrading facilities. Actions that would improve management capability, although not essential for safety, would be undertaken, and spent nuclear fuel research and development (including stabilization technology) would be performed.

The Decentralization alternative at the naval sites is similar to the No Action alternative because naval reactors would continue to be defueled and refueled as planned, and the fuel would be stored close to the refueling/defueling site. Three Decentralization options are included. The options differ only with regard to the examination of the fuel: no examination, limited examination, and full examination. Each option would require a transition period of about three years to develop storage facilities. During the transition period, spent nuclear fuel would be transported in shipping containers to the Idaho National Engineering Laboratory and the containers would be unloaded and reused.

The various small non-DOE, university, and foreign research reactors would only transport spent nuclear fuel in limited amounts to permit continued operations. No additional storage facilities would be constructed at these locations.

1992/1993 Planning Basis Alternative

The 1992/1993 Planning Basis alternative represents DOE's plans (in 1992 and 1993) for management of its spent nuclear fuel. Under this alternative, DOE would transport and store newly generated spent nuclear fuel at the Idaho National Engineering Laboratory or the Savannah River Site (Figure 5). Most existing spent nuclear fuel located at major DOE sites would remain at those sites.

Some existing spent nuclear fuel at other sites would be consolidated at the Idaho National Engineering Laboratory or Savannah River Site. The Savannah River Site and Idaho National Engineering Laboratory would also receive some test reactor fuel and some fuel from university and foreign research reactors. The Hanford Site would receive only limited quantities of fuel for research on storage and dispositioning technologies. DOE sites would generally upgrade facilities and construct new facilities to manage

1992/1993 Planning Basis

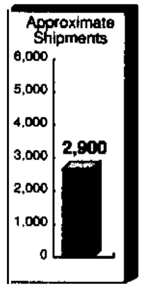
Transport to and store newly generated spent nuclear fuel at the Idaho National Engineering Laboratory or Savannah River Site. Consolidate some existing fuels at the Idaho National Engineering Laboratory or the Savannah River Site.

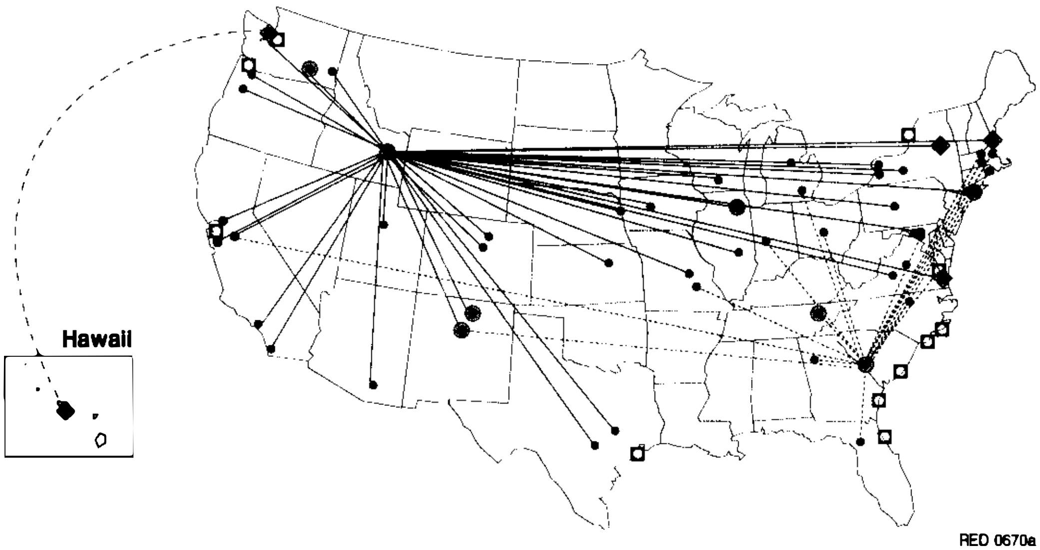
- **Fuel would be transported as follows:**
  - **TRIGA fuel from the Hanford Site to the Idaho National Engineering Laboratory; Hanford Site receives limited fuel for research of storage and dispositioning technologies**
  - **Naval fuel to the Idaho National Engineering Laboratory for examination and storage**
  - **West Valley Demonstration Project and Fort St. Vrain fuel to Idaho National Engineering Laboratory**
  - **Oak Ridge Reservation fuel to the Savannah River Site**
  - **Domestic research fuel, and foreign research reactor fuel as may yet be determined, divided between the Savannah River Site and the Idaho National Engineering Laboratory.**
- **Facilities upgrades and replacements that were planned would proceed, including increased storage capacity.**
- **Research and development for spent nuclear fuel management would be undertaken, including stabilization technology.**
- **Spent nuclear fuel processing might need to be conducted. Other forms of stabilization might occur to provide for safe storage and/or transport.**

3. 1992 - 1993 Planning Basis

Radiation Risk

Estimated latent cancer fatalities less than 1 over 40-year period for normal operations.





Shipments going to Savannah River Site
Shipments going to Idaho National Engineering Laboratory
Shipments going to Puget Sound Naval Shipyard and then to the INEL

DOE

Production reactor SNF remains at Hanford

Fuel Source

- **DOE Research**
  - Brookhaven National Laboratory, NY
  - Hanford, WA
  - Oak Ridge Reservation, TN
  - Idaho National Engineering Laboratory, ID
  - Los Alamos National Laboratory, NM
  - Savannah River Site, SC
  - Sandia National Laboratories, NM
  - Argonne National Laboratory-East, IL
- **Special Case Commercial**
  - West Valley, NY
  - Lynchburg, VA
  - Fort St. Vrain, CO

Approximate Shipments	
To: Idaho National Engineering Laboratory (INEL)	410
To: Savannah River Site (SRS)	120

◆ Naval Fuel

Approximate Shipments	
To: INEL for examination and storage	580

• University

Approximate Shipments	
To: INEL	260
To: SRS	260

Foreign Fuel [a] (potential points of entry)

Approximate Shipments	
To: INEL	460
To: SRS	550

• Domestic Non-DOE

Approximate Shipments	
To: INEL	30
To: SRS	190

a. Foreign fuel could enter the U.S. at any one of the identified points of entry for transport to the INEL or SRS

Figure 5. *Spent nuclear fuel distribution for the 1992/1993 Planning Basis alternative.*

Regionalization

Regionalization Alternative 4A - Preferred Alternative: Distribute existing and projected spent nuclear fuel among DOE sites primarily on the basis of fuel type.

- Naval fuel would be transported to, examined, and stored at the Idaho National Engineering Laboratory.
- Aluminum-clad fuel would be transported to the Savannah River Site; TRIGA and non-aluminum fuel would be transported to the Idaho National Engineering Laboratory; defense production fuel would be retained at the Hanford Site.
- Spent nuclear fuel processing might need to be conducted. Other forms of stabilization might occur to provide for safe storage and/or transport.
- Facilities required to support spent nuclear fuel management would be upgraded or built as necessary.
- Research and development for spent nuclear fuel management would be undertaken, including stabilization technology.

Regionalization Alternative 4B: Distribute existing and projected spent nuclear fuel between an Eastern Regional Site (either Oak Ridge Reservation or Savannah River Site) and a Western Regional Site (either Hanford Site, Idaho National Engineering Laboratory, or Nevada Test Site).

- The Eastern Regional Site would receive fuel from east of the Mississippi River and the Western Regional Site would receive fuel from west of the Mississippi River.
- Naval fuel would be transported to, examined, and stored at either the Western Regional Site or the Eastern Regional Site.
- Spent nuclear fuel processing might need to be conducted. Other forms of stabilization might occur to provide for safe storage and/or transport.
- Facilities required to support spent nuclear fuel management would be upgraded or built as necessary.
- Research and development for spent nuclear fuel management would be undertaken, including stabilization technology.

spent nuclear fuel. Activities related to spent nuclear fuel treatment would include research and development and pilot programs to support future decisions on the ultimate disposition of spent nuclear fuel.

Naval reactors would continue to be refueled and defueled as planned. Naval spent nuclear fuel would be transported from naval sites to the Expended Core Facility at the Idaho National Engineering Laboratory for examination. Following examination, fuel would remain in storage at the Idaho National Engineering Laboratory pending ultimate disposition.

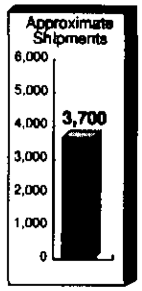
Under this alternative, other generator and storage locations would continue to ship spent nuclear fuel to the Idaho National Engineering Laboratory and Savannah River Site. No additional storage facilities would be constructed at these originating locations.

Regionalization and Preferred Alternative

This alternative would require a redistribution of spent nuclear fuel among DOE sites, either on the basis of fuel type (Regionalization Alternative 4A - Preferred Alternative) or on the basis of geography (Regionalization Alternative 4B). Regionalization by fuel type (Alternative 4A- Preferred Alternative)(Figure 6) would involve the use of the Idaho National Engineering Laboratory and Savannah River Site for storage of most newly generated spent nuclear fuel. Existing defense production spent nuclear fuel at the Hanford Site would remain there. Intersite transportation of fuel would depend on the site's existing capabilities to manage specific fuel types with respect to cladding material, physical and chemical composition, fuel condition, and adequate facilities to handle increased

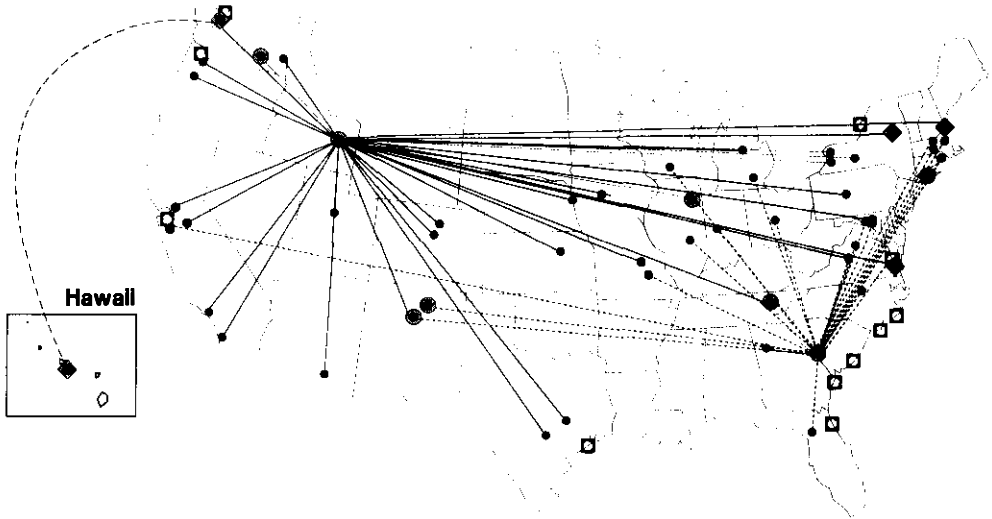
4. DOE - Regionalization (by Fuel Type)

Alternative 4A - Preferred Alternative



Radiation Risk

Estimated latent cancer fatalities less than 1 over 40-year period for normal operations.



Shipments going to Savannah River Site
Shipments going to Idaho National Engineering Laboratory
Shipments going to Puget Sound Naval Shipyard and then to the INEL

DOE

Production reactor SNF remains at Hanford

Approximate Shipments

To: Idaho National Engineering Laboratory (INEL)	1,050
To: Savannah River Site (SRS)	280

Foreign Fuel [a] (potential points of entry)

Approximate Shipments

To: INEL	170
To: SRS	840

Naval Fuel

Approximate Shipments

To: INEL for examination and storage	580

University

Approximate Shipments

To: INEL	120
To: SRS	400

Domestic Non-DOE

Approximate Shipments

To: INEL	30
To: SRS	190

RED 0671

a. Foreign fuel could enter the U.S. at any one of the identified points of entry for transport to the INEL or SRS

Figure 6. *Spent nuclear fuel distribution for Regionalization Alternative 4A.*

Centralization

Manage all existing and projected spent nuclear fuel inventories at one site until ultimate disposition.

- **Existing spent nuclear fuel would be transported to the central site.**
- **Naval fuel would be transported to, examined at, and stored at the central site.**
- **Projected spent nuclear fuel receipts would be transported to the central site.**
- **Spent nuclear fuel processing might need to be conducted. Other forms of stabilization might occur to provide for safe storage and/or transport.**
- **Facility upgrade/ replacement and new storage capacity would be provided at the central site; stabilization facilities would be provided at the transporting sites.**
- **Research and development would be undertaken for spent nuclear fuel management, including stabilization technology.**

quantities of fuel. Naval fuel would be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for examination. Following examination, fuel would remain in storage at the Idaho National Engineering Laboratory. Facility upgrades, replacements, and additions would be undertaken to the extent required, including research and development activities.

Regionalization by geography (Alternative 4B) (Figure 7) would involve consolidation of spent nuclear fuel from the eastern United States at the Eastern Regional Site (Oak Ridge Reservation or Savannah River Site) and consolidation of fuel from the western United States at one of the Western Regional Sites (Hanford Site, Idaho National Engineering Laboratory, or Nevada Test Site). Naval spent nuclear fuel would be transported to, examined, and stored at either the Eastern or the Western Regional Site. Regionalization Alternative 4B has 10 options, based on the combination of sites selected as the Eastern and Western Regional Sites, and the placement of the Expended Core Facility at either of the sites. There are three potential Western and two potential Eastern Regional Sites that could be paired, with either supporting the Expended Core Facility. However, neither of the two possible combinations that include the Idaho National Engineering Laboratory as the Western Regional Site would consider moving the Expended Core Facility to the eastern site because of the estimated $1 billion cost of construction. Facility upgrades, replacements, and additions would be undertaken to the extent required, including research and development.

Under this alternative, other generator and storage locations would continue to transport spent nuclear fuel to the Idaho National Engineering Laboratory and the Savannah River Site. The exact destination of fuels would vary, depending on the fuel type under Regionalization Alternative 4A and on the generator/ storage location under Regionalization Alternative 4B.

Centralization Alternative

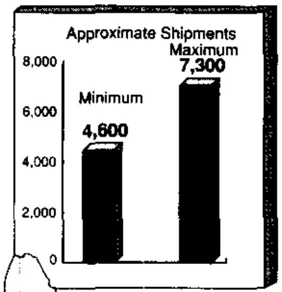
Under the Centralization alternative, all spent nuclear fuel that DOE is obligated to manage would be transported to one DOE site (Figure 8). Candidate sites include the Hanford Site (Option A), Idaho National Engineering Laboratory (Option B), Savannah River Site (Option C), Oak Ridge Reservation (Option D), and Nevada Test Site (Option E). New facilities would be built at the Centralization site to accommodate the increased inventories. Some spent nuclear fuel would require stabilization before transport. All spent nuclear fuel facilities at the transporting sites would then be closed. Activities related to stabilization of fuel, including research and development and pilot programs, would also be centralized at this same site.

Transport of naval spent nuclear fuel to the Idaho National Engineering Laboratory would continue only until storage and examination facilities are constructed at the central site. For Centralization at sites other than the Idaho National Engineering Laboratory, a new facility with capabilities comparable to the Expended Core Facility at the Idaho National Engineering Laboratory would be constructed.

All spent nuclear fuel from the other generator and storage sites would be transported to the selected central DOE site.

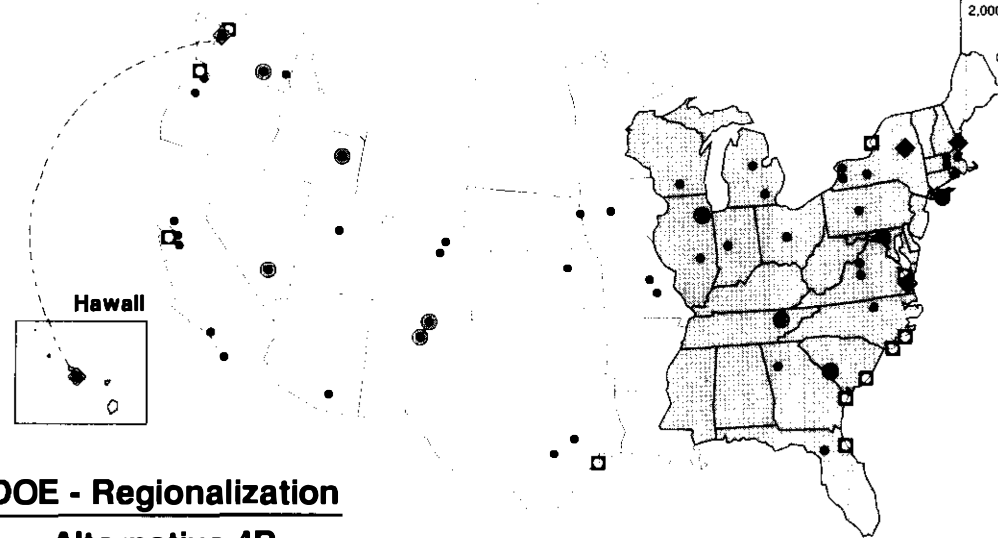
4. DOE - Regionalization (by Geography)

Alternative 4B



Radiation Risk

Estimated latent cancer fatalities less than 1 over 40-year period for normal operations.



Legend

Source

- U.S. Department of Energy Facilities
- Naval Sites
- Foreign Returns (potential points of entry)
- Special-Case Commercial
- Domestic Non-DOE
- Universities

Sites ship to either Hanford, INEL or NTS

Sites ship to either ORR or SRS'

------ Shipments going to Puget Sound Naval Shipyard and then to the regional site

DOE - Regionalization

Alternative 4B (West - Hanford)

Approximate Shipments[a]	
To: Hanford	2,700
Naval shipments if Expended Core Facility at Hanford	580

DOE - Regionalization

Alternative 4B (West - INEL)

Approximate Shipments	
To: Idaho National Engineering Laboratory (INEL)	2,500
Naval shipments if Expended Core Facility at the INEL	580

DOE - Regionalization

Alternative 4B (West - NTS)

Approximate Shipments[a]	
To: Nevada Test Site (NTS)	4,400
Naval shipments if Expended Core Facility at NTS	580

DOE - Regionalization

Alternative 4B (East - SRS)

Approximate Shipments[a]	
To: Savannah River Site (SRS)	1,600
Naval shipments if Expended Core Facility at SRS	580

DOE - Regionalization

Alternative 4B (East - ORR)

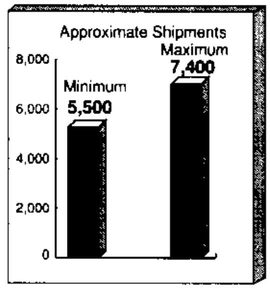
Approximate Shipments[a]	
To: Oak Ridge Reservation (ORR)	2,300
Naval shipments if Expended Core Facility at ORR	580

RED 0672

a. Shipment numbers exclude shipments that would be made during transition period (see text).

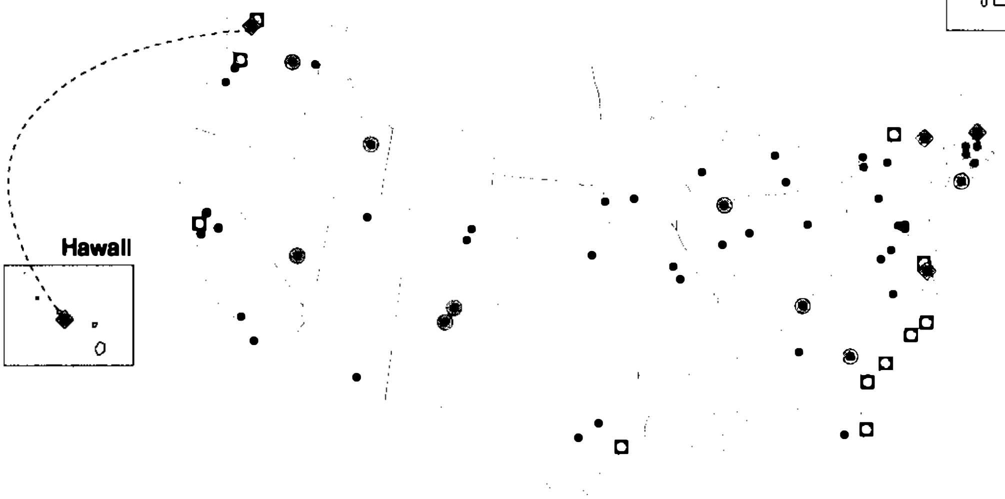
Figure 7. *Spent nuclear fuel distribution for Regionalization Alternative 4B.*

5. Centralization



Radiation Risk

Estimated latent cancer fatalities less than 2 over 40-year period for normal operations.



Legend

Source

- **U.S. Department of Energy Facilities**
- **Naval Sites**
- **Foreign Returns (potential points of entry)**
- **Special-Case Commercial**
- **Domestic Non-DOE**
- **Universities**

...... Shipments going to Puget Sound Naval Shipyard and then to the central site

Centralization Alternative 5A (Hanford)

Approximate Shipments[a]

To: Hanford	5,100
Naval Shipments	580

Centralization Alternative 5B (INEL)

Approximate Shipments

To: Idaho National Engineering Laboratory (INEL)	4,900
Naval Shipments	580

Centralization Alternative 5C (SRS)

Approximate Shipments[a]

To: Savannah River Site (SRS)	6,000
Naval Shipments	580

Centralization Alternative 5D (ORR)

Approximate Shipments[a]

To: Oak Ridge Reservation (ORR)	6,700
Naval Shipments	580

Centralization Alternative 5E (NTS)

Approximate Shipments[a]

To: Nevada Test Site (NTS)	6,800
Naval Shipments	580

a. Shipment numbers exclude shipments that would be made during transition period (see text).

RED 0673

Figure 8. *Spent nuclear fuel distribution for the Centralization alternative.*

Estimates in the EIS of potential environmental consequences resulting from programmatic (DOE-wide) alternatives are based on conservative assumptions (that is, with a tendency to overestimate). Analytical approaches are designed to provide estimates of the maximum reasonably foreseeable consequences.

As indicated in the EIS, the environmental consequences of the five spent nuclear fuel management alternatives would be small. For example, analyses of air quality, water quality, and land use for each alternative showed little or no impact. The details of these examinations are discussed in Chapter 5 of Volume 1. The comparison of alternatives in this Summary, therefore, concentrates on (a) the areas in which the public has expressed considerable interest and (b) programmatic factors important to DOE decisionmaking. The following factors were selected for comparison:

- Number of shipments among sites
- Public and worker health effects
- Spent nuclear fuel-related employment
- Generation of radioactive waste
- Impact on DOE or Navy missions
- Cost of implementation
- Cumulative impacts.

Number of Shipments

Figure 9 shows the number of offsite shipments that would occur under each alternative. It quantifies shipments of test specimens, as well as fuel elements. Shipments of naval test specimens are included because of their contribution to cumulative impacts of naval spent nuclear fuel transportation. The No Action alternative would involve only a limited number of naval spent nuclear fuel shipments (about 200).

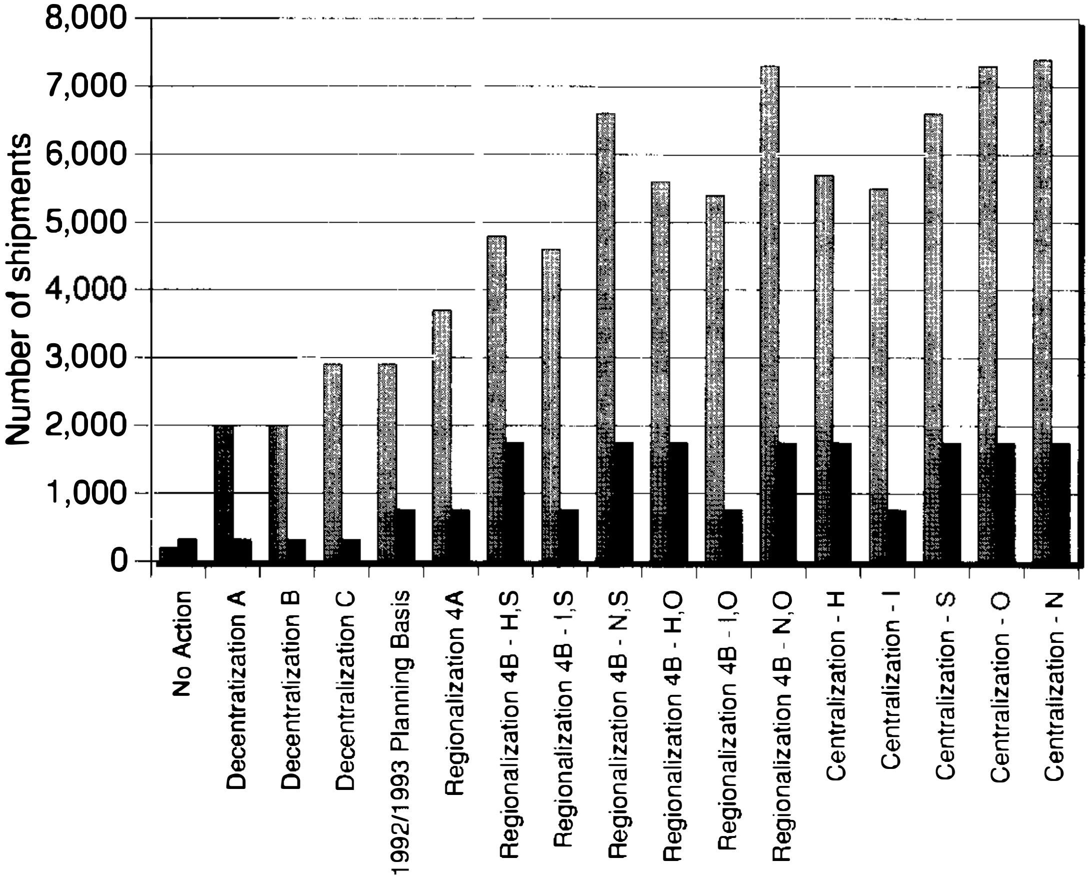
The Decentralization alternative, 1992/1993 Planning Basis alternative, and Regionalization Alternative 4A (Preferred Alternative) mostly involve shipments from the smaller reactor and storage sites and the naval sites to DOE sites. These shipments would range in number from approximately 2,000 shipments under Decentralization Options A or B to approximately 3,700 under Regionalization Alternative 4A (Preferred Alternative).

Decentralization Option C and the 1992/1993 Planning Basis alternative each would involve approximately 2,900 shipments over the 40-year period.

For the Centralization alternative and Regionalization Alternative 4B (by geography), spent nuclear fuel would be transported to one or two sites, respectively. For these Alternatives, the number of shipments would range from approximately 4,600 under the Regionalization Alternative 4B (with Idaho National Engineering Laboratory and Savannah River Site as the western and eastern sites respectively) to about 7,400 shipments under the Centralization Option E (Centralization at the Nevada Test Site).

Public and Worker Health Effects

Spent nuclear fuel management activities would result in radiation exposures to the workers and the public from facility operations and transportation activities. Additional radiation exposures could occur as a result of transportation or facility accidents. Any radiation exposures from spent nuclear fuel management activities would be in addition to exposures that normally occur from



Key:

Decentralization A: No examination of naval fuels
Decentralization B: Limited examination of naval fuels at Puget Sound Naval Shipyard
Decentralization C: Full examination of naval fuels at Idaho National Engineering Laboratory with spent nuclear fuel stored at naval sites
Regionalization 4A: Regionalization by fuel type
Regionalization 4B: Regionalization by geography

Site initials:
H: Hanford Site
I: Idaho National Engineering Laboratory
S: Savannah River Site
O: Oak Ridge Reservation
N: Nevada Test Site

Spent fuel
Test specimens[a]

a. Test specimens are small quantity fuel samples shipped for laboratory analysis

Figure 9. *Number of spent nuclear fuel and test specimen shipments between the years 1995 and 2035.*

natural sources such as cosmic radiation (involuntary exposure) and from artificial sources such as chest x-rays (voluntary exposure).

The effects of radiation exposure on humans (and the environment) depend on (a) the kind of radiation received, (b) the total amount of radiation received (the rate of exposure times the length of exposure), and (c) the part(s) of the body exposed. Radiation can cause a variety of health effects in people. The most significant health effect to describe the consequences of public and worker radiation exposures is "latent cancer fatality." It is referred to as "latent" because the cancer may take many years to develop and for death to occur. Section 5.1.1 of Volume 1 of this EIS discusses the scientific basis and methods used to estimate latent cancer fatalities that could result from exposure to radiation.

Other health effects that can result from radiation exposure include non-fatal cancers and genetic effects. This EIS focuses on latent cancer fatalities as the primary health risk from radiation exposure and uses the risk of latent cancer fatality as the basis for comparison of radiation-induced impacts among alternatives. As stated in this EIS, the total estimated health effects for the public (fatal cancers, non-fatal cancers, and genetic effects) may be obtained by multiplying the estimates of latent cancer fatalities by 1.46, based on risk estimates developed by the International Commission on Radiological Protection.

Under all alternatives (over a 40-year period), the estimated number of latent cancer fatalities to the public from normal DOE spent nuclear fuel management activities (facility operations plus transportation) would range from approximately zero to about two latent cancer fatalities, or about 0.05 latent cancer fatalities per year (Figure 10). In general, the greatest radiation exposure from normal spent nuclear fuel site activities and incident-free transportation results when large quantities of spent nuclear fuel are transported among sites, such as under Regionalization Alternative 4B or the Centralization alternative. Under incident-free transportation, the estimated total latent cancer fatalities are less than two for all alternatives, with the highest estimates being those associated with the Centralization options. This reflects the higher number of shipments associated with these options.

The risk of latent cancer fatalities associated with facility accidents is

Latent Cancer Fatalities Caused Per Rem for an Individual Member of the General Public

Dose:

Radioactivity from all sources combined, including natural background radiation and medical sources, produces about a 0.3 rem dose to the average individual per year.

Probability:

The probability of receiving the above dose is essentially one.

Average life span:

72 years is considered to be the average lifetime.

Latent cancer fatalities caused per rem for an individual member of the general public:

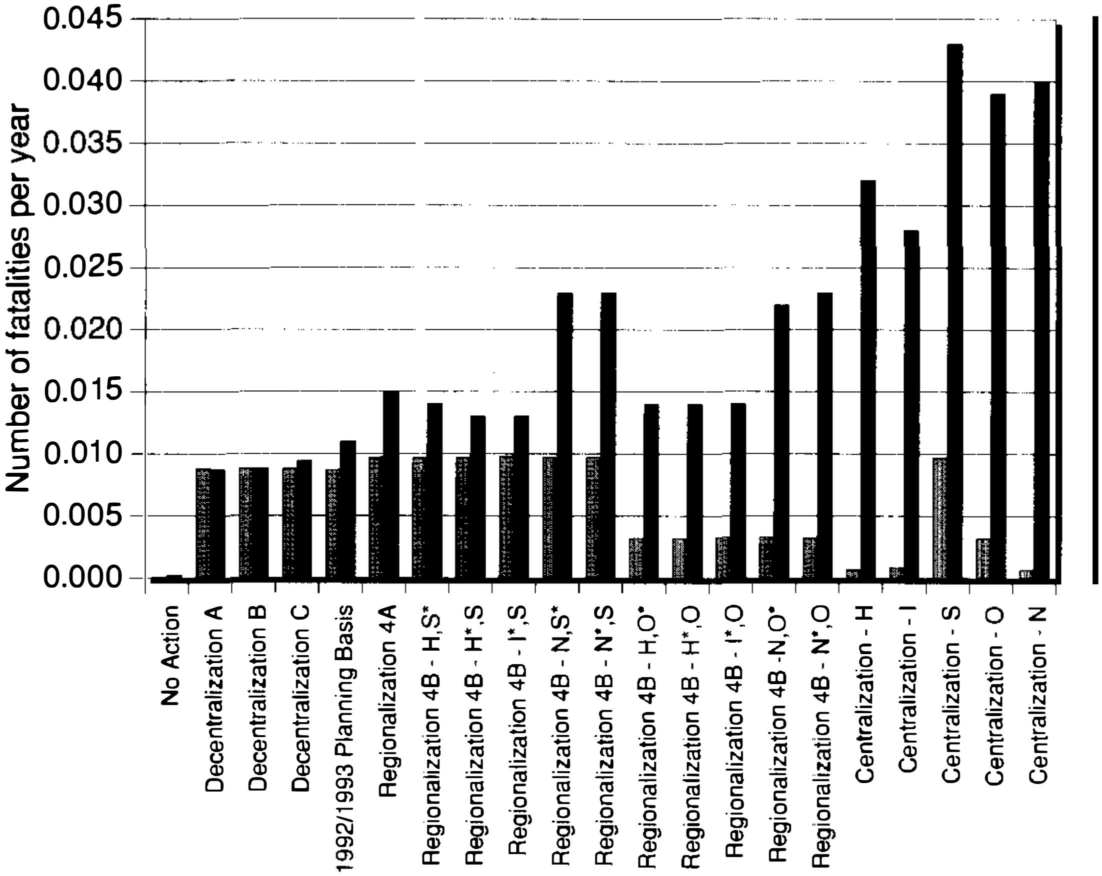
0.0005 cancers are estimated to be caused by exposure to 1 rem.

Calculation:

Dose rate x life span x cancers caused per rem = 0.3 rem/year x 72 years x 0.0005 cancers per rem = 0.01 fatal cancers per individual lifetime.

Risk:

Probability x fatal latent cancers = 1 x 0.01 = 0.01 fatal cancer, which is a probability of about 1 in 100 of death from exposure to natural background radiation and medical sources over a lifetime.



Key:

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Decentralization C: Full examination of naval fuels at Idaho National Engineering Laboratory with spent nuclear fuel stored at naval sites
Regionalization 4A: Regionalization by fuel type
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Site initials:
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S: Savannah River Site
O: Oak Ridge Reservation
N: Nevada Test Site

Operations
Transportation[a]

* Location of Expended Core Facility

a. Total fatalities are the sum of the estimated number of radiation-related latent cancer fatalities for workers and the general population and the estimated number of nonradiological fatalities from vehicular emissions. Average annual risk for incident free transportation was determined by dividing the cumulative risks over the entire transportation campaign by the estimated duration of the transportation compaign. Cumulative risks are presented in Chapter 5 of EIS Volume 1.

Figure 10. *Maximum estimated latent cancer fatalities per year in the general population from normal spent nuclear fuel site operations and total fatalities from incident-free transportation.*

small across all the alternatives, as shown in Figure 11. The evaluated facility accident scenario with the highest risk (breach of a fuel assembly for the Centralization alternative at the Savannah River Site) would result in an estimated risk of 0.0072 latent cancer fatality per year (one latent fatal cancer in 140 years).

The risk associated with radiation from transportation accidents poses a lower risk than facility accidents (Figure 12). The risks associated with traffic fatalities (nonradiological) are greater than the risks associated with cancer caused by radiation exposure, although both are very small (Figure 12). The evaluated transportation accident scenario with the largest consequences (spent nuclear fuel transportation accident in a suburban area) would lead to 55 latent cancer fatalities; the probability of this occurrence is about 1 in 10 million years.

In summary, for radiation-induced latent cancer fatalities to the public over 40 years of spent nuclear fuel management under all the alternatives evaluated, the most likely outcome is as follows:

- Essentially zero latent cancer fatalities from normal facility operations and facility accidents
- Essentially zero latent cancer fatalities from transportation accidents
- Up to about one latent cancer fatality from most incident-free transportation under most alternatives; up to two latent cancer fatalities under the Centralization alternative.

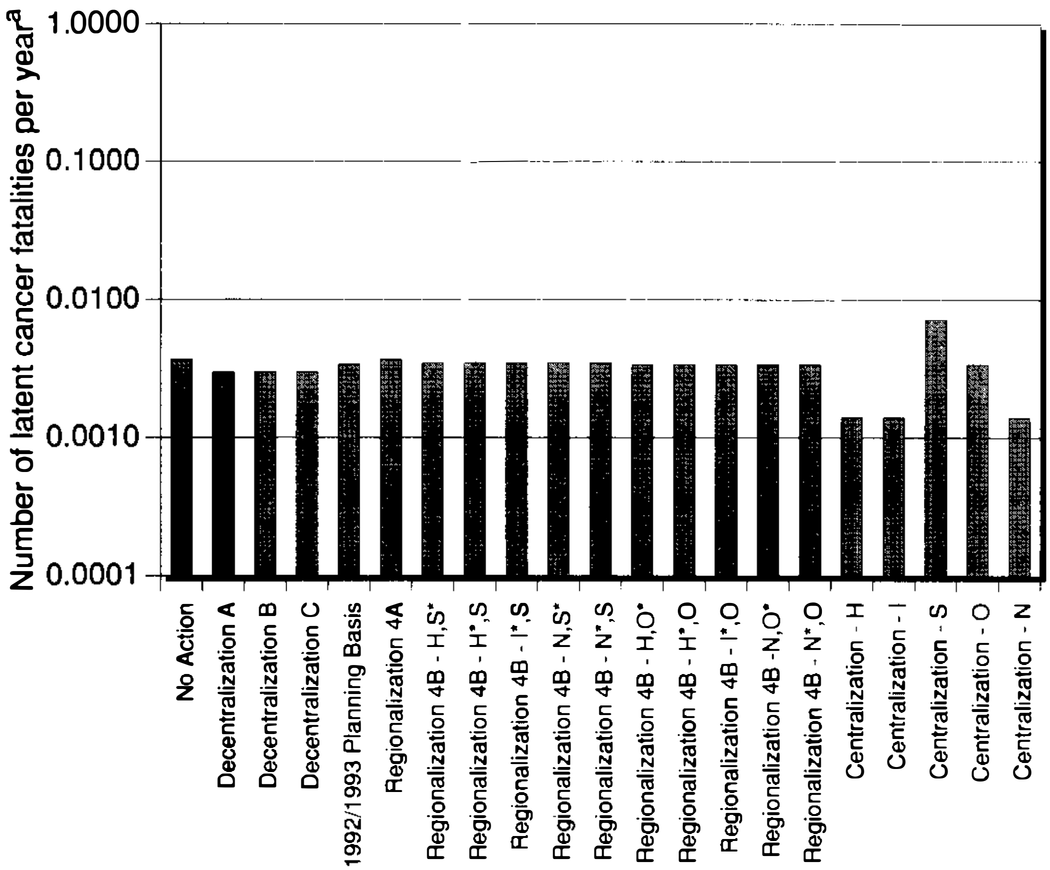
Up to about two fatalities could result over the 40-year period from nonradiological traffic accidents. By comparison about 40,000 people are killed annually in U.S. traffic accidents.

Although the anticipated potential for radiation exposures would be small, DOE would use the "as low as reasonably achievable" principle for controlling exposures to workers and the public. For example, practices would be implemented to avoid or reduce production of potentially harmful substances and waste minimization would be practiced to reduce the toxicity and volume of secondary wastes to be managed. Furthermore, all sites would update their current worker training, emergency planning, emergency preparedness, and emergency response programs to address new spent nuclear fuel management activities.

Spent Nuclear Fuel-Related Employment

Under various alternatives, the total labor force involved in spent nuclear fuel management could decrease by 180 jobs or increase by more than 2,100 jobs, averaged over the period 1995 to 2005, as compared with the 1995 baseline (Figure 13). The peak employment is difficult to estimate because it depends on implementation timing and funding profiles; however, Regionalization Alternative 4B (by geography) with the Nevada Test Site as the western site and Oak Ridge Reservation as the eastern site would result in the highest employment peak. The peak, estimated to be approximately 4,600 jobs in the year 2000, includes employment at sites preparing spent nuclear fuel for shipment to the selected sites.

Under the No Action alternative, employment would not increase substantially for any site, and the closure of the Expended Core Facility at the Idaho National Engineering Laboratory would result in a net loss of just over 500 spent nuclear fuel management-related jobs.



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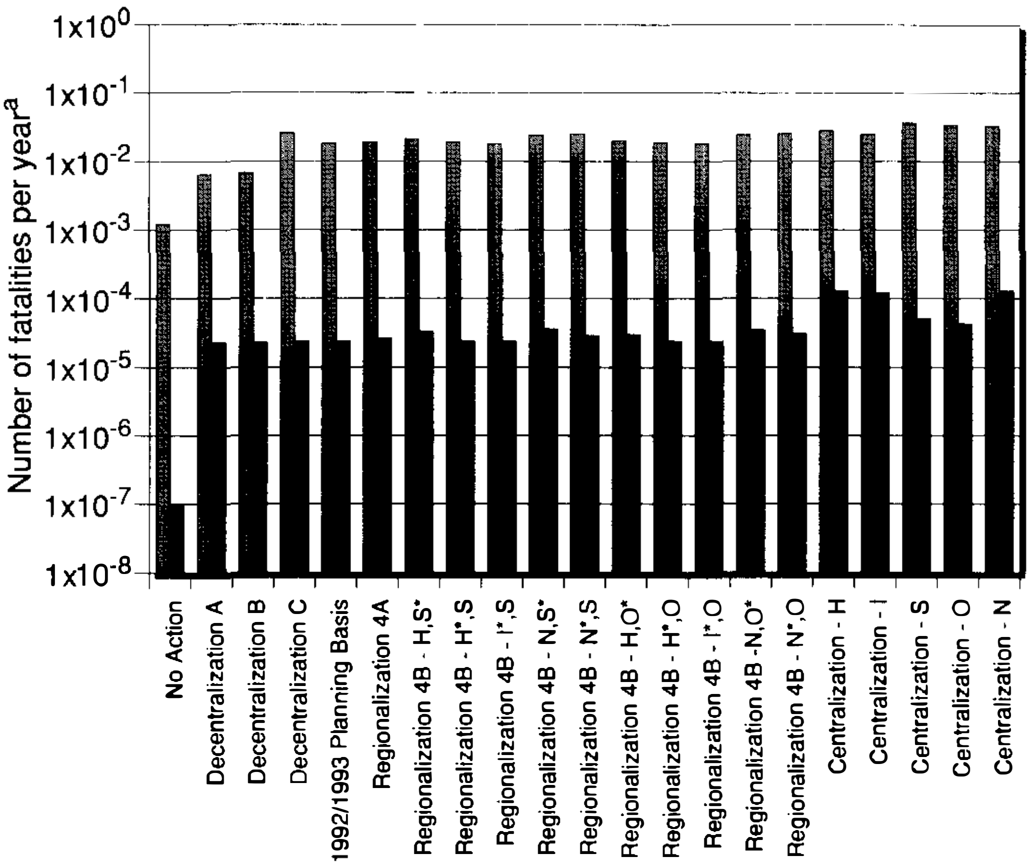
* Location of Expended Core Facility

a. Facility risks are based on the product of the probability and consequences of the respective maximum foreseeable facility accident for each alternative and expressed in latent cancer fatalities per year.

Figure 11. *Estimate of risk of latent cancer fatalities in general population from facility accidents for spent nuclear fuel management activities.*



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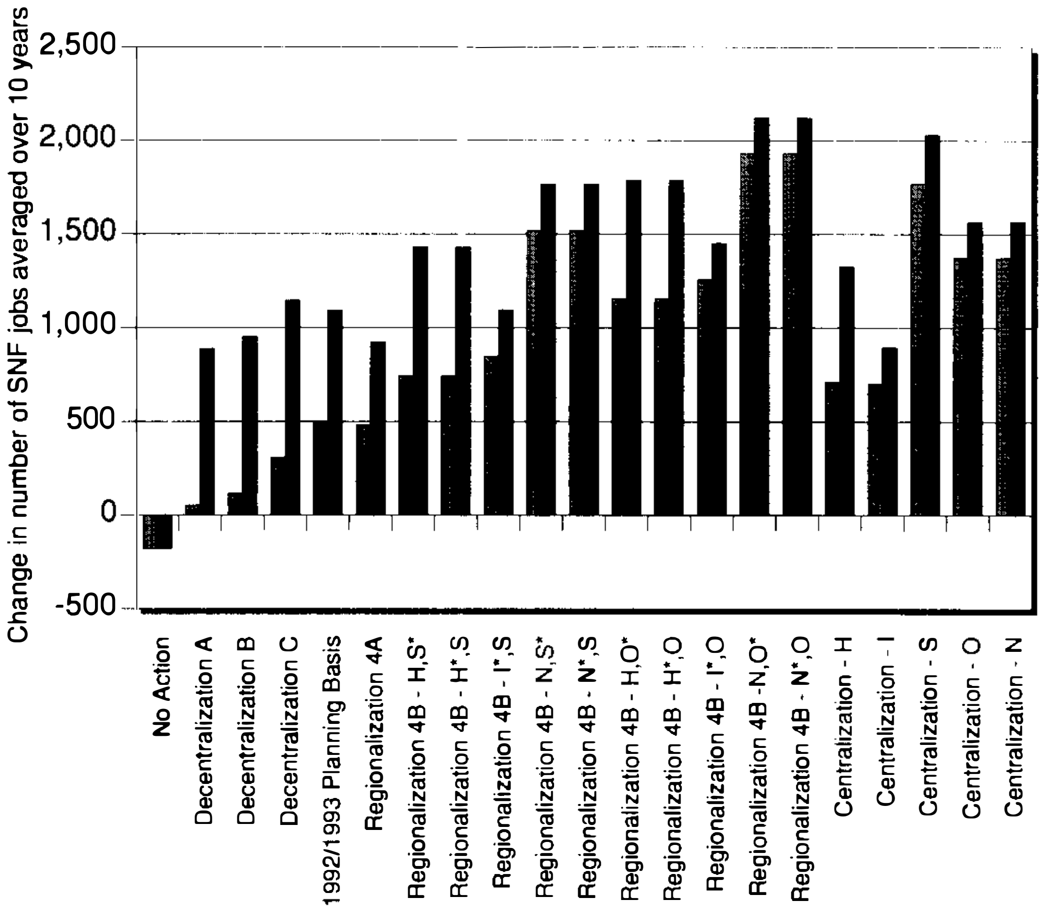
Traffic fatality risk
Radiological risk

* Location of Expended Core Facility

a. Radiological risk is in terms of latent cancer fatalities per year from spent nuclear fuel shipments; traffic fatality risk is in terms of estimated nonradiological traffic accident fatalities per year from spent nuclear fuel shipments.

b. Average annual risk was determined by dividing the cumulative accident risks over the entire transportation campaign by the estimated duration of the transportation campaign. Cumulative transportation accident risks are presented in Chapter 5 of EIS Volume 1.

Figure 12. *Estimate of average annual risk[b] from transportation accidents for spent nuclear fuel management activities.*



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Min[a]
Max[a]

* Location of Expended Core Facility

a. The maximum values occur with processing; the minimum values occur without processing.

Figure 13. *Change in the number of jobs averaged over the years 1995 to 2005 for spent nuclear fuel management activities.*

Relocating large amounts of spent nuclear fuel, such as under Regionalization Alternative 4B (by geography) and the Centralization alternative, would eventually result in the closure of spent nuclear fuel management facilities at major DOE sites and, thus, long-term job loss at the closed facilities. However, some of the job losses at closed facilities would be accompanied by job gains at the sites receiving the shipped fuels.

For all three Decentralization options, the 1992/1993 Planning Basis alternative and Regionalization Alternative 4A (Preferred Alternative), no more than an average additional 1,150 jobs would be required over the period 1995 to 2005 for implementation. Some of the more significant spent nuclear fuel employment requirements (particularly those involving the Hanford Site) would result from the development and operation of processing facilities needed to stabilize stored spent nuclear fuel. In addition, relocating the Expended Core Facility to sites other than the Idaho National Engineering Laboratory would result in an increase of about 500 jobs in the support of naval spent nuclear fuel examinations at those sites, and would result in a corresponding loss of approximately 500 jobs at the Idaho National Engineering Laboratory.

Thus, minor employment-related impacts are anticipated. To mitigate these impacts, DOE would coordinate its planning efforts with local communities and county planning agencies to address changes in community services, housing, infrastructure, utilities, and transportation. Such coordination with local planning agencies is intended to avoid placing undue burdens on local agency resources.

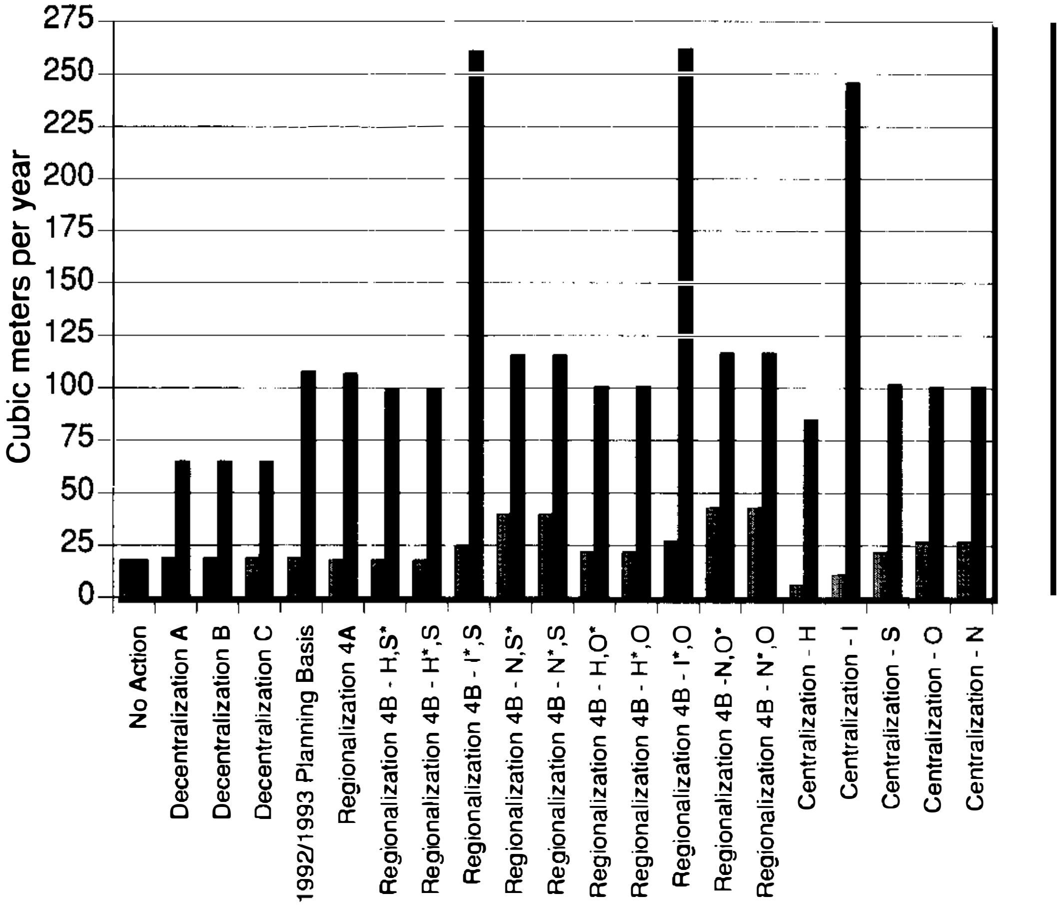
Generation of Radioactive Wastes

When spent nuclear fuel is stored onsite, very little high-level, transuranic, or mixed waste is generated (see Figure 14). These small quantities of radioactive wastes would usually be generated during stabilization activities. As a result, under the No Action alternative fewer than 20 cubic meters (26 cubic yards) per year of transuranic wastes would be generated from spent nuclear fuel management nationwide because spent nuclear fuel would not be stabilized. Under all other alternatives, where stabilization activities would occur, between 20 and 190 cubic meters (26 and 250 cubic yards) of high-level waste and between 20 and 90 cubic meters (26 and 120 cubic yards) of transuranic waste would be generated each year. The lower generation rates would occur in the Decentralization alternative, where small amounts of spent nuclear fuel would be transported among major DOE sites (and stabilization for transport would not be necessary).

For all other alternatives, greater amounts of spent nuclear fuel would be transported among sites; therefore, more spent nuclear fuel would require stabilization before transport and more waste would be generated.

Low-level waste also is generated as a result of spent nuclear fuel management. Figure 15 indicates an estimated range of annual volumes for each of the alternatives. The higher values are principally the result of processing for stabilization.

To control the volume of waste generated and reduce impacts on the environment, pollution prevention practices would be implemented.



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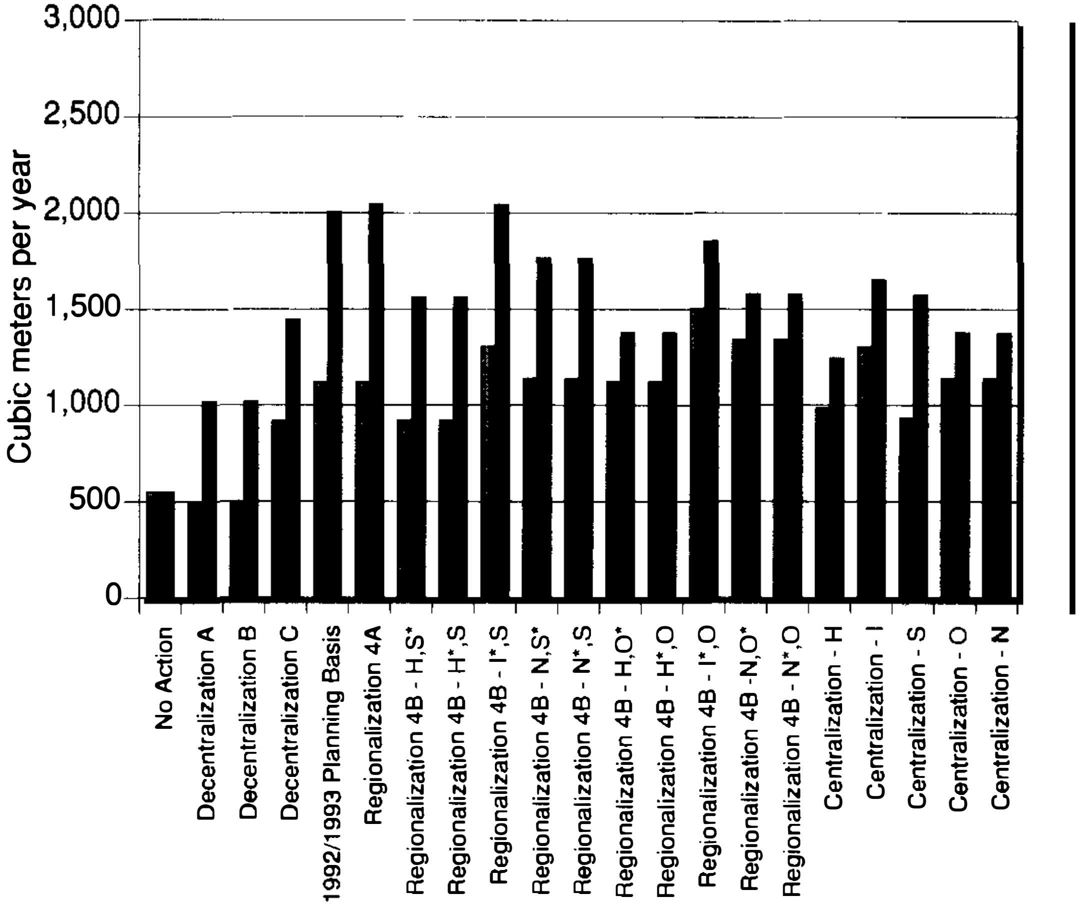
Min[a]
Max[a]

* Location of Expended Core Facility

a. The maximum values occur with processing; the minimum values occur without processing.

Figure 14. *Average volume of high-level, transuranic, and mixed waste generated per year over the years 1995 to 2005 for spent nuclear fuel management activities.*



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Min[a]
Max[a]

* Location of Expended Core Facility

a. The maximum values occur with processing; the minimum values occur without processing.

Figure 15. *Average volume of low-level wastes generated per year over the years 1995 to 2005 for spent nuclear fuel management activities.*

DOE is responding to Executive Order 12856, "Federal Compliance with Right to Know Laws and Pollution Prevention Requirements," and associated DOE orders and guidelines by reducing the use of toxic chemicals; improving emergency planning, response, and accident notification; and encouraging the development and use of clean technologies and testing of innovative pollution prevention technologies. Pollution prevention programs have already been implemented at DOE sites. Program components include waste minimization, source reduction and recycling, and procurement practices that preferentially procure products made from recycled materials.

Impact on DOE and Navy Missions

The mission concerns of DOE and the Navy relate to storing spent nuclear fuel safely, meeting obligations, preparing spent nuclear fuel for ultimate disposition, and examining naval fuel. Under the 1992/1993 Planning Basis, Regionalization, and Centralization alternatives, the missions of DOE and the Navy would be met. However, under the No Action and Decentralization alternatives, some parts of their current missions would not be achieved.

DOE's mission is most severely impacted under the No Action alternative. In this alternative, only the minimal actions necessary would be undertaken to store spent nuclear fuel. This means that there would be no facility upgrades or replacements (except those needed for safe storage of spent nuclear fuel) and research and development activities would be limited to activities already approved. The consequences of pursuing this alternative could include any or all of the following:

- Loss of margin in storage capacity
- More frequent and possibly more costly repairs to equipment and facilities as the frequency of breakdowns increases
- Eventual loss of the use of existing storage facilities because equipment or facilities are beyond repair or because there is no flexibility in storage capacity to permit repair work
- Limited development of improved storage technologies and facilities, reducing DOE's ability to meet future needs and implement future decisions regarding ultimate disposition of spent nuclear fuel.

The Navy's mission would be hindered if the full examination of fuels at an Expended Core Facility were not possible. No or limited examination would occur under the No Action alternative and Decentralization alternative (Options A, no examination, and B, limited examination). The examinations are an important aspect of the Navy's ongoing advanced fuel research and development program. The information derived from the examinations provides engineering data to support the design of new reactors, continued safety of existing reactors, and improvements in nuclear fuel performance and reactor operation by providing confirmation of their proper design and allowing maximum use of their fuel.

The No Action alternative would also impact ongoing nuclear research and training activities at universities that have little or no storage capacity for spent nuclear fuel. Such activities would cease once storage capacity is exhausted.

Cost of Implementation

Since publication of the draft EIS, DOE has completed an evaluation of potential costs associated with management of its spent nuclear fuel for an interim period (up to 40 years), and through ultimate disposition. For each alternative, the cost evaluation considered capital cost for upgrades to existing facilities and new facilities, operation and maintenance costs for existing and new facilities, decontamination and decommissioning costs for new facilities, and spent nuclear fuel transportation costs. Because each alternative would manage various amounts of spent nuclear fuel and the potential use of existing facilities would vary among alternatives, two cost ranges were considered—a minimum (lower) cost range that considered maximum use of existing facilities and a maximum (upper) cost range that minimized use of existing facilities in favor of additional new management facilities (Figure 16).

The cost analysis found that when use of existing facilities was maximized, it would be least costly to manage spent nuclear fuel under alternatives that involve sites with existing capabilities (e.g., Decentralization, 1992/1993 Planning Basis, and Regionalization), as opposed to the Centralization alternative that would require the construction of storage facilities (Figure 16).

When minimum use of existing facilities is considered, economies of scale would be realized as it is more cost effective to build and operate one larger facility than to build and operate several smaller facilities with the same combined capacity. Thus, for example, Regionalization 4A (by fuel type), in which all spent nuclear fuel would be transported to sites that have existing fuel management infrastructures, is less costly than the 1992/1993 Planning Basis and Decentralization alternatives (Figure 16).

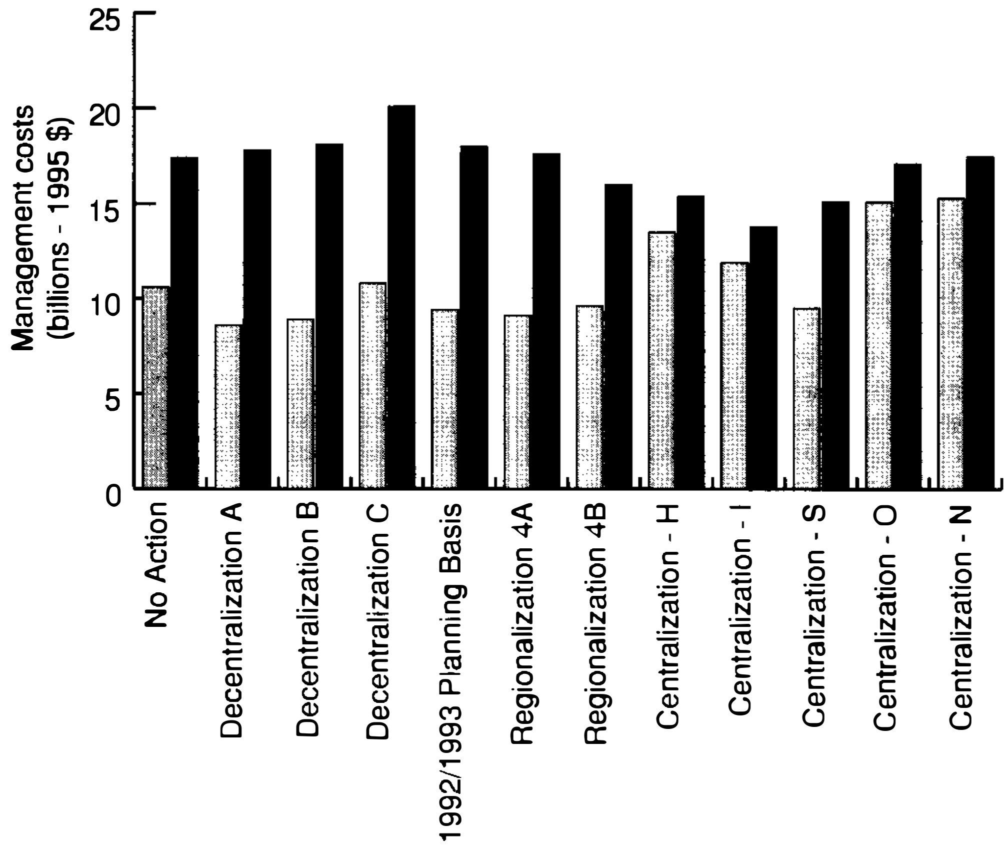
Cumulative Impacts

A cumulative impact results from the incremental impact associated with implementing an alternative plus the impacts of other past, present, and reasonably foreseeable future actions. "Other" actions include DOE projects at the potentially affected sites not related to spent nuclear fuel management, as well as projects of other Government agencies, private businesses, or individuals.

On a nationwide basis, the implementation of any of the spent nuclear fuel management alternatives would not significantly contribute to cumulative impacts. Although impacts to the natural environment (for example, water, air, ecology, and land use) were analyzed, the cumulative impacts are very small, especially if impact avoidance and mitigation measures are taken.

In general, the contribution to cumulative impacts from activities required for spent nuclear fuel management would be very small at sites where fuel is stored, in comparison to other ongoing and reasonably expected nonfuel-related projects. Even for those alternatives (Regionalization or Centralization) where the use of nonrenewable resources would be relatively large, increases in the impacts at the selected site(s) would be offset by changes at nonselected sites—resulting in a very small net change.

On a site-specific basis, the implementation of any of the alternatives would not significantly contribute to cumulative impacts. Generally, the contribution to cumulative impacts from spent nuclear fuel management activities at a specific site is minor, relative to other DOE and non-DOE projects. Radiological emissions from normal operations and from transportation of



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min[a]
max[b]

a. Minimum (lower) cost range with maximum use of existing facilities
b. Maximum (upper) cost range with minimum use of existing facilities

SAA0081

Figure 16. Management costs for interim storage of spent nuclear fuel through the year 2035.

spent nuclear fuel would be well within regulatory requirements. The volumes of waste produced from fuel management activities would be a small addition to waste volumes generated by other ongoing and expected projects.

Depending on the economic status and outlook for an area, spent nuclear fuel activities coupled with other actions could have the potential to strain or overburden the socioeconomic resources of certain areas, particularly if either the Regionalization or Centralization alternatives were implemented with the Expended Core Facility placed at the site. Although each site is anticipating an overall decline in site employment over the next few years, the in-migration of construction workers associated with proposed spent nuclear fuel management alternatives combined with other reasonably foreseeable activities could have small impacts on communities surrounding the Hanford Site, the Nevada Test Site, and the Oak Ridge Reservation. Such socioeconomic impacts would not be expected to occur at the other sites.

Environmental Justice

In February 1994, Executive Order 12898 entitled, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" was issued to federal agencies. This order requires federal agencies to identify and address disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations. Mitigation measures are to be identified, if necessary, and federal agencies are to increase communications with these communities, in order to promote increased awareness of Federal activities and involvement in Federal decisionmaking.

In accordance with the Executive Order, an interagency Federal Working Group on Environmental Justice has been convened to provide guidance to agencies on implementation of environmental justice. Draft Guidance for Federal Agencies on Terms in Executive Order 12898 provide draft definitions of certain terms in the Executive Order. The definitions adopted for this Final EIS are consistent with the draft guidance. Disproportionately high and adverse human health effects are defined to occur when the risk or rate for a minority or low-income population from exposure to an environmental hazard significantly exceeds the risk or rate to the general population and, where available, to another appropriate comparison group. Disproportionately high and adverse environmental effects are defined to be any deleterious environmental impact affecting minority populations or low income populations that significantly exceed those on general population or other appropriate unit of geographic analysis.

The programmatic management of DOE spent nuclear fuel and associated transportation was reviewed under each alternative. This review included potential impacts that would arise for each of the environmental disciplines, under normal operating conditions and under potential accident conditions, to minority and low-income communities with in 50 miles (80 kilometers) of each potential site. Demographic information was gathered from the U.S. Census Bureau to identify minority populations and low-income communities in the zone of potential impact [(50 mile (80 kilometer)] surrounding each of the sites under consideration. Analysis of environmental justice concerns was based on a qualitative assessment of the human health and environmental impacts of each alternative. The analysis found that the impacts of the programmatic management of spent nuclear fuel under all alternatives would not constitute a disproportionately high and adverse impact on minority or low-income communities and, thus, do not present an environmental justice concern.

Consultations and Environmental Requirements

DOE is committed to operating its spent nuclear fuel management program in compliance with all applicable environmental laws, regulations, executive orders, DOE orders, and permits and compliance agreements with regulatory agencies. The DOE regulations that implement the National Environmental Policy Act require consultation with other agencies, when appropriate, to incorporate any relevant requirements as early as possible in the process. These consultation and coordination requirements will commence and be completed as site-specific spent nuclear fuel management projects and decisions are proposed. To the extent that this EIS supports existing site-specific proposals, those consultations and coordination efforts are contained within Volume 1 Section 7.2 and Volume 2 Appendix B-3. DOE has reviewed all comments received on the draft EIS. To more fully understand, evaluate, and consider certain agency comments, consultations have taken place among agency, Idaho National Engineering Laboratory and Navy officials on the EIS.

Relationship Between Volumes 1 and 2

DOE is currently in the process of making two important sets of decisions. The first involves programmatic (DOE-wide) decisions regarding DOE's future spent nuclear fuel management (addressed in Volume 1 of the EIS). The second involves site-specific decisions regarding the future direction of environmental restoration and waste management programs, which include spent nuclear fuel, at the Idaho National Engineering Laboratory (addressed in Volume 2 of this EIS).

DOE's programmatic decisions regarding spent nuclear fuel affect the Idaho National Engineering Laboratory-specific decisions about spent nuclear fuel. Therefore, the spent nuclear fuel components of the Idaho National Engineering Laboratory-specific alternatives have been constructed to bear a relationship to those of Volume 1.

Volume 1—Programmatic Spent Nuclear Fuel Management Alternatives – Summary

No Action
Take minimum actions required for safe and secure management of spent nuclear fuel at, or close to, the generation site or current storage location.

Decentralization
Store most spent nuclear fuel at or close to the generation site or current storage location, with limited shipments to DOE facilities.

1992/1993 Planning Basis
Transport and store newly generated spent nuclear fuel at the Idaho National Engineering Laboratory or Savannah River Site. Consolidate some existing fuels at the Idaho National Engineering Laboratory or the Savannah River Site.

Regionalization
Distribute existing and projected spent nuclear fuel among DOE sites, based primarily on fuel type (Preferred Alternative) or on geography.

Centralization
Manage all existing and projected spent nuclear fuel inventories from DOE and the Navy at one site until ultimate disposition.

Volume 2—Idaho National Engineering Laboratory Spent Nuclear Fuel Management Alternatives – Summary

No Action
- Phase out inspection of naval spent nuclear fuel. Close Expended Core Facility.
- Receive no non-naval spent nuclear fuel.
- Phase out Idaho Chemical Processing Plant-603 storage pools.

Ten-Year Plan and Preferred Alternative (for spent nuclear fuel)
- Examine and store naval spent nuclear fuel.
- Receive additional offsite spent nuclear fuel.
- Transfer aluminum-clad spent nuclear fuel to Savannah River Site.
- Phase out Idaho Chemical Processing Plant-603 storage pools.
- Expand storage capacity in existing Idaho Chemical Processing Plant-666 pools.
- Phase in dry storage.
- Demonstrate electrometallurgical process.

Minimum Treatment, Storage, and Disposal
- Phase out inspection of naval spent nuclear fuel. Close Expended Core Facility.
- Transport all spent nuclear fuel to another DOE site.
- Phase out spent nuclear fuel handling facilities.
- Demonstrate electrometallurgical process.

Maximum Treatment, Storage, and Disposal
- Examine and store naval spent nuclear fuel.
- Receive DOE-wide spent nuclear fuel.
- Phase out Idaho Chemical Processing Plant-603 storage pools.
- Expand storage capacity in existing Idaho Chemical Processing Plant-666 pools.
- Phase in expanded dry storage.
- Demonstrate electrometallurgical process.
- Phase in spent nuclear fuel stabilization.

Attachment—Reading Rooms and Information Locations

U.S. Department of Energy Reading Rooms

Public Reading Room for U.S. Department of Energy Headquarters
Room 1E-190, Forrestal Building
Freedom of Information Reading Room
1000 Independence Avenue, SW
Washington, DC 10585
(202) 586-6020
Monday-Friday 9:00 a.m. to 4:00 p.m.

Public Reading Room for U.S. Department of Energy Oakland Operations Office
Environmental Information Center
1301 Clay Street, Room 700 N
Oakland, CA 94612
(510) 637-1762
Monday-Friday 8:30 a.m. to 5:00 p.m.

Public Reading Room for U.S. Department of Energy Rocky Flats Operations Office
Front Range Community College Library
3645 W. 112th Ave.
Level B, Center or the Building
Westminister, CO 80030
(303) 469-4435
Monday and Tuesday 10:30 a.m. to 6:30 p.m.,
Wednesday 10:30 a.m. to 4:00 p.m.,
Thursday 8:00 a.m. to 4:00 p.m.

Public Reading Room for U.S. Department of Energy Idaho Operations Office
Public Reading Room
1776 Science Center Drive
Idaho Falls, ID 83402
(208) 526-9162
Monday-Friday 8:00 a.m. to 5:00 p.m.

Public Reading Room for U.S. Department of Energy
University of Illinois at Chicago Library
Government Documents Section
801 South Morgan Street
Chicago, IL 60607
(312) 996-2738
Monday-Thursday 8:00 a.m. to 10:00 p.m.,
Friday 8:00 a.m. to 7:00 p.m., Saturday 10:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 9:00 p.m.

Public Reading Room for U.S. Department of Energy
National Atomic Museum
20358 Wyoming Boulevard, SE
Albuquerque, NM 87185
(505) 845-4378
Monday-Friday 9:00 a.m. to 5:00 p.m.

Public Reading Room for U.S. Department of Energy Nevada Operations Office
Coordination and Information Center
3084 South Highland Drive
P.O. Box 98521
Las Vegas, NV 89106
(702) 295-0731
Monday-Friday 7:00 a.m. to 4:30 p.m.

Public Information Room for U.S. Department of Energy Fernald Operations Office Public Environmental Center
JANTER Building 10845
Hamilton-Cleves Highway
Harrison, OH 445030
(513) 738-0164
Monday and Thursday 9:00 a.m. to 7:00 p.m.,
Tuesday, Wednesday, and Friday 9:00 a.m. to 4:30 p.m.,
Saturday 9 a.m. to 1 p.m.

Public Reading Room for U.S. Department of Energy Savannah River Operations Office
Public Reading Room
Road 1A, Building 703A, D232
Aiken, SC 29802
(803) 641-3320
Monday-Thursday 8:00 a.m. to 11:00 p.m.,
Friday 8:00 a.m. to 5:00 p.m.,
Saturday 10:00 a.m. to 5:00 p.m.,
Sunday 2:00 p.m. to 11:00 p.m.

Public Reading Room for U.S. Department of Energy Oak Ridge Operations Office
Public Reading Room
55 Jefferson Avenue
Oak Ridge, TN 37831
(615) 576-1216
Monday-Friday 8:00 a.m. to 11:30 a.m. and 12:30 p.m. to 5:00 p.m.

Public Reading Room for U.S. Department of Energy Richland Operations Office
Washington State University Tri-Cities
100 Sprout Road, Room 130 West
Richland, WA 99352
(509) 376-8583
Monday-Friday 8:00 a.m. to 12:00 noon and
1:00 p.m. to 4:30 p.m.

Navy Information Locations

Norfolk Naval Shipyard

Chesapeake Central Library
298 Cedar Rd.
Chesapeake, VA 23320-5512
(804) 436-8300
Monday-Thursday 9:00 a.m to 9:00 p.m.,
Friday and Saturday 9:00 a.m to 5:00 p.m.,
Sunday 1:00 p.m to 5:00 p.m.

Newport News Public Library
Grissom Branch
366 Deshazor Dr.
Newport News, VA 23602
(804) 886-7896
Monday-Thursday 9:00 a.m. to 9:00 p.m.,
Friday and Saturday 9:00 a.m. to 6:00 p.m.,
Sunday 1:00 p.m. to 5:00 p.m.

Kiln Library
301 East City Hall Ave.
Norfolk, VA 23510
(804) 441-2429
Monday-Thursday 9:00 a.m. to 9:00 p.m.,
Friday 9:00 a.m. to 5:30 p.m.,
Saturday 9:00 a.m. to 5:00 p.m.

Hampton Public Library
4207 Victoria Boulevard
Hampton, VA 23669
(804) 727-1154
Monday-Thursday 9:00 a.m. to 9:00 p.m.,
Friday and Saturday 9:00 a.m. to 5:00 p.m.,
Sunday 1:00 p.m. to 5:00 p.m.

Portsmouth Public Library
Main Branch
601 Court St.
Portsmouth, VA 23704
(804) 393-8501
Monday-Thursday 9:00 a.m to 9:00 p.m,
Friday and Saturday 9:00 a.m to 5:00 p.m.

Virginia Beach Central Library
4100 Virginia Beach Blvd.
Virginia Beach, VA 23452
(804) 431-3001
Monday-Thursday 10:00 a.m. to 9:00 p.m.,
Friday and Saturday 10:00 a.m. to 5:00 p.m.,
Sunday 1:00 p.m. to 5:00 p.m.

Puget Sound Naval Shipyard

Kitsap Regional Library
1301 Sylvan Way
Bremerton, WA 98310
(206) 377-7601
Monday-Thursday 9:30 a.m. to 9:00 p.m.,
Friday and Saturday 9:30 a.m. to 5:30 p.m.,
Sunday 12:30 p.m. to 5:30 p.m.

Kitsap Regional Library
Downtown Branch
612 5th Ave.
Bremerton, WA 98310
(206) 377-3955
Monday-Friday 10:00 a.m. to 5:30 p.m.

Suzallo Library SM25
University of Washington Libraries
University of Washington
Seattle, WA 98185
(206) 543-9158
Monday-Thursday 7:30 a.m. to 12:00 midnight,
Friday 7:30 a.m. to 6:00 p.m.,
Saturday 9:00 a.m. to 5:00 p.m.,
Sunday 12:00 noon to 12:00 midnight

Portsmouth Naval Shipyard

Rice Public Library
8 Wentworth Street
Kittery, ME 03904
(207) 439-1553
Monday-Wednesday, Friday 10:00 a.m. to 5:00 p.m.,
Thursday 10:00 a.m. to 8:00 p.m.,
Saturday 10:00 a.m. to 4:00 p.m.

Portsmouth Public Library
8 Islington Street
Portsmouth, NH 03801
(603) 427-1540
Monday-Thursday 9:00 a.m. to 9:00 p.m.,
Friday 9:00 a.m. to 5:30 p.m.,
Saturday 9:00 a.m. to 5:00 p.m.

Pearl Harbor Naval Shipyard

Aiea Public Library
99-143 Monalua Rd.
Aiea, HI 96701
(808) 488-2654
Monday and Thursday 10:00 a.m. to 8:00 p.m.,
Tuesday, Wednesday, Friday, and Saturday
10:00 a.m. to 5:00 p.m

Hawaii State Library
478 South King Street
Honolulu, HI 96813
(808) 586-3535
Monday, Wednesday, and Friday,
9:00 a.m. to 5:00 p.m.,
Tuesday and Thursday 9:00 a.m. to 8:00 p.m.,
Saturday 10:00 a.m. to 5:00 p.m.

Pearl City Public Library
1138 Waimano Home Rd.
Pearl City, HI 96782
(808) 455-4134
Monday-Wednesday 10:00 a.m. to 8:00 p.m.,
Thursday and Saturday 10:00 a.m. to 5:00 p.m.,
Friday and Sunday 1:00 p.m. to 5:00 p.m.

Pearl Harbor Naval Base Library
Code 90L
1614 Makalapa Dr.
Pearl Harbor, HI 96860-5350
(808) 471-8238
Tuesday-Thursday 10:00 a.m. to 7:00 p.m.,
Friday and Saturday 9:00 a.m. to 5:00 p.m.,
Sunday 1:00 p.m. to 5:00 p.m.

Kesselring Site

Albany Public Library
Reference and Adult Services
161 Washington Ave.
Albany, NY 12210
(518) 449-3380
Monday-Thursday 9:00 a.m. to 9:00 p.m.,
Friday 9:00 a m to 6:00 p.m.
Saturday 9:00 a.m. to 5:00 p.m.,
Sunday 1:00 p.m. to 5:00 p.m.

Saratoga Springs Public Library
320 Broadway
Saratoga Springs, NY 12866
(518) 584-7860
Monday-Thursday 9:00 a.m. to 9:00 p.m.
Friday 9:00 a.m. to 6:00 p.m.,
Saturday 9:00 a.m. to 5:00 p m.,
Sunday 1:00 p.m. to 5:00 p.m.

Schenectady County Library
99 Clinton Street
Schenectady, NY 12305
(518) 388-4511
Monday-Thursday, 9:00 a.m. to 9:00 p.m.,
Friday and Saturday, 9:00 a.m. to 5:00 p.m.,
Sunday 1:00 p.m. to 5:00 p.m.

Other Locations

Main Library
University of Arizona
Tucson, AZ 85721
(602) 621-6421
Monday-Thursday 7:30 a.m. to 1:00 a.m.,
Friday 7:30 a.m. to 6:00 p.m.,
Saturday 10:00 a.m. to 6:00 p.m.,
Sunday 11:00 a.m. to 1:00 a.m.

Main Library
University of California at Irvine
Government Publications Receiving Dock
Irvine, CA 92717
(714) 824-6836
School Hours:
Monday-Thursday 8:00 a.m. to 1:00 a.m.,
Friday 8:00 a.m. to 9:00 p.m.,
Saturday 9:00 a.m. to 6:00 p.m.,
Sunday 12:00 noon to 1:00 a.m.
Summer Hours:
Monday-Friday 8:00 a.m. to 5:00 p.m.,
Saturday and Sunday 1:00 p.m. to 5:00 p.m.

Pleasanton Public Library - Reference Desk
400 Old Bernal Avenue
Pleasanton, CA 94566
(510) 462-3535
Monday and Tuesday 1:00 p.m. to 8:00 p.m.,
Wednesday 10:00 a.m. to 8:00 p.m.,
Thursday 10:00 a.m. to 6:00 p.m.,
Closed Friday
Saturday and Sunday 1:00 p.m. to 5:00 p.m.,

San Diego Public Library
820 "E" Street
San Diego, CA 92101
(619) 236-5867
Monday-Thursday 10:00 a.m. to 9:00 p.m.,
Friday and Saturday 9:30 a.m. to 5:30 p.m.,
Sunday 1:00 p.m. to 5:00 p.m.

Denver Public Library
1357 Broadway
Denver, CO 80203
(303) 640-8845
Monday-Wednesday 10:00 a.m. to 9:00 p.m.,
Thursday-Saturday 10:00 a.m. to 5:30 p.m.,
Sunday 1:00 p.m. to 5:00 p.m.

George A. Smathers Libraries, Library West
University of Florida Library, Room 241
P.O. Box 117001
Gainesville, FL 32611-7001
(904) 392-0367
Monday-Thursday 8:00 a.m. to 9:30 p.m.,
Friday 8:00 a.m. to 5:00 p.m.,
Sunday 2:30 p.m. to 9:30 p.m.

Atlanta Public Library
1 Margaret Mitchell Square
Atlanta, GA 30303
(404) 730-1700
Monday-Thursday 9:00 a.m. to 9:00 p.m.,
Friday and Saturday 9:00 a.m. to 6:00 p.m.,
Sunday 2:00 p.m. to 6:00 p.m.

Reese Library
Augusta College
2500 Walton Way
Augusta, GA 30904-2200
(706) 737-1744
School Hours:
Monday-Thursday 7:45 a.m. to 10:30 p.m.,
Friday 7:45 a.m. to 5:00 p.m.,
Saturday 9:00 a.m. to 5:00 p.m.,
Sunday 1:30 p.m. to 9:30 p.m.
Summer Hours:
Monday-Friday 8:00 a.m. to 5:00 p.m.

Chatham-Effingham-Liberty Regional Library
2002 Bull Street
Savannah, GA 31401
(912) 652-3600
Monday-Thursday 9:00 a.m. to 9:00 p.m.,
Friday 9:00 a.m. to 6:00 p.m.,
Saturday 10:00 a.m. to 6:00 p.m.,
Sunday 2:00 p.m. to 6:00 p.m.

Parks Library
Iowa State University
Government Publications Department
Ames, IA 50011-2140
(515) 294-3642
School Hours:
Monday-Thursday 7:30 a.m. to 12:00 midnight,
Friday 7:30 a.m. to 10:00 p.m.,
Saturday 10:00 a.m. to 10:00 p.m.,
Sunday 12:30 p.m. to 12:00 midnight,
Summer Hours:
Monday-Thursday 7:30 a.m. to 10:00 p.m.,
Friday 7:30 a.m. to 5:00 p.m.,
Saturday 12:30 p.m. to 5:00 p.m.,
Sunday 12:30 p.m. to 10:00 p.m.

Boise Public Library
715 South Capitol Boulevard
Boise, ID 83702
(208) 384-4023
Monday and Friday 10:00 a.m. to 6:00 p.m.,
Tuesday–Thursday 10:00 a.m. to 9:00 p.m.,
Saturday and Sunday 12:00 noon to 5:00 p.m.

Idaho State Library
325 West State Street
Boise, ID 83702
(208) 334-2152
Monday-Friday 9:00 a.m. to 5:00 p.m.

Shoshone-Bannock Library
Bannock and Pima Streets, HRDC Building
Fort Hall, ID 83203
(208) 238-3882
Monday-Friday 8:00 a.m. to 5:00 p.m.

Idaho Falls Public Library
457 Broadway
Idaho Falls, ID 83402
(208) 529-1462
Monday-Thursday 9:00 a.m. to 9:00 p.m,
Friday and Saturday 9:00 a.m. to 5:30 p.m.,
Sunday 1:30 p.m. to 5:30 p.m.

University of Idaho Library
Rayburn Street
Moscow, ID 83844-2353
(208) 885-6344
Monday-Friday 8:00 a.m. to 12:00 midnight,
Saturday 9:00 a.m. to 12:00 midnight,
Sunday 10:00 a.m. to 12:00 midnight

Pocatello Public Library
812 East Clark Street
Pocatello, ID 83201
(208) 232-1263
Monday-Thursday 9:30 a.m. to 8:00 p.m,
Friday and Saturday 9:30 a.m. to 5:30 p.m.

Twin Falls Public Library
434 Second Street East
Twin Falls, ID 83301
(208) 733-2964
Monday, Friday, and Saturday 10:00 a.m. to 6:00 p.m.,
Tuesday–Thursday 10:00 a.m. to 9:00 p.m.

Main Library, Third Floor
University of Illinois
801 South Morgan, Mail Code 234
Chicago, IL 60607
(312) 413-2594
Monday-Thursday 7:30 a.m. to 10:00 p.m.,
Friday 7:30 a.m. to 5:00 p.m.,
Saturday 10:00 a.m. to 5:00 p.m.,
Sunday 1:00 p.m. to 9:00 p.m.

Documents Library, 200-D
University of Illinois
1408 W. Gregory Drive
Urbana, IL 61801
(217) 244-2060
School Hours:
Monday-Thursday 8:00 a.m. to 12:00 midnight,
Friday 8:00 a.m. to 6:00 p.m.,
Saturday 9:00 a.m. to 6:00 p.m.,
Sunday 1:00 p.m. to 12:00 midnight
Summer Hours:
Monday-Thursday 8:00 a.m. to 9:00 p.m.,
Friday 8:00 a.m. to 6:00 p.m.,
Saturday 9:00 a.m. to 5:00 p.m..
Sunday 1:00 p.m. to 5:00 p.m.

Engineering Library
Purdue University
West Lafayette, IN 47907
(317) 494-2871
School Hours:
Monday-Thursday 8:00 a.m. to 12:00 midnight,
Friday 8:00 a.m. to 10:00 p.m.,
Saturday 8:00 a.m. to 5:00 p.m.,
Sunday 1:00 p.m. to 12:00 midnight,
Summer Hours:
Monday-Friday 8:00 a.m. to 5:00 p.m.

Manhattan Public Library
Julliette and Poyntz
Manhattan, KS 66502
(913) 776-4741
Monday-Friday 9:00 a.m. to 9:00 p.m.,
Saturday 9:00 a.m. to 6:00 p.m.,
Sunday 2:00 p.m. to 6:00 p.m.

Massachusetts Institute of Technology Science Library
160 Memorial Drive Building 14
Cambridge, MA 02139
(617) 253-5685
Monday-Thursday 8:00 a.m. to 12:00 midnight,
Friday and Saturday 8:00 a.m. to 8:00 p.m.,
Sunday 12:00 noon to 12:00 midnight

O'Leary Library
University of Massachusetts
1 University Ave
Lowell, MA 01854
(508) 934-3205
School Hours:
Monday-Thursday 7:30 a.m. to 12:00 midnight,
Friday 7:30 a.m. to 5:00 p.m.,
Saturday 10:00 a.m. to 6:00 p.m.,
Sunday 1 00 p.m. to 12 midnight
Summer Hours:
Monday-Friday 8:30 a.m. to 9:00 p.m.,
Sunday 2 00 p.m. to 7:00 p.m.

Worcester Public Library
3 Salem Square
Worchester, MA 01608
(508) 799-1655
Monday-Thursday 9:00 a.m. to 9:00 p.m.,
Friday and Saturday 9:00 a.m. to 5:30 p.m.

Bethesda Public Library
7400 Arlington Road
Bethesda. MD 20814
(301) 986-4300
Monday-Thursday 10:00 a.m. to 8:30 p.m.,
Friday 10:00 a.m. to 5:00 p.m.,
Saturday 9:00 a.m. to 5:00 p.m.,
Sunday 1 00 p.m. to 5:00 p.m.

Gaithersburg Regional Library
18330 Montgomery Village Avenue
Gaithersburg, MD 20879
(301) 840-2515
Monday-Thursday 10:00 a.m. to 8:30 p.m.,
Friday 10:00 a.m. to 5:00 p.m.,
Saturday 9:00 a.m. to 5:00 p.m.,
Sunday 1 00 p.m. to 5:00 p.m.

Hyattsville Public Library
6530 Adelphi Road
Hyattsville, MD 20782
(301) 779-9330
Monday-Thursday 10:00 a.m. to 9:00 p.m.,
Friday 10 00 a.m. to 6:00 p.m.,
Saturday 10:00 a.m. to 5:00 p.m.,
Sunday 1 00 p.m. to 5:00 p.m.

Ann Arbor Public Library
343 South 5th Avenue
Ann Arbor, MI 48104
(313) 994-2335
Monday 10:00 a.m. to 9:00 p.m.,
Tuesday-Friday 9:00 a.m. to 9:00 p.m.,
Saturday 9:00 a.m. to 6:00 p.m.,
Sunday 1 00 p.m. to 5:00 p.m.

Zanhow Library
Saginaw Valley State University
7400 Bay Road
University Center, MI 48710
(517) 790-4240
School Hours:
Monday-Thursday 8:00 a.m. to 11:00 p.m.,
Friday 8:00 a.m. to 4:30 p.m.,
Saturday 9:00 a.m. to 5:00 p.m.,
Sunday 1:00 p.m. to 9:00 p.m.
Summer Hours:
Monday-Thursday 8:00 a.m. to 10:30 p.m.,
Friday 8:00 a.m. to 4:30 p.m.,
Saturday 10:00 a.m. to 2:00 p.m.,
Sunday 1:00 p.m. to 5:00 p.m.

Ellis Library
University of Missouri
Columbia, MO 65201
(314) 882-0748
School Hours:
Monday-Thursday 7:30 a.m. to 12:00 midnight,
Friday 7:30 a.m. to 11:00 p.m.,
Saturday 9:00 a.m. to 9:00 p.m.,
Sunday 12:00 noon to 1:00 a.m.
Summer Hours:
Monday and Thursday 8:00 a.m. to 8:00 p.m.,
Tuesday, Wednesday, and Friday 8:00 a.m. to 5:00 p.m.,
Saturday 12:00 noon to 5:00 p.m.

Curtis Laws Wilson Library
University of Missouri Library
Rolla, MO 65401-0249
(314) 341-4227
School Hours:
Monday-Thursday 8:00 a.m. to 12:00 midnight,
Friday 8:00 a.m. to 10:30 p.m.,
Saturday 8:00 a.m. to 5:00 p.m.,
Sunday 2:00 p.m. to 12:00 midnight,
Summer Hours:
Monday-Friday 8:00 a.m. to 5:00 p.m.

D.H. Hill Library
North Carolina State University
P.O. Box 7111
Raleigh, NC 27695-7111
(919) 515-3364
School Hours:
Monday-Thursday 7:00 a.m. to 1:00 a.m.,
Friday 7:00 a.m. to 9:30 p.m.,
Saturday 9:30 a.m. to 6:00 p.m.,
Sunday 1:00 p.m. to 1:00 a.m.
Summer Hours:
Monday-Thursday 7:00 a.m. to 11:00 p.m.,
Friday 7:00 a.m. to 6:00 p.m.,
Saturday 9:30 a.m. to 5:30 p.m.,
Sunday 1:00 p.m. to 11:00 p.m.

Omaha Public Library
215 S. 15th Street
Omaha, NE 68102
(402) 444-4800
Monday-Thursday 9:00 a.m. to 9:00 p.m.,
Friday and Saturday 9:00 a.m. to 5:30 p.m.,
Sunday 1:00 p.m. to 5:00 p.m.

General Library
University of New Mexico
Albuquerque, NM 87131-1466
(505) 277-5441
School Hours:
Monday-Thursday 8:00 a.m. to 9:00 p.m.,
Friday 8:00 a.m. to 5:00 p.m.,
Saturday and Sunday 12:00 noon to 4:00 p.m.,
Summer Hours:
Monday-Friday 8:00 a.m. to 6:00 p.m.,
Saturday 10:00 a.m. to 5:00 p.m.

U.S. DOE Community Reading Room
1450 Central Avenue, Suite 101
MS C314
Los Alamos, NM 87544
(505) 665-2127
Monday-Friday 9:00 a.m. to 5:00 p.m.

Lockwood Library
State University of New York-Buffalo
Buffalo, NY 14260-2200
(716) 645-2816
School Hours:
Monday-Thursday 8:00 a.m. to 10:45 p.m.,
Friday 8:00 a.m. to 9:00 p.m.,
Saturday 9:00 a.m. to 5:00 p.m.,
Sunday 1:00 p.m. to 9:00 p.m.,
Summer Hours:
Monday, Wednesday, Thursday and
Friday 9:00 a.m. to 6:00 p.m.,
Tuesday 9:00 a.m. to 10:00 p.m.
Sunday 1:00 p.m. to 9:00 p.m.

Engineering Library
Cornell University
Carpenter Hall, Main Floor
Ithaca, NY 14853
(607) 255-5762
School Hours:
Monday-Thursday 8:00 a.m. to 11:00 p.m.,
Friday 8:00 a.m. to 6:00 p.m.,
Saturday 10:00 a.m. to 6:00 p.m.,
Sunday 12:00 noon to 11:00 p.m.,
Summer Hours:
Monday-Friday 8:00 a.m. to 6:00 p.m.,
Saturday 12:00 noon to 6:00 p.m.

Cardinal Hayes Library
Manhattan College
4531 Manhattan College Parkway
Riverdale, NY 10471
(718) 920-0100
School Hours:
Monday-Thursday 8:00 a.m. to 11:00 p.m.,
Friday 8:00 a.m. to 6:30 p.m.,
Saturday 10:00 a.m. to 5:00 p.m.,
Sunday 1:00 p.m. to 11:00 p.m.,
Summer Hours:
Monday-Thursday 8:30 a.m. to 6:30 p.m.,
Friday 8:00 a.m. to 4:00 p.m.

Brookhaven National Laboratory
25 Brookhaven Avenue, Building 477 A
P.O. Box 5000
Upton, NY 11973-5000
(516) 282-3489
Monday-Friday 8:30 a.m. to 9:00 p.m.,
Saturday and Sunday 9:00 a.m. to 5:00 p.m.

Columbus Metropolitan Library
96 South Grant Avenue
Columbus, OH 43215
(614) 645-2710
Monday-Thursday 9:00 a.m. to 9:00 p.m.,
Friday and Saturday 9:00 a.m. to 6:00 p.m.,
Sunday 1:00 p.m. to 5:00 p.m.

Kerr Library
Oregon State University
Corvallis, OR 97331-4905
(503) 737-0123
Monday-Friday 7:45 a.m. to 12:00 midnight,
Saturday and Sunday 10:00 a.m. to 12:00 midnight,
Summer Hours:
Monday- Friday 7:45 a.m. to 9:00 p.m.,
Saturday 10:00 a.m. to 5:00 p.m.,
Sunday 10:00to 9:00 p.m.

Brantford Price Millar Library
Portland State University
934 S.W. Harrison
Portland, OR 97201
(503) 725-4617
Monday-Thursday 8:00 a.m. to 12:00 midnight,
Friday 8:00 a.m. to 10:00 p.m.,
Saturday 10:00 a.m. to 10:00 p.m.,
Sunday 11:00 a.m. to 12:00 midnight

Pattee Library
Pennsylvania State University
University Park, PA 16801
(814) 865-2112
School Hours:
Monday-Thursday 8:00 a.m. to 12:00 midnight,
Friday 8:00 a.m. to 10:00 p.m.,
Saturday 8:00 a.m. to 9:00 p.m.,
Sunday 1:00 p.m. to 12:00 midnight,
Summer Hours:
Monday-Thursday 7:45 a.m. to 10:00 p.m.,
Friday 7:45 a.m. to 9:00 p.m.,
Saturday 8:00 a.m. to 9:00 p.m.,
Sunday 1:00 p.m. to 10:00 p.m.

Narragansett Public Library
35 Kingston Road
Narragansett, RI 02882
(401) 789-9507
Monday 10:00 a.m. to 9:00 p.m.,
Tuesday-Friday 10:00 a.m. to 6:00 p.m.,
Saturday 10:00 a.m. to 5:00 p.m.
(Saturday hours September to May only)

Charleston County Main Library
404 King Street
Charleston, SC 29403
(803) 723-1645
Monday-Thursday 9:30 a.m. to 9:00 p.m.,
Friday-Saturday 9:30 a.m. to 6:00 p.m.,
Sunday 2:00 p.m. to 5:00 p.m.

South Carolina State Library
1500 Senate Street
Columbia, SC 29201
(803) 734-8666
Monday-Friday 8:15 a.m. to 5:30 p.m.,
Saturday 9:00 a.m. to 1:00 p.m.

Clinton Public Library
118 South Hicks Street
Clinton, TN 37716
(615) 457-0519
Monday and Thursday 10:00 a.m. to 8:00 p.m.,
Tuesday, Wednesday, Friday, and
Saturday 10:00 a.m. to 5:00 p.m.

Harriman Public Library
601 Walden Street
Harriman, TN 37748
(615) 882-3195
Monday-Thursday 9:00 a.m. to 5:00 p.m.,
Friday and Saturday 9:00 a.m. to 1:00 p.m.

Kingston Public Library
1000 Bradford Way Building #3
Kingston, TN 37763
(615) 376-9905
Monday and Thursday 10:00 a.m. to 7:30 p.m.,
Tuesday, Wednesday, and
Friday 10:00 a.m. to 5:30 p.m.,
Saturday 10:00 a.m. to 2:00 p.m.

Lawson McGhee Public Library
500 West Church Avenue
Knoxville, TN 37902
(615) 544-5750
Monday-Thursday 9:00 a.m. to 8:30 p.m.,
Friday 9:00 a.m. to 5:30 p.m.,
Saturday and Sunday 1:00 p.m. to 5:00 p.m.

Oak Ridge Public Library
Civic Center
Oak Ridge, TN 37830
(615) 482-8455
Monday-Thursday 10:00 a.m. to 9:00 p.m.,
Friday 10:00 a.m. to 6:00 p.m.,
Saturday 9:00 a.m. to 6:00 p.m.,
Sunday 2:00 p.m. to 6:00 p.m.

Oliver Springs Public Library
607 Easterbrook Avenue
Oliver Springs, TN 37840
(615) 435-2509
Tuesday-Thursday 2:00 p.m. to 4:00 p.m.,
Saturday 9:00 a.m. to 12:00 midnight

Rockwood Public Library
117 North Front Avenue
Rockwood, TN 37854
(615) 354-1281
Monday, Wednesday, Friday, and
Saturday 10:00 a.m. to 5:00 p.m.,
Tuesday and Thursday 10:00 a.m. to 8:00 p.m.

General Library
University of Texas
PCL 2.402X
Austin, TX 78713
(512) 495-4262
School Hours:
Monday-Friday 8:00 a.m. to 12:00 midnight,
Saturday 9:00 a.m. to 12:00 midnight,
Sunday 12:00 noon to 12:00 midnight,
Summer Hours:
Monday-Friday 8:00 a.m. to 10:00 p.m.,
Saturday 9:00 a.m. to 10:00 p.m.,
Sunday 12:00 noon to 10:00 p.m.

Evans Library
Texas A&M University, MS 5000
College Station, TX 77843-5000
(409) 845-8850
School Hours:
Monday-Thursday 7:00 a.m. to 12:00 midnight,
Friday 7:00 a.m. to 7:00 p.m.,
Saturday 9:00 a.m. to 5:00 p.m.,
Sunday 1:00 p.m. to 11:00 p.m.,
Summer Hours:
Monday-Thursday 7:00 a.m. to 11:00 p.m.,
Friday 7:00 a.m. to 7:00 p.m.,
Saturday 9:00 a.m. to 5:00 p.m..
Sunday 1 00 p.m. to 11:00 p.m.

Marriott Library
University of Utah
Salt Lake City, UT 84112
(801) 581 8394
School Hours:
Monday-Thursday 7:00 a.m. to 11:00 p.m.,
Friday 7:00 a.m. to 8:00 p.m.,
Saturday 9:00 a.m. to 8:00 p.m.,
Sunday 11:00 a.m. to 11:00 p.m.
Summers Hours:
Monday-Thursday 7:00 a.m. to 10:00 p.m.,
Friday 7:00 a.m. to 5:00 p.m.,
Saturday 9:00 a.m. to 5:00 p.m.,
Sunday 1:00 p.m. to 5:00 p.m.

Alderman Library
University of Virginia
Charlottesville, VA 22903-2498
(804) 924-3133
School Hours:
Monday-Thursday 8:00 a.m. to 12:00 midnight,
Friday 8:00 a.m. to 9:00 p.m.,
Saturday 9:00 a.m. to 6:00 p.m.,
Sunday 12:00 noon to 12:00 midnight,
Summer Hours:
Monday-Thursday 8:00 a.m. to 10:00 p.m.,
Friday 8:00 a.m. to 6:00 p.m.,
Saturday 9:00 a.m. to 6:00 p.m.,
Sunday 2:00 p.m. to 10:00 p.m.

Owen Science & Engineering Library
Washington State University
Pullman, WA 99164-3200
(509) 335-4181
School Hours:
Monday-Thursday 8:00 a.m. to 11:00 p.m.,
Friday 8:00 a.m. to 9:00 p.m.,
Saturday 12:00 noon to 9:00 p.m.,
Sunday 12:00 noon to 11:00 p.m.,
Summer Hours:
Monday and Thursday 7:30 a.m. to 11:00 p.m.,
Tuesday, Wednesday, and
Friday 7:30 a.m. to 6:00 p.m.,
Saturday and Sunday 12:00 noon to 6:00 p.m.

Foley Center
Gonzaga University
East 502 Boone Avenue
Spokane, WA 99258
(509) 328-4220, extension 3125
School Hours:
Monday-Thursday 8:00 a.m. to 12:00 midnight,
Friday and Saturday 8:00 a.m. to 9:00 p.m.,
Sunday 11:00 a.m. to 12:00 midnight,
Summer Hours:
Monday-Friday 8:00 a.m. to 5:00 p.m.,
Saturday 10:00 a.m. to 5:00 p.m.,
Sunday 1:00 p.m. to 7:00 p.m.

Madison Public Library
201 W. Mifflin Street
Madison, WI 53703
(608) 266-6350
Monday-Wednesday 8:30 a.m. to 9:00 p.m.,
Thursday and Friday 8:30 a.m. to 5:30 p.m.,
Saturday 9:00 a.m. to 5:30 p.m.

Teton County Public Library
320 South King Street
Jackson, WY 83001
(307) 733-2164
Monday, Wednesday
and Friday 10:00 a.m. to 5:30 p.m.,
Tuesday and Thursday 10:00 a.m. to 9:00 p.m.,
Saturday 10:00 a.m. to 5:00 p.m.,
Sunday 1:00 p.m. to 5:00 p.m.

CONTENTS

FIGURES

TABLES

1. INTRODUCTION

The U.S. Department of Energy (DOE) is evaluating its options for two separate but related sets of decisions pertinent to the management of the spent nuclear fuel (SNF) for which the DOE is responsible. As a result, this Environmental Impact Statement[a] (EIS) is divided into two parts. Volume 1 involves programmatic (DOE-wide) approaches to the management of DOE's SNF; Volume 2 discusses site-specific approaches for environmental restoration and waste management activities at the Idaho National Engineering Laboratory, including SNF management. This EIS has been prepared in accordance with the National Environmental Policy Act and its applicable implementing regulations (40 CFR Parts 1500-1508 and 10 CFR Part 1021).

The DOE's proposed action for Volume 1 is to safely, efficiently, and responsibly manage existing and projected quantities of DOE's SNF through the year 2035, pending ultimate disposition. Volume 1 has been developed to support DOE's decisionmaking on the most appropriate location for implementing national strategies for managing DOE's SNF until its ultimate disposition is determined and implemented. For planning purposes, it has been assumed that decisions regarding ultimate disposition strategies may require as long as 40 years to implement. The general environmental consequences of managing SNF in a range of configurations at various sites are summarized in this volume.

Volume 1 is supported by site-specific appendices (under separate cover) that provide detailed information on the consequences of management activities under each alternative at the Hanford Site (Appendix A); Idaho National Engineering Laboratory (Appendix B); Savannah River Site (Appendix C); naval SNF management facilities, including management of naval SNF at DOE facilities (Appendix D); other generator/storage sites (Appendix E); and the Oak Ridge Reservation and the Nevada Test Site (Appendix F). This EIS does not select site-specific technical management options presented in Appendices A through F. The management options are representative of potential activities at each of the sites under consideration.

Volume 2 addresses the Environmental Restoration and Waste Management Programs at the Idaho National Engineering Laboratory. DOE objectives for the next 10 years are to mitigate the impacts of past operations through environmental restoration and to treat, store, or dispose of waste at the Idaho National Engineering Laboratory in a way that minimizes future adverse impacts.

Volume 3 summarizes the comments that DOE received on the Draft EIS during the public comment period and provides responses to those comments. Volume 3 also discusses the extent to

a. The Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (SNF and INEL EIS).

which public comments resulted in changes to this EIS and describes how to find specific comment summaries and responses.

1.1 Overview of Spent Nuclear Fuel in the DOE Complex

This section is an introduction to the nature, types, and quantities of DOE SNF; the historic generation and storage of SNF; and the current program structure as it existed in April 1995. This section also explains what SNF is not included in this EIS as DOE SNF.

1.1.1 What is Spent Nuclear Fuel

Nuclear reactors use a process called fission to generate heat to produce electricity and to generate power to propel Navy ships and submarines. Production reactors have been used to produce defense materials at DOE facilities and radioisotopes for industrial and medical use. Some colleges and universities, government facilities, and commercial establishments use nuclear reactors for research and educational purposes, as well. Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated, is called spent nuclear fuel, or SNF. The EIS also evaluates uranium/neptunium target materials, blanket subassemblies, pieces of fuel, and debris. Contact-handled fuel/targets (that is, fuel/targets with radiation levels low enough to permit handling without shielding or remote operations), even though slightly irradiated, are not included. This material will be managed by DOE along with the other excess nuclear materials.

1.1.1.1 Configuration of Nuclear Fuel. The fuel in a nuclear reactor consists of fuel assemblies that may range in number from one to several hundred, depending upon the reactor size and the design of the reactor and fuel assemblies. Fuel assemblies are constructed in many configurations, but they generally consist of the fuel matrix, cladding, and structural hardware.

The fuel matrix contains the fissionable material (typically uranium oxide or uranium metal). The matrix form is typically plates or cylindrical pellets. For gas-cooled reactors, the matrix may be small particles. The cladding is the encapsulation (typically zirconium, aluminum, or stainless steel) that surrounds the fuel, confining and protecting it. For gas-cooled reactors, this may be a ceramic coating over the fuel particles.

The structural parts of a fuel assembly hold fuel in the proper configuration and direct coolant flow (typically water) over the fuel. Structural hardware is generally nickel alloys, stainless steel, zirconium, or aluminum, or, for gas-cooled reactors, graphite. The size of a fuel assembly ranges from a weight of 1 kilogram (2.2 pounds) and a length of less than 1 meter (3 feet) to a weight of more than 450 kilograms (1,000 pounds) and a length of more than 3 meters (10 feet). Figure 1-1 illustrates a representative fuel element.

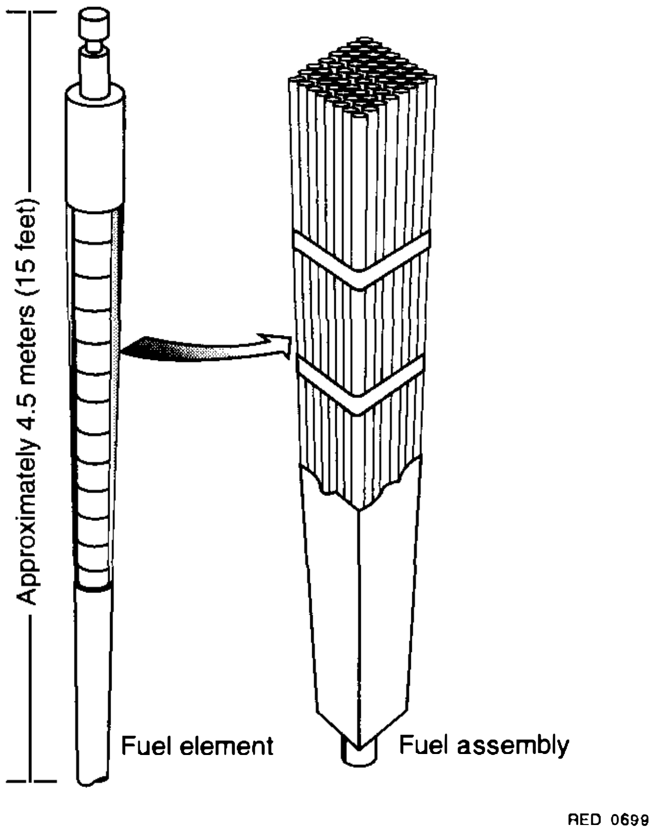


Figure 1-1. Representative reactor fuel assembly and element.

1.1.1.2 Properties of Spent Nuclear Fuel. When it is initially removed from a reactor, SNF is highly radioactive. A fraction of the initial mass of fissionable material (uranium-235 or plutonium) has been converted into fission products, some of which are radioactive with half-lives ranging from a few seconds to thousands of years. At the time of withdrawal from the reactor, most of the radioactivity is associated with fission products with very short half-lives. The radioactivity from SNF decreases very rapidly over time after irradiation. After 1 year, the levels are about 1 percent of that at the time of removal. After 10 years, these levels have decreased by another factor of 10.

The radiation of most concern from SNF is gamma rays. Although the radiation levels can be very high, the gamma-ray intensities are readily reduced by shielding fuel elements with such materials as concrete, lead, steel, and water. The thickness of the required shielding is dependent on the energy of the radiation source, the desired protection level, and the density of the shielding material. Typically, shielding thicknesses for concrete or lead are much smaller than for water.

The radioactivity produces heat, and the assemblies must be cooled for a period of months to years following removal from the reactor to prevent excessive fuel temperatures from being reached. Typically, the SNF removed from reactors has been stored in water pools for a period of 3 to 18 months for cooling before transfer to other facilities for storage or processing. Storage systems are designed to prevent nuclear criticality (nuclear chain reaction).

Many fuel elements that are now SNF, particularly production reactor fuel, were designed to be easily dissolved in nitric acid for uranium-235 and plutonium recovery. Because the fuels were designed for only short-term storage, prolonged storage sometimes presents problems. For example, some fuels, such as aluminum-clad fuels, corrode during prolonged storage in water pools unless the water chemistry within the pool is carefully controlled. Corrosion can result in cladding failures and the release of small quantities of fission products, especially radioactive gases and readily soluble isotopes.

1.1.1.3 SNF Management Vulnerabilities. Prolonged storage of some types of SNF has resulted in deterioration of the cladding, degradation of the fuel matrix, or other storage problems leading to significant environmental, safety, and health concerns. DOE reported its evaluation of these concerns in a *Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and Other Reactor Irradiated Nuclear Materials and their Environmental, Safety and Health Vulnerabilities* in November 1993 (DOE 1993a). This evaluation was followed by a *Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities* in February 1994, which identified three phases to resolve those vulnerabilities (DOE 1994a). This Phase I Action Plan, which addresses the most urgent activities, was issued immediately. The Phase II Action Plan was released April 1994 for public comment (DOE 1994b). The Phase III plan was issued in October 1994 (DOE 1994c). Phases I, II, and III corrective actions include activities at the main DOE SNF storage sites. Examples of corrective action projects include installing equipment to improve storage pool water quality at the Savannah River Site; transferring fuel from an old, inadequate water pool to a newer pool at the Idaho National Engineering Laboratory; removal of all fuel and sludge from the 105-K basins at the Hanford Site.

Some of the SNF Action Plan activities could potentially result in emission and effluents. These effects are not individually analyzed because their impacts are no greater than the impacts of normal SNF management activities reported and analyzed for each site in Volume 1 and the respective site appendices. Successful completion of the corrective actions would reduce the potential for health and safety problems to the workers and public and minimize degradation to the environment.

In addition to the Spent Fuel Working Group report on vulnerabilities and the associated plans of action to resolve the identified vulnerabilities, the Defense Nuclear Facilities Safety Board issued Recommendation 94-1 (Conway 1994) calling for DOE to develop an expedited schedule for resolving identified vulnerabilities across the DOE complex. Recommendation 94-1 was critical of DOE's lack of urgency in correcting known SNF management deficiencies. Further, Recommendation 94-1 criticized DOE's lack of prioritization of corrective actions and lack of an integrated systems approach to resolving previously identified SNF management issues. DOE has developed a plan for implementing Recommendation 94-1 across the DOE complex. DOE's Implementation Plan (DOE 1995a) for Recommendation 94-1 was submitted to the Defense Nuclear Facilities Safety Board on February 28, 1995. The plan includes a prioritization of corrective actions to remedy known deficiencies utilizing a DOE complex-wide systems approach and considering limited budgets. The plan focuses on fulfilling outstanding commitments to other parties (for example, court-ordered milestones) and fully recognizes the urgency required to rectify long-standing SNF management issues.

1.1.2 DOE Spent Nuclear Fuel Management

For the purposes of this document, SNF is separated into two categories: commercial SNF and DOE-managed SNF. The management of commercial SNF (with a few special-case exceptions) is outside the scope of this SNF and INEL EIS and is not discussed further herein.[a]

Since 1943, DOE and its predecessor agencies have generated more than 100,000 metric tons of heavy metal[b] (MTHM) of SNF, of which about 2,700 metric tons remains. This SNF was generated in various programs in different types of reactors, including DOE defense production reactors, United States naval reactors, and DOE test and experimental reactors. In addition, DOE has accepted responsibility for SNF from non-DOE sources, including United States university research reactors, special-case commercial power reactors, and selected foreign research reactors.

In 1992, the Secretary of Energy directed the DOE to develop an integrated, long-term SNF management program. This program is assessing DOE's SNF and fuel storage facilities, integrating DOE's many existing SNF activities into one program, deciding the most appropriate and responsible means of facility operation, and ensuring that issues associated with SNF are resolved safely and cost

a. The Atomic Energy Act of 1954, as amended, gives DOE the responsibility and ultimate title for the Nation's SNF. The Nuclear Waste Policy Act of 1982, as amended, sets up the process for disposition of the Nation's commercial nuclear power reactor SNF in a mined geologic repository and makes provisions for cost recovery for the ultimate disposition of that SNF. It also specifies the procedures for ultimate disposition of DOE's high-level waste and SNF.

b. Quantities of fresh nuclear fuel, SNF, and targets are traditionally expressed in terms of metric tons of heavy metal (typically uranium), without the inclusion of other materials, such as cladding, alloy materials, and structural materials. A metric ton equals approximately 2,200 pounds.

effectively. Solutions to the storage questions may require changes in the management strategies for these fuels, including such options as the construction of new facilities and stabilization of certain fuels. The program has also established a programmatic objective to define a management path and proceed toward ultimate disposition of DOE-managed SNF, as outlined in DOE (1994d). A number of activities are currently in process to meet or address this objective. Appendix J, Spent Nuclear Fuel Management, provides an overview of technologies for SNF management.

For various reasons, including the lack of characterization data on the interim storage behavior of certain SNF types and the fact that the acceptance criteria for ultimate disposition have not yet been defined, DOE cannot yet make all the decisions for the full 40-year period. Therefore, this EIS focuses on issues relating to deciding the locations of future SNF management activities.

DOE faces a number of major programmatic and site-specific decisions regarding SNF management over the next 40 years including

- Where should DOE locate specific SNF management activities? Broadly, the alternatives include managing the SNF where it is and minimizing shipments; consolidating the SNF at a limited number of sites (the Decentralization, 1992/1993 Planning Basis, and Regionalization 4A and 4B alternatives); or consolidating the SNF at a central site.

- What capabilities, facilities, and technologies are needed for SNF management? DOE has identified the need for SNF interim storage sites and must select appropriate means at each site for meeting these needs under each of the SNF siting alternatives.

- What research and development activities should support the SNF management program?

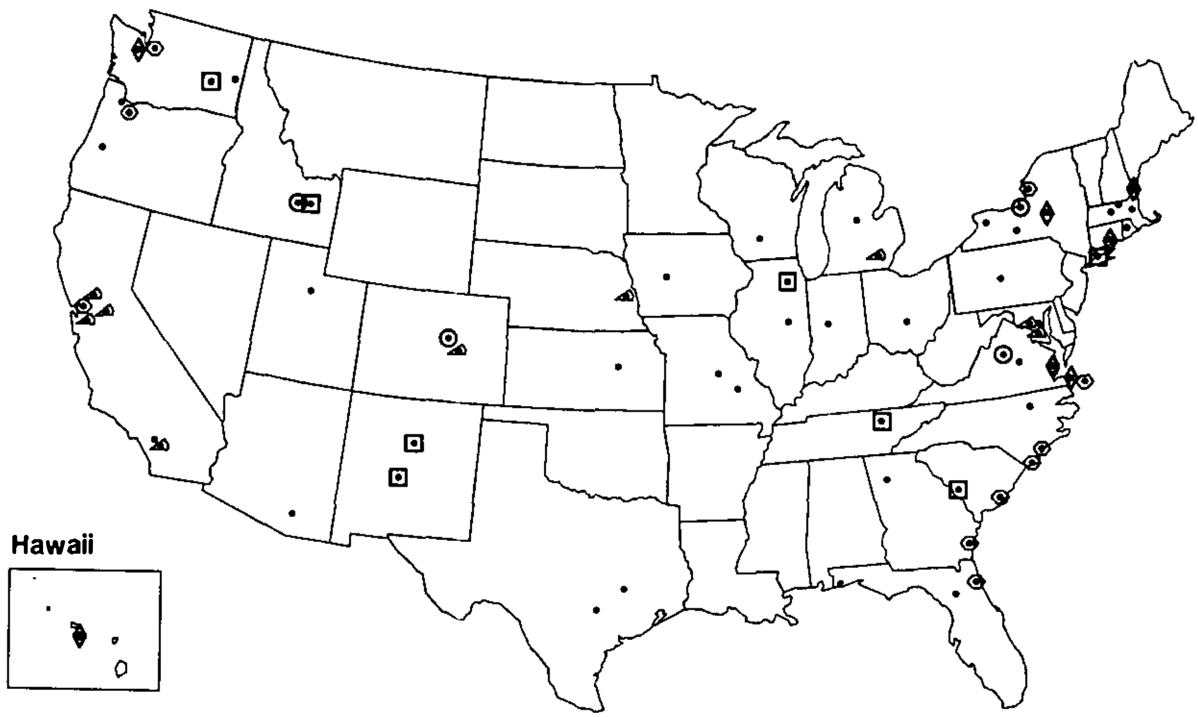
1.1.2.1 Current and Projected Spent Nuclear Fuel Inventories. Table 1-1 summarizes the current inventories of SNF at DOE and other facilities and those projected to be generated through the year 2035. These estimates are based on assumptions regarding reasonably foreseeable future reactor operations and the generation rates of SNF for which DOE is responsible. The principal SNF generators and storage sites for SNF are described below and in Appendices A through F. Figure 1-2 illustrates those locations, as well as representative points of entry for foreign fuels under consideration in this EIS.

1.1.2.2 DOE Facilities. During the last four decades, DOE and its predecessor agencies have transported, received, reprocessed, and stored SNF at various facilities in the nationwide DOE complex. Three of the DOE facilities have primary responsibility for managing DOE SNF; several others have smaller roles in SNF management.

Table 1-1. Spent nuclear fuel inventory.[a]

Generator or storage site[b]	Existing (1995) MTHM[c]	Existing (1995) Percent	Future increases (through 2035) MTHM[c]	Future increases (through 2035) Percent	Total (2035) MTHM[c]	Total (2035) Percent
DOE Sites						
Hanford Site	2132.44	80.6	0.00	0.0	2132.44	77.8
Idaho National Engineering Laboratory	261.23	9.9	12.92	13.5	274.14	10.0
Savannah River Site	206.27	7.8	0.00	0.0	206.27	7.5
Oak Ridge Reservation	0.65	<0.1	1.13	1.2	1.78	<0.1
Other DOE Sites	0.78	<0.1	1.50	1.6	2.28	<0.1
Naval Nuclear Propulsion Reactors	0.00[d]	0.0	55.00	57.6	55.0	2.0
Foreign Research Reactor	0.00	0.0	21.70	22.7	21.70	0.8
Non-DOE Domestic						
Domestic Research and Test Reactors[e]	2.22	<0.1	3.28	3.4	5.50	0.2
Special-Case Commercial SNF at non-DOE locations[f]	42.69	1.6	0	0	42.69	1.6
Total[g,h]	2646.27		95.53		2741.80	
Percent of 2035 total	96.5		3.5		100.0	

a. Source: Wichmann (1995). Changes to the spent nuclear fuel (SNF) inventory contained in the Draft Environmental Impact Statement were made to reflect updated inventories at domestic research and test reactors and to remove materials that are contact-handled (i.e., materials unirradiated or slightly irradiated).
b. The Nevada Test Site does not currently store or generate SNF and is not expected to generate SNF through 2035.
c. MTHM = metric tons of heavy metal. One MTHM equals approximately 2,200 pounds.
d. Existing inventory of naval SNF (10.23 MTHM) is included in the Idaho National Engineering Laboratory totals.
e. Includes research reactors at commercial, university, and government facilities.
f. The total inventory of SNF from special-case commercial reactors is 186.41 MTHM. The 42.69 MTHM indicated here is just that stored at the Babcock & Wilcox Research Center, Fort St. Vrain Reactor, and West Valley Demonstration Project. The remaining special-case commercial SNF is stored at the Idaho National Engineering Laboratory, Oak Ridge Reservation, Hanford Site, and Savannah River Site and is included in the totals (in this table) for those sites.
g. Changes to the fuel inventory occurred due to recalculation of the Idaho National Engineering Laboratory inventory at the Experimental Breeder Reactor-II and Hot Fuel Examination Facility and the removal of contact-handled fuel.
h. Numbers may not sum due to rounding.



Legend

	Source	No. of locations
▣	U.S. Department of Energy Facilities	8
◈	Naval Sites	7
⊙	Special-Case Commercial	4
△	Domestic Non-DOE	9
◉	Foreign Returns (potential point of entry)	10
•	Universities	29

Figure 1-2. Locations of principal spent nuclear fuel generators and storage sites.

Hanford Site—The Hanford Site was dedicated to producing plutonium for more than 40 years, until production was halted in 1989. Hanford's production reactors (including the N Reactor and Single-Pass Reactor) have generated 2100 MTHM of the existing DOE SNF. The ongoing actions at Hanford are focused on improving worker health and safety and protecting the environment. SNF management activities include reducing water contamination levels, performing physical upgrades necessary to assure facility safety for near-term storage, characterizing SNF condition, and stabilization or repackaging for storage and/or ultimate disposition.

The SNF at facilities associated with the Hanford Site include N-Reactor SNF, Single-Pass Reactor SNF, Shippingport Core II SNF, Fast Flux Test Facility SNF, and miscellaneous special-case commercial and experimental SNF. As shown in Table 1-1, the Hanford Site currently stores over 80 percent (by MTHM) of the current complex-wide SNF.

Idaho National Engineering Laboratory—The Idaho National Engineering Laboratory is one of the principal centers in the DOE complex for nuclear research and development. Ongoing activities include continued safe storage of SNF, continued reactor operations, and onsite fuel transfers to reduce identified vulnerabilities.

As a result of its historic mission, the Idaho National Engineering Laboratory has been safely managing SNF for over 40 years. This site is the home of the Expended Core Facility and the Naval Reactors Facility, which are central to the Navy's nuclear propulsion program. Currently, the site stores approximately 261 MTHM (about 10 percent) of DOE's SNF from a variety of DOE programs and a limited number of commercial and foreign sources.

Savannah River Site—The Savannah River Site was constructed in the early 1950s to produce the basic materials used in nuclear weapons—primarily plutonium and tritium.

Savannah River's production reactors have generated about 150 MTHM of the existing DOE SNF. Most of the SNF from Savannah River Site reactor operations is stored underwater in concrete, water-filled reactor storage basins. These reactor disassembly basins were originally intended for only short-term storage of production reactor SNF. Some of the SNF stored at Savannah River consists of uranium clad in stainless steel or zirconium alloy, which Savannah River Site cannot process without facility modifications. Ongoing activities include improving the use of existing storage facilities to provide for continued safe storage of the less corrosion-resistant aluminum-clad SNF. DOE currently manages approximately 206 MTHM (about 8 percent) of its SNF at the Savannah River Site.

Oak Ridge Reservation—The Oak Ridge Reservation was originally developed as part of the Manhattan Project—the effort to build the first nuclear weapons. The missions of Oak Ridge Reservation facilities include weapons dismantlement, storage of enriched uranium, maintaining production capability, technology research and development, and environmental management. Less than 1 MTHM (0.07 percent) of DOE's SNF is either in storage or being generated at several facilities at the Oak Ridge Reservation.

Other Department of Energy Sites—A number of other DOE sites also store SNF, principally from experimental and test reactors that have operated at many Department sites nationwide. Four of these DOE sites storing SNF are as follows:

- **Argonne National Laboratory-East** has one reactor that is being decontaminated and decommissioned. This site currently manages 0.08 MTHM of SNF.

- **Brookhaven National Laboratory** is generating and storing SNF at two facilities. The Brookhaven High Flux Beam Reactor and the Brookhaven Medical Research Reactor are both operating at the present time. This site currently manages 0.24 MTHM of the DOE's SNF.

- **Los Alamos National Laboratory** has SNF at the Omega West Reactor, which has been shut down since December 1992. There is 0.014 MTHM of SNF in storage at Los Alamos.

- **Sandia National Laboratories** have reactors that operate as needed. These reactors will generate small quantities (0.4 MTHM) of SNF when shut down and defueled.

1.1.2.3 Navy Nuclear Propulsion Program. Naval SNF is removed from naval reactors at shipyards and prototype sites and placed in shielded shipping containers. Since 1957, the SNF removed from nuclear-powered naval vessels and prototypes has been transported from shipyards and prototype sites to the Naval Reactors Facility at the Idaho National Engineering Laboratory. The SNF is then removed from the shielded shipping containers and placed into a water pool at the Expended Core Facility. In the water pool, each naval fuel assembly receives, as a minimum, an internal and external visual examination to confirm that it performed as designed and to identify anomalies that would warrant more detailed examination. After examination, the SNF is loaded into shielded containers and transferred to the Idaho Chemical Processing Plant for storage.

Currently, four naval shipyards and one commercial shipyard (Norfolk, Puget Sound, Portsmouth, Pearl Harbor, and Newport News) and the Kesselring Site support the refueling of nuclear-powered ships and prototypes. Other naval shipyards that formerly supported defuelings and refuelings, such as Charleston and Mare Island, are being closed because of military base closure decisions. An existing water pool facility, constructed to support the refueling of nuclear-powered aircraft carriers, is located within the industrial zone of the Puget Sound Naval Shipyard. To date, the facility has been used for refueling equipment demonstrations and testing. The facility contains a radiologically controlled, high bay structure and a Personnel Support Building, which provides office and other nonradiological support functions. The high bay structure contains the water pool and general work areas. At Newport News, SNF is removed from naval vessels and temporarily stored near the removal site before transport.

1.1.2.4 Foreign Research Reactors. In accordance with national nuclear nonproliferation goals, DOE has accepted (and is considering the renewal of the policy to accept) SNF that contains enriched uranium of United States origin that was used in foreign research reactors. In April 1994, DOE decided to accept up to 409 additional SNF elements from eight foreign research reactors in seven European countries for storage at the Savannah River Site. One hundred fifty-three of these elements were actually received before an order by the court in the case of South Carolina v. O'Leary, No. 3:94-2419-0 (District of South Carolina January 27, 1995) preventing the receipt of additional shipments. That order is currently on appeal to the United States Court of Appeal for the Fourth Circuit. The United States Government is currently considering the acceptance of SNF from approximately 40 nations. This foreign research reactor SNF is estimated to amount to 21.7 MTHM and is the subject of the Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (see Section 1.2.5), due to be published in 1995.

1.1.2.5 Non-DOE Domestic. This category includes non-DOE domestic, licensed facilities, including training, research, and test reactors at university, commercial establishments, and government-owned installations for which DOE has contractual obligations to accept SNF. Appendix E provides additional detail on these sites. These locations currently have less than 1 percent of the existing DOE SNF.

Domestic Research and Test Reactors—Fifty-seven domestic non-DOE facilities have been licensed by the U.S. Nuclear Regulatory Commission, 38 of which are expected to be small generators of DOE SNF during the next 40 years. These facilities include colleges, universities, government, and commercial establishments in the United States that use reactors for educational and research activities. The reactors are of several different types and are used for training, experimentation, and teaching in nuclear science and engineering. Some of these research sites have limited storage capacity compared with generation rates. Table 1-2 provides a summary of these locations, the SNF currently at these locations, and the amount of SNF they currently have stored plus projected generation through the year 2035.

Special-Case Commercial Power Reactors—DOE also has taken possession of SNF assemblies and complete or sectioned SNF rods from various commercial nuclear power reactors that were to be used to support DOE-sponsored research and development programs. By way of a

Table 1-2. Summary of domestic research and test reactors.

Type	Number of locations	MTHM[a] (ROD[b])	MTHM[a] (2035)
Universities[c]	29	2.01	4.96
Government, non-DOE[c]	5	0.11	0.42
Commerical[c]	4	0.10	0.12
Total	38	2.22	5.50

a. MTHM = metric tons of heavy metal.
b. ROD = Record of Decision, June 1995.
c. See Appendix E of Volume 1 of this EIS for a discussion of these locations.

three-party agreement among the Public Services Company of Colorado, General Atomics, and the Atomic Energy Commission, the DOE has agreed to provide dry storage at the Idaho National Engineering Laboratory for eight segments of Fort St. Vrain SNF (approximately 1,920 SNF elements). Three segments of this SNF have been transported to the Idaho National Engineering Laboratory; the other five are currently being stored at the Fort St. Vrain site. Other SNF in this category includes SNF from development reactors (Shippingport and Peach Bottom Unit 1); SNF used for destructive and nondestructive examination and testing; SNF remaining at the West Valley Demonstration Project; SNF from fuel performance testing at the Babcock & Wilcox Research Center; and special-case SNF debris (Three-Mile Island Unit 2).

Table 1-3 summarizes the types and quantities of special-case commercial power reactor SNF in storage. This SNF currently is in storage at either the West Valley Demonstration Project in West Valley, New York, the Babcock & Wilcox Research Center in Lynchburg, Campbell County, Virginia, or the Fort St. Vrain facility in Colorado. Additionally, special-case commercial SNF (such as from Three-Mile Island, Peach Bottom, and Shippingport) is also stored at the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, and Oak Ridge Reservation.

1.1.3 Technologies for the Management of Spent Nuclear Fuel

DOE must safely manage SNF until its ultimate disposition. Some SNF, such as naval reactor fuel, was designed for long-term operation and to survive combat conditions; therefore, it is rugged enough to retain its integrity during prolonged storage. Commercial reactor fuel is also inherently stable and suitable for prolonged storage. The DOE will not select SNF technologies on the basis of Volume 1 of this EIS. These technology-based decisions are most appropriately dealt with on a fuel type-specific or site-specific basis.

Table 1-3. Special-case commercial power reactor spent nuclear fuel (SNF).

Storage location	Category	SNF in storage[a]	MTHM[b]
West Valley, NY	Light-water reactor fuel	125 elements	27
Lynchburg, VA	Light-water reactor partial fuel elements	3 full-length rods and 17 sectioned rods	0.044
Fort St. Vrain, CO	High-temperature gas-cooled reactor fuel	1,464 elements	16

a. No additions projected through 2035.

b. MTHM = metric tons of heavy metal. One MTHM equals approximately 2,200 pounds. (The approximate total of SNF currently at these locations is 43 MTHM.)

1.1.3.1 Storage. Interim storage may be accomplished with either dry or wet storage technology. Wet storage normally involves the use of belowgrade water-filled pools. Dry storage places the SNF in a shielded container for aboveground storage. Dry storage technologies range from the use of casks, which hold only a few fuel elements, to vaults that are capable of holding a large quantity of fuel. Casks are normally constructed of steel or reinforced concrete, and vaults are normally constructed of concrete. For dry storage, a number of similar concepts have been used for commercial power reactor-type fuels and may be suitable for some of the DOE SNF. While both wet and dry storage are being evaluated for SNF management, dry storage has several unique advantages when heat dissipation is not a major concern. These advantages include lower emissions, simpler operation, lower cost, shorter times for design and construction, and capability for licensing by the U.S. Nuclear Regulatory Commission, if required.

1.1.3.2 Stabilization. Stabilization may be necessary to provide safe interim storage of SNF. Stabilization technologies can be placed in three broad categories: containerization, processing without fissile material separation, and processing with fissile material separation. Containerization can involve processes such as canning, coating, and passivation. Canning involves placing the fuel in a sealed canister of durable construction (such as stainless steel). Coating involves depositing a protective film on the fuel to inhibit corrosion. Passivation involves treating the SNF to place exposed surfaces in a less reactive form when the SNF is stored in either water or air.

Processing without fissile material separation involves processes such as direct dissolving of the fuel elements or oxidation of the fuel elements. Oxidation involves separation of the fuel matrix from the cladding using oxygen at elevated temperatures [up to 800°C (1,472°F)]. The principal existing approach for processing with fissile material separation is aqueous processing. Aqueous processing involves breaking down the fuel through mechanical means (shearing, chopping, cutting) or chemical means (acid or electrolytic dissolution, combustion, hydrolysis) and then chemically separating the fuel constituents by solvent extraction. Aqueous processing would normally be followed by a vitrification process where the high-level waste is processed into a glass or ceramic form. The Savannah River Site currently has the capability to process aluminum-clad fuel.

Appendix J provides more details on fuel management technologies. Appendices A through F provide details on the storage and stabilization technologies evaluated for each of the potential SNF management sites. These technologies are representative of those discussed above. This EIS evaluates the environmental impact of these technologies to illustrate, at a programmatic level, the characteristic impacts from implementing each programmatic alternative.

The DOE will conduct additional National Environmental Policy Act reviews for research and development and characterization activities that help select technologies for placing the SNF in a form suitable for interim storage and ultimate disposition.

1.1.3.3 Transportation. Depending on the SNF management options selected, some of the SNF may be moved one or more times before being transported. SNF is transported in massive, lead and steel shielded casks that can weigh above 100 tons. These casks must conform to both U.S. Nuclear Regulatory Commission and U.S. Department of Transportation regulations. Shipment by both rail cars and trucks is common, with the chief advantage of rail being the ability to transport heavier, more massive casks and, thus, transport more SNF per shipment.

The casks serve two functions: (a) providing gamma radiation shielding from the SNF so that the radiation level outside the casks meets regulatory requirements, and (b) providing protection to and containment of the SNF even in case of accidents. The casks are designed to withstand a wide range of very severe accidents. Because the SNF is generally metallic in form, most of the radionuclides stay within the metal fuel even in maximum foreseeable transportation accidents. The risks to both workers and the public have been evaluated many times, most recently in Appendix I of this EIS, and have been shown to be low.

1.1.3.4 Ultimate Disposition. In the Nuclear Waste Policy Act, as amended, Congress established a national policy for disposal of high-level waste and commercial SNF in a geologic repository, and directed DOE to characterize the Yucca Mountain site in Nevada for suitability as the site of a first United States repository. That Act authorizes disposal of DOE SNF, as well as commercial spent fuel, in the first repository, subject to a limit on repository capacity and the payment of appropriate fees. For planning purposes, the DOE assumes that some or all of the SNF in its inventory that satisfies the repository's acceptance criteria could be placed in the first geologic repository developed under the Nuclear Waste Policy Act of 1982, as amended.

Although beyond the scope of this EIS, two broad strategies may at this point be envisioned for the ultimate disposition of DOE SNF. The DOE could (a) work toward direct disposal of SNF in a geologic repository, or (b) chemically dissolve the fuel and produce a waste form (such as vitrified glass) for repository disposal. Variations on these broad strategies are also possible, and both remain under consideration. It is possible that some of DOE's SNF could qualify for direct disposal. Aggressive characterization and, if appropriate, preparation programs would be necessary, and would need to be coordinated with plans to develop one or more repositories.

Sufficient quantity and quality of information is still not available to determine at this time whether the Yucca Mountain site is a suitable candidate for geologic disposal of SNF and high-level radioactive waste. The DOE, however, is in the early planning stages for a repository EIS, which will be prepared pursuant to the directives of the Nuclear Waste Policy Act of 1982, as amended. The DOE plans to issue in mid-1995 a formal notice of its intent to prepare this analysis. The repository EIS is being prepared to evaluate potential environmental impacts, based on the best available information and data, that would be associated with the repository's development and operation, and to support the Secretary of Energy's final recommendation to the President, as required by the Nuclear Waste Policy Act of 1982, as amended. The repository EIS will examine the site-specific environmental impacts from construction, operation, and eventual closure of the repository, including potential post-closure radiological effects to the environment. Until the repository EIS is complete, no final decision could be made concerning what DOE SNF would be accepted in a geologic repository.

As part of its SNF management program, DOE would (a) stabilize the SNF as needed to ensure safe interim storage, (b) characterize the existing SNF inventory to assess compliance with the repository acceptance criteria as they are developed, and (c) determine what processing, if any, is required to meet the criteria. Decisions regarding the actual disposition of DOE's SNF would follow appropriate review under the National Environmental Policy Act, and would be subject to licensing by the U.S. Nuclear Regulatory Commission. This "path forward" would be implemented so as to minimize impacts on the first repository schedule. The current planning assumption is that any DOE material (vitrified high-level waste and/or SNF) qualified and selected for emplacement in the first repository would be disposed beginning in the year 2015. Disposition of the remaining DOE SNF and vitrified high-level waste that is not emplaced in the first repository would not be decided until the DOE recommendation on the need for a second repository (which would consider such factors as the physical and statutory limits of the first repository). The Nuclear Waste Policy Act of 1982, as amended, requires DOE to make that recommendation between January 1, 2007, and January 1, 2010.

Except perhaps for a need to develop them further, the technologies described above for stabilization and safe storage are available for the management of SNF and appear adequate to meet the needs of ultimate disposition. Disposal in a repository, for example, may require canning, canisterization, encapsulation, or processing the fuel to create a vitrified waste form. Resource recovery requires dissolving the fuel to separate the fissile material from the waste and producing a stable waste form. These required technologies have already been applied and are under continued development in several countries. Once the acceptance criteria are established, the appropriate technologies can be identified and finalized to ensure that the SNF can be put in an acceptable form for ultimate disposal.

1.2 Relationship to Other National Environmental Policy Act Documents

DOE currently has a range of National Environmental Policy Act reviews planned or under way that are interrelated with or tier from this SNF management review. Because the scope of SNF management includes a wide variety of proposals, multiple National Environmental Policy Act reviews are, or will be, necessary. Related reviews are identified in Table 1-4. Figure 1-3 graphically presents the interrelationships of the various National Environmental Policy Act reviews. Discussion in the following subsections centers primarily on reviews with an interrelationship with this SNF management review. The remaining documents in Table 1-4 are site-specific reviews of SNF management, or individual project reviews that have a relationship to SNF management.

Table 1-4. Major National Environmental Policy Act (NEPA) reviews related to Volume 1 of this Environmental Impact Statement (EIS) as of March 1995.

Site	Subject	Type of NEPA Review	Status
DOE (Headquarters)	Waste Management Programmatic EIS	EIS	In preparation
	Programmatic EIS for Tritium Supply and Recycling[a]	EIS	In preparation
	Stockpile Stewardship and Management EIS	EIS	Future
	EIS for a potential repository at Yucca Mountain for disposal of high-level radioactive waste	EIS	Future
	EIS on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel	EIS	In preparation
	Storage and Disposition of Weapons-Usable Fissile Materials	EIS	In preparation
	Fabrication and Deployment of a Multi-Purpose Canister-Based System for the Management of Civilian Spent Nuclear Fuel	EIS	In preparation
U.S. Navy	Short-Term Storage of Naval Spent Nuclear Fuel (SNF)	EA/FONSI[b]	Issued
West Valley Demonstration Project	Management of SNF in Storage at the West Valley Demonstration Project (interim onsite dry storage)	EA	In preparation
	West Valley Demonstration Project Completion and Site Closure	EIS	In preparation
Savannah River Site	Urgent-Relief Acceptance of Foreign Research Reactor SNF[c]	EA/FONSI	Issued
	Interim Management of Nuclear Materials at Savannah River Site	EIS	In preparation
Oak Ridge Reservation	High Flux Isotope Reactor SNF storage reracking	EA/FONSI	Issued
	High Flux Isotope Reactor Dry Storage Pad	EA	Future
Idaho National Engineering Laboratory	Programmatic SNF and Idaho National Engineering Laboratory Environmental Restoration and Waste Management, Volume 2	EIS	In preparation
	Fort St. Vrain Fuel Shipments to the Idaho Chemical Processing Plant	EA/FONSI[d]	Issued
	Test Area North Pool Stabilization Project (also known as Dry Cask Storage Project)	EA	In preparation
Nevada Test Site	Nevada Test Site and Other Off-Site Test Locations Within the State of Nevada Site-Wide EIS	EIS	In preparation
Hanford Site	105-KE and 105-KW Basins Fuel Encapsulation and Repackaging, 100-K Area	EA/FONSI	Issued
	Transfer of Plutonium Uranium Extraction Plant and N-Reactor Irradiated Fuel for Encapsulation and Storage at the K-Basins	EA	In preparation
	Shutdown of the Fast Flux Test Facility	EA	In preparation
	Relocating TRIGA[e] Reactor Fuel from 308 Building (covers SNF, lightly irradiated fuel, and unirradiated fuel)	EA	In preparation
	Characterization of Stored Defense Production SNF and Associated Materials at Hanford Site, Richland, Washington	EA	In preparation
	Hanford SNF Management EIS	EIS	Future
	Preparation of an EIS for Management of SNF from the K-basins at the Hanford Site, Richland, Washington	EIS	In preparation

a. The Nuclear Weapons Complex Reconfiguration Study was replaced by two separate National Environmental Policy Act reviews: the Programmatic EIS for Tritium Supply and Recycling and the Stockpile Stewardship and Management Programmatic EIS.
b. Environmental Assessment (EA): A concise public document provided by a Federal agency that presents evidence and analysis for determining whether to prepare an EIS or a Finding of No Significant Impact (FONSI).
c. After the FONSI was issued, one shipment of foreign research reactor fuel was actually received in the U.S. A lawsuit by the State of South Carolina resulted in an order preventing the receipt of additional shipments (South Carolina v. O'Leary, No. 3:94-2419-0 (D.S.C. January 27, 1995). That order is currently on appeal to the United States Court of Appeal for the Fourth District.
d. The EA and FONSI were determined by the District Court to be inadequate. Volumes 1 and 2 of this EIS address shipments of Fort St. Vrain fuel.
e. TRIGA: Training, research, and isotope reactors built by General Atomics.

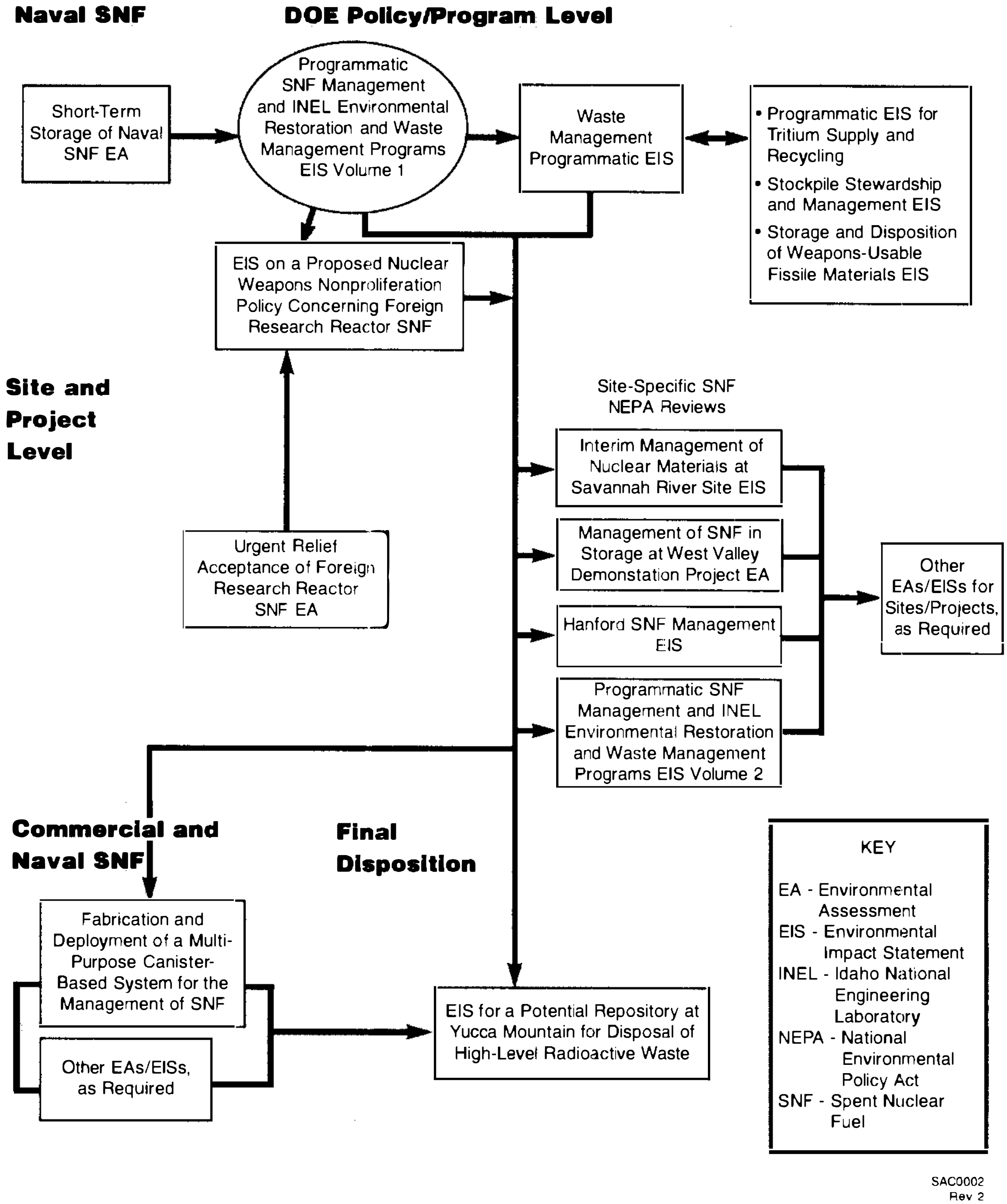


Figure 1-3. Interrelationships of National Environmental Policy Act reviews related to SNF management.

Volume 1 of this EIS provides the overall programmatic National Environmental Policy Act review of the management of DOE SNF. This review and the Record of Decision will be summarized and incorporated in the DOE Waste Management Programmatic EIS, currently in development. Programmatic reviews for nuclear weapons disposition and weapons-usable fissile materials will also provide input to the DOE Waste Management Programmatic EIS. This SNF EIS will provide input to the EIS for the management of SNF from foreign research reactors. Except for special-case commercial reactors, commercial SNF is not evaluated in this SNF EIS. DOE is also preparing an EIS for a multipurpose canister system. Additional National Environmental Policy Act reviews for DOE and commercial SNF will be prepared as needed.

Table 1-4 and Figure 1-3 also identify site- or project-specific National Environmental Policy Act reviews currently planned or underway. This Volume 1 is a DOE-wide programmatic EIS covering a full range of strategic alternatives for the management of SNF. As such, this document is an upper tier EIS, intended to provide National Environmental Policy Act review of related and potential actions. By tiering National Environmental Policy Act documentation, DOE is able to look at the overall potential impact of a group of connected actions. Lower-tier reviews provide more specific and detailed analyses on specific sites and projects that stem from the programmatic decisions. The tiering of National Environmental Policy Act reviews as they relate to this SNF management review is shown schematically in Figure 1-3. This programmatic EIS does not replace site-specific or project-specific National Environmental Policy Act documentation, except where adequate coverage is provided in this EIS to evaluate reasonably foreseeable impacts. For the Idaho National Engineering Laboratory, the site-specific documentation is provided by Volume 2 of this EIS.

1.2.1 Waste Management Programmatic Environmental Impact Statement

DOE is currently analyzing nationwide and site-specific alternative strategies to maximize efficiency for DOE's waste management program. The nationwide analyses will be part of the DOE Waste Management Programmatic Environmental Impact Statement (PEIS) (previously known as the Environmental Management Programmatic Environmental Impact Statement). This PEIS evaluates proposed DOE actions regarding the

- Type, size, and number of waste storage, treatment, and disposal facilities needed and where to build them, including the transportation network
- Proposed action formulating and implementing an integrated Waste Management Program
- Alternative configurations for each waste type (except hazardous waste) to provide a framework for siting future facilities at specific locations.

The alternatives are structured to ensure analysis of the impacts of the mixed waste configuration that will be defined in the site treatment plans developed pursuant to the Federal Facility Compliance Act.

The Draft Waste Management PEIS is scheduled to be available for public and agency review and comment by mid-1995. Although the DOE Waste Management PEIS was originally intended to provide the programmatic analyses of alternatives for SNF management, these analyses are also presented in this volume. The Waste Management PEIS is expected to summarize and consider, as part of its analysis of cumulative environmental consequences, the impacts of the SNF alternatives identified in this EIS.

1.2.2 Programmatic Environmental Impact Statement for Tritium Supply and Recycling

The Nuclear Weapons Complex Reconfiguration Program has evolved considerably since its original Notice of Intent to prepare a Nuclear Weapons Complex Reconfiguration PEIS was issued in February 1991. DOE has now separated the Nuclear Weapons Complex Reconfiguration EIS into two programmatic EISs: (a) a PEIS for Tritium Supply and Recycling (expected completion in November 1995) and (b) a Stockpile Stewardship and Management PEIS. In the original Notice of Intent, DOE proposed to reconfigure the Nation's nuclear weapons complex to be smaller, less diverse, and less expensive to operate. This proposal offered the advantage of enabling the closure and remediation of the Mound and Rocky Flats Plants. At that time, no new plutonium or highly enriched uranium storage facilities were envisioned, and a new tritium production facility was being planned as part of a separate New Production Reactor Program. Later, the New Production Reactor Program was incorporated into the Reconfiguration PEIS. DOE's needs have evolved since then for many reasons, but primary among them is the end of the Cold War. The tangible effects of this include the significant reduction in the size of the Nation's stockpile of nuclear weapons and reduced requirements for production of tritium.

Accordingly, the Tritium Supply and Recycling PEIS addresses alternatives associated with new tritium production and the recycling of tritium recovered from weapons being retired from the stockpile. Alternative technologies for producing tritium are planned to be analyzed at five candidate sites (Savannah River Site, Oak Ridge Reservation, the Pantex Plant, the Idaho National Engineering Laboratory, and the Nevada Test Site). The PEIS was issued in draft form February 28, 1995.

1.2.3 Stockpile Stewardship and Management Environmental Impact Statement

The Stockpile Stewardship and Management Environmental Impact Statement was originally part of the Nuclear Weapons Complex Reconfiguration Programmatic Environmental Impact Statement (see Section 1.2.2). DOE expects to begin the scoping process for the Stockpile Stewardship and Management PEIS in 1995. Stockpile stewardship includes activities required to maintain a high level of confidence in the safety, reliability, and performance of nuclear weapons in the absence of underground testing, and to be prepared to test weapons if directed by the President. Stockpile management activities include maintenance, evaluation, repair, or replacement of weapons in the existing stockpile. The review will take into account the latest information on current and projected future stockpile requirements.

1.2.4 Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement

In response to the President's Nonproliferation and Export Control Policy issued on January 24, 1994, the Department created a separate Department-wide project for developing recommendations and for directing implementation of decisions concerning disposition of excess nuclear materials. Through this PEIS, DOE proposes to develop a comprehensive national policy for the management and disposition of fissile materials (primarily separated plutonium and highly enriched uranium, but also other excess nuclear materials including neptunium, americium, and uranium-233) that are no longer required for military purposes.

1.2.5 Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel Environmental Impact Statement

DOE proposes to adopt and implement a policy concerning management of SNF containing enriched uranium that originated in the United States and was used by foreign research reactors. Under the proposed policy, the United States may manage approximately 22,750 elements (19.2 MTHM) of high-enriched uranium or low-enriched uranium SNF during a 10-year period from foreign research reactors in approximately 40 nations. Alternative methods of implementing the proposed action and the No Action alternative are being analyzed in an EIS. DOE will not make a final decision on the acceptance of SNF from these foreign research reactors until after the EIS for the Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor SNF and this programmatic SNF EIS are both completed. Both of these EISs are scheduled to be completed in 1995.

The proposed action would support the nuclear nonproliferation policy of the United States by removing the highly enriched uranium from these reactors from international commerce. The implementation of this policy could result in the receipt of foreign research reactor SNF at one or more United States points of entry and overland transport to one or more DOE sites for storage and/or processing.

1.2.6 Fabrication and Deployment of a Multipurpose Canister-Based System for the Management of Civilian Spent Nuclear Fuel Environmental Impact Statement

This environmental impact statement is addressing the potential environmental impacts associated with alternative systems for storage and transport of SNF assemblies for civilian and naval

SNF. The review will analyze the following: (a) manufacturing of multipurpose canister system components, (b) packaging and handling of SNF as it is transferred to canisters or casks, (c) canister transfer and loading operations, (d) storage of SNF in canisters and casks at the reactor sites, (e) SNF transport from the reactor sites to a hypothetical monitored retrievahle storage facility and/or repository, (f) handling and storage of SNF at a hypothetical monitored retrievable storage facility, and (g) surface activities involving the handling and disposal of SNF at a repository.

The multipurpose canister-based technology may have application for DOE and Navy SNF.

1.2.7 Environmental Impact Statement for a Potential Repository at Yucca Mountain for Disposal of High-Level Radioactive Waste

Under the Nuclear Waste Policy Act of 1982, as amended, DOE is investigating the suitability of the Yucca Mountain, Nevada, site as the nation's first licensed geologic repository for SNF and high-level radioactive waste. The Nuclear Waste Policy Act of 1982, as amended, requires that DOE's recommendation of a repository site to the President must be accompanied by an EIS. DOE has tentatively scheduled the Notice of Intent for the repository EIS for 1995 and the Record of Decision for 2000. Yucca Mountain is a potential disposal site for DOE SNF.

1.3 Scope of this Volume

1.3.1 Scoping Process

On October 22, 1990, DOE published a Notice of Intent in the *Federal Register* announcing its intent to prepare a PEIS addressing environmental restoration and waste management (including SNF management) activities across the entire DOE complex. DOE then invited the public to submit written comments on the scope of the PEIS, held 23 scoping meetings across the country, and issued a draft Implementation Plan in January 1992 reflecting the comments provided. DOE held six regional public workshops on the draft Implementation Plan and recorded public comments given at these workshops. The Implementation Plan for the PEIS was issued in January 1994 and addressed the comments received from scoping and the regional workshops.

On October 5, 1992, DOE published a Notice of Intent to prepare an EIS for Environmental Restoration and Waste Management at the Idaho National Engineering Laboratory in the *Federal Register*. The notice invited Government agencies and the public to participate in five scoping meetings throughout Idaho and to provide written comments. Oral testimony from the meetings was transcribed and made available at DOE public reading rooms. The comment period lasted from October 5, 1992, to December 4, 1992.

On September 3, 1993, DOE published a Notice of Opportunity to Comment in the *Federal Register* proposing to expand the scope of the Idaho National Engineering Laboratory Environmental

Restoration and Waste Management EIS to include impacts related to transportation, receipt, processing, and storage of DOE SNF at locations other than the Idaho National Engineering Laboratory. This comment period started on September 3, 1993, and ended on October 4, 1993. Government agencies and the public were invited to provide comments on the *DOE Programmatic SNF and the Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs EIS.* A toll-free telephone number was provided for questions, requests for documents or other information, and for the public to provide oral comments that were transcribed for DOE's consideration. The Implementation Plan (issued October 29, 1993, and amended on May 9, 1994) for this EIS summarizes these comments and DOE's responses.

As existing large-scale SNF management operations, the Hanford Site at Richland, Washington; the Idaho National Engineering Laboratory in southeastern Idaho; and the Savannah River Site near Aiken, South Carolina, were logically identified as reasonable site alternatives for SNF management in the October 29, 1993, Implementation Plan. In addition, four Navy shipyards and the Kesselring Site (in West Milton, New York) with years of SNF handling experience were identified for consideration in the EIS for activities limited to naval SNF. The four Navy shipyards are the Norfolk Naval Shipyard, Portsmouth, Virginia; the Portsmouth Naval Shipyard, Kittery, Maine; the Pearl Harbor Naval Shipyard, Honolulu, Hawaii; and the Puget Sound Naval Shipyard, Bremerton, Washington.

In response to public scoping comments, DOE committed to consider other sites for SNF management in an effort to broaden the range of reasonable alternatives for locations at which SNF management activities could be conducted. DOE developed a screening process, which resulted in selection of the Oak Ridge Reservation, near Oak Ridge, Tennessee, and Nevada Test Site, near Mercury, Nevada, as additional site alternatives for regionalized or centralized SNF management (DOE-ID 1994). The EIS Implementation Plan was amended on May 9, 1994, to reflect this addition.

1.3.2 Scope

1.3.2.1 Programmatic Spent Nuclear Fuel Disposition. The DOE will not analyze the ultimate disposition of SNF in this EIS. The focus of this Volume 1 of the EIS is the management of SNF in a safe and environmentally sound manner until decisions regarding its ultimate disposition are made and implemented. Decisions regarding the actual disposition of DOE's SNF will follow appropriate review under separate National Environmental Policy Act documentation. Congress has mandated that the Federal Government pursue the development of mined geologic repositories for the permanent disposal of SNF and high-level waste, and has directed DOE to study the Yucca Mountain, Nevada, site to determine whether it is a suitable site. Ultimate disposition of DOE SNF, however, is outside the scope of this programmatic SNF EIS.

1.3.2.2 Programmatic Spent Nuclear Fuel Stabilization. DOE is phasing out reprocessing activities because of decreased demand for the recovery and reuse of certain nuclear materials. Fuel stabilization activities potentially required for safe interim storage and management of SNF, such as canning of some degraded fuels or processing as necessary, are relevant to the safe storage of SNF and within the scope of this EIS. Worker safety, public health, and potential environmental impacts associated with SNF stabilization, research and development of technologies, and pilot programs are topics of importance in analyzing the appropriate alternatives for interim storage of SNF and are included in this EIS.

In April 1992, the Secretary of Energy directed that DOE phase out defense-related chemical separations activities due to a reduction in the demand for new material for nuclear weapons (Claytor 1992). DOE no longer produces plutonium-239 and highly enriched uranium, and, in December 1994, DOE committed to prohibit the use of plutonium-239 and highly enriched uranium separated and/or stabilized during the phaseout, shutdown, and cleanout of weapons complex facilities for nuclear explosives purposes (Reis and Grumbly 1994). However, the use of chemical separations or other processing technologies is a reasonable site-specific option to assure the safe interim management of some types of SNF (or its constituents). Selection of chemical processing as a potential management option will be made after detailed analyses in site-specific National Environmental Policy Act reviews tiered from this EIS. Specific technologies for managing SNF are described in Volume 1, Appendix J. The potential impacts from a representative processing technology have been evaluated to aid in the analysis of reasonable technology options for interim storage of SNF and are included in this EIS. The DOE selected chemical separations for stabilization of degrading SNF as the technology for evaluation. The DOE believes the impacts from this activity are representative of the overall potential impacts of other similar technologies. This EIS assesses the impacts of processing only at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site because DOE determined it would require significant resources to consider undertaking such processing activities at sites with no facilities or infrastructure to support these processes. Processing operations that modify the SNF form to create new forms suitable for interim storage are much more complex than the activities associated with either dry storage or wet storage of intact SNF. For example, processing by chemical separation requires large-scale facilities for: SNF storage, SNF dissolution and chemical element separation operations, liquid high-level waste storage, storage for special nuclear material, and facilities to process the liquid high-level waste into a stable form, for example, vitrification, for storage. Additionally, all these facilities must be supported by a complex infrastructure of services and utilities. The Hanford Site, Idabo National Engineering Laboratory, and Savannab River Site have some or all these facilities and all of the infrastructure for these types of operations. The other sites (that is, Nevada Test Site and Oak Ridge Reservation) lack this level of plant facilities or high-level waste infrastructure. The cost alone to create this level of capability makes evaluating the other sites less than desirable. Construction of the necessary high-level waste infrastructure is estimated to be several billion dollars.

1.3.2.3 Programmatic Spent Nuclear Fuel Storage. Current and projected DOE SNF inventories are considered in this EIS. Existing storage facilities are identified, and their status, capacities, and accident histories are described. SNF container design, integrity, corrosion and corrosion byproducts, storage technologies, and storage facility design life are factored into the EIS analysis for each alternative. Storage options at the site of generation and other storage options are analyzed. The analysis of the storage options for each alternative includes the estimated type and size of representative storage facilities potentially needed at each site.

1.3.2.4 Programmatic Spent Nuclear Fuel Transportation. The EIS includes an analysis of the potential impacts of SNF transportation, including safety and emergency preparedness requirements. A review of the safety record for past SNF transportation activity is included, along with an analysis of potential transportation impacts from normal transport and from transportation accidents.

Transportation modes and routes deemed reasonable for SNF shipment have been analyzed to estimate potential risks to worker safety, public health, and the environment. Federal and state regulations that place restrictions on certain aspects of SNF shipment and limits on shipment size, types of containers, and number of shipments have been accounted for in the analyses. Hazardous materials manifests, required for each shipment of SNF, include information on the carrier, the materials involved and their characteristics, and the containers.

The potential impacts of transporting nuclear fuel for ultimate disposition will be included in the appropriate National Environmental Policy Act documentation. Therefore, an alternative to transport SNF directly to a repository is not considered in this EIS.

1.3.2.5 Special-Case Commercial Fuels. This EIS addresses the management of certain small quantities of special-case commercial SNF for which DOE has responsibility. Some of this SNF is currently being managed at DOE facilities; some is being managed at non-DOE facilities.

1.3.2.6 Naval Spent Nuclear Fuel. This EIS addresses the impacts of and alternatives to transporting, receiving, and storing SNF from naval reactors (Navy warships and reactor prototypes) at a number of sites across the country, including sites near the point of refueling or defueling. The analysis includes alternative sites for naval fuel examination, as well as the possibility of phasing out this examination. This EIS addresses existing naval SNF inventories and fuel to be generated from future refuelings and defuelings.

1.4 Response to Public Comments

Volume 3, Response to Public Comments, was added to this EIS to fully address and respond to public comments. In addition, DOE considered public comments, along with other factors such as programmatic need, technical feasibility, and cost, in arriving at DOE's preferred alternatives. During the public comment period for the Draft EIS, more than 1,430 individuals, agencies, and organizations provided DOE with comments. A broad spectrum of private citizens; businesses; local, state, and Federal officials; Native American tribes; and public interest groups are represented within this volume of comments. Comments were received from all affected DOE and shipyard communities.

Volume 3 summarizes the comments on the EIS received by DOE during the public comment period and provides responses to those comments. In addition, Volume 3 explains how public comments influenced the selection of the preferred alternatives, discusses the extent to which public comments resulted in changes to the EIS, and describes how to find specific comment summaries and responses in this volume.

Responses to comments consist of two parts. The first part summarizes the comment(s), and the second part responds to the comment(s). Identical or similar comment(s) were frequently provided by more than one commentor and, in such cases, DOE grouped the comments and prepared a single response for each group. This summarization was also appropriate due to the large volume of comments received.

In compliance with National Environmental Policy Act and Council on Environmental Quality regulations, public comments on the Draft EIS were assessed and considered both individually and collectively by DOE and the Navy. Some comments resulted in modifications in the EIS or explanations of why comments did not warrant further response. Most comments not requiring a change to the EIS resulted in a response to correct factual misinterpretations, to explain or communicate government policy, to clarify the scope of the EIS, to explain the relationship of the EIS to other related policy, to clarify the scope of the EIS, to explain the relationship of the EIS to other related National Environmental Policy Act documentation, to refer commentors to information in the EIS, to answer technical questions, or to further explain technical issues. The Record of Decision will include the decision made by the Secretary of Energy, which will consider public comments on the Draft EIS.

1.4.1 How DOE Considered Public Comments in the National Environmental Policy Act Process

As required in the Council on Environmental Quality regulations [40 CFR 1502.14(e)], DOE's preferred alternatives are identified in the Final EIS. The preferred alternatives for Volumes 1 and 2 were identified based on the consideration of environmental impacts, regulatory compliance, DOE and SNF programmatic missions, public issues and concerns, national security and defense, cost, and DOE policy. Public input considered in the decisionmaking and preferred alternatives selection process included concerns, desires, and opinions regarding the activities addressed in the EIS and expectations of DOE in making the management decisions on complex-wide programmatic SNF management and environmental restoration and waste management programs at the Idaho National Engineering Laboratory. Public input contributed to the development of performance factors, defined as desirable attributes or characteristics that measure the relative acceptability of alternatives, which were used to select candidate preferred alternatives. The candidate preferred alternatives were then evaluated against a number of technical and nontechnical sensitivities, including public perception of environmental impact, indicated stakeholder preferences, implementation flexibility, regulatory risk, SNF processing potential, environmental justice, potential resistance to implementation, and fairness. DOE's preferred alternative reflects DOE consensus that SNF should be actively managed in preparation for ultimate disposition. In addition, DOE's preferred alternative supports the implementation of a path forward for the ultimate disposition of SNF, a significant issue raised by the public. The EIS, including its preferred alternatives, will be considered by the Secretary of Energy, along with other factors, in arriving at a decision to be documented in a formal Record of Decision.

1.4.2 Changes to the Environmental Impact Statement Resulting from Public Comment

A major purpose of the National Environmental Policy Act is to promote efforts that will prevent or eliminate damage to the environment by ensuring informed decisionmaking on major Federal actions significantly affecting the quality of the human environment. Consideration of public comments on the Draft EIS helps to ensure that the EIS is an adequate decisionmaking tool; accordingly, this EIS has been enhanced, as appropriate, in response to public comments. While a number of specific issues and concerns were raised by commentors, none of the issues or concerns identified new reasonable alternatives requiring assessment or resulted in significant change in the results of the analysis of the potential environmental consequences.

Based on review of public comments, coupled with the consultations held with commenting agencies as well as State and tribal governments, the main EIS enhancements include the following:

- Seismic and water resources discussions were reviewed, clarified, and enhanced for all alternative sites, and current data and analyses were added to Volumes 1 and 2, as appropriate. A discussion of potential accidents caused by a common initiator was added. The option of stabilizing some of DOE's SNF (specifically from the N Reactor) by processing it at available facilities located overseas was added, thus enhancing the processing options discussed in the EIS. An analysis of barge transportation was added to the EIS, with respect to the option of transporting N-Reactor fuel to a shipping point for overseas processing, as well as to support the potential transport of Brookhaven National Laboratory SNF to another site, as appropriate. In addition, an analysis of shipboard fires was added, primarily in response to comments related to receiving SNF containing uranium of U.S. origin from foreign research reactors.

- In Volume 2 of the EIS, the air quality analysis was revised to upgrade the existing baseline conditions and impacts of alternatives in terms of the amount of Prevention of

Significant Deterioration (PSD) increment consumed, thus updating the baseline conditions presented for the Idaho National Engineering Laboratory. Additionally, the Waste Experimental Reduction Facility project summary was enhanced and clarified. This EIS was also revised to reflect current projections of employment, including the projected downsizing of the Idaho National Engineering Laboratory due to contractor consolidation.

- In response to public comments, a brief summary of the results of a separate evaluation of the costs of the various alternatives was added to the EIS, althougb the cost evaluation was performed independently of the EIS for additional purposes. The discussion of the options regarding the management of Fort St. Vrain SNF currently stored in Colorado has been expanded. As committed to in the Draft EIS, the evaluation and discussion of environmental justice has been expanded in both Volumes 1 and 2 of the EIS. This analysis was based on interim DOE guidance in the absence of interagency policy in this regard and reflects limited public comments received regarding environmental justice. Consultation with the commenting Native American tribes is reflected in the environmental justice analysis, as well as in the various sections of the EIS, as appropriate.

- Other enhancements include a clarification that potential shipment of SNF containing uranium of U.S. origin from foreign research reactors consists of a bounding estimate of 22 MTHM. In addition, as a result of public comments, Volume 1 of the EIS was enhanced to clarify the relationship between current DOE National Environmental Policy Act actions and this EIS. Likewise, the relationship between the EIS and the Spent Fuel Vulnerability Action Plans was clarified in this EIS. With respect to the naval SNF, Appendix D of Volume 1 was modified to more fully explain the import of naval SNF and to discuss potential effects of terrorist attacks at naval shipyards.

2. PURPOSE AND NEED FOR AGENCY ACTION

DOE, according to the Atomic Energy Act of 1954, as amended, is responsible for developing and maintaining a capability to manage nuclear materials [Atomic Energy Act Sections 11(z), 11(aa), and 11(e)]. During the last four decades, DOE and its predecessor agencies have transported, received, stored, and reprocessed approximately 100,000 MTHM of SNF from various sources, including DOE production reactors; the Naval Nuclear Propulsion Program; DOE, university, and other research and test reactors; special case commercial power reactors; and certain foreign research reactors. Approximately 2,700 MTHM of SNF was not reprocessed and is stored at various locations in the United States and overseas. Approximately 100 MTHM of additional SNF is projected to be received in the next 40 years. This SNF is in a wide range of enrichments, types, and conditions.

The end of the Cold War led DOE to reevaluate the scale of its weapons production, nuclear propulsion, and research missions. In April 1992, the Secretary of Energy directed DOE to phase out reprocessing of SNF for recovery and recycling of plutonium and highly enriched uranium to support the nuclear weapons stockpile. In 1993, a DOE report[a] documented current and potential environmental, safety, and health vulnerabilities regarding existing DOE SNF storage facilities. The report identified locations with degraded fuel cladding integrity and other problems that require action to ensure continued safe storage. As a result of the Secretary's directive and the information in the DOE report, the proposed action is to safely, efficiently, and responsibly manage existing and projected quantities of spent nuclear fuel through the year 2035, pending ultimate disposition.

As part of establishing an effective SNF Management Program, DOE needs to make complex-wide strategic decisions for the management of SNF for the next 40 years, including (a) where to conduct SNF management activities, after evaluating existing and potential locations, (b) the appropriate capabilities, facilities, and technologies for SNF management, and (c) the research and development activities to support the SNF Management Program.

Volume 1 of this EIS focuses on strategies for where to conduct SNF management activities as in (a) above. Decisions on the site-specific and technical implementation of the program, as in (b) and (c) above, would be made after subsequent, tiered National Environmental Policy Act reviews, as appropriate.

a. *Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and Other Reactor Irradiated Nuclear Materials and Their Environmental, Safety and Health Vulnerabilities* (DOE 1993b).

3. ALTERNATIVES

Chapter 3 describes a range of programmatic alternatives for managing the DOE SNF currently stored within the DOE complex and at non-DOE generator sites. These alternatives also address SNF that is projected to be generated through the year 2035. Figure 1-2, given in Chapter 1, identifies locations within the United States where DOE SNF is being generated and stored.

The five alternatives analyzed in Volume 1 of this EIS are summarized in the box to the right. These alternatives, which are consistent with the alternatives under consideration for the DOE Waste Management Programmatic EIS, present a range of programmatic approaches for managing existing and projected SNF inventories. The alternatives involve varying amounts of SNF shipments, levels of fuel stabilization, numbers and types of storage facilities, and the scope of research and development efforts for SNF management technologies.

Summary of Alternatives for the Management of DOE Spent Nuclear Fuel

No Action
Take minimum actions required for safe and secure management of SNF at or close to the generation site or current storage location.

Decentralization
Store most SNF at or close to the generation site or current storage location, with limited shipments to DOE facilities.

1992/1993 Planning Basis
Transport and store newly generated SNF at the Idaho National Engineering Laboratory or Savannah River Site. Consolidate some existing fuels at the Idaho National Engineering Laboratory or at the Savannah River Site.

Regionalization
Distribute existing and projected SNF among DOE sites based primarily on fuel type (Regionalization 4A) or geographic loca ion (Regionalization 4B).

Centralization
Manage all existing and projected SNF inventories at one site until ultimate disposition.

The programmatic action that DOE ultimately selects is not necessarily limited to one of the alternatives presented. A hybrid alternative could, for example, be developed that would incorporate actions from one or more of the five alternatives analyzed. Moreover, the programmatic decisions will not identify all site-specific SNF management options. If appropriate, the decisions would be made after additional site-specific National Environmental Policy Act evaluations.

In developing the alternatives, the need to comply with applicable regulations, permits, and DOE orders was assumed. Under some of the alternatives (for example, No Action and Decentralization), DOE would be required to renegotiate existing commitments to accept SNF from utilities (for example, Fort St. Vrain), domestic research reactor SNF, and potential agreements to accept foreign research reactor SNF. Under all alternatives, actions to resolve outstanding SNF management deficiencies identified and prioritized according to the Defense Nuclear Facilities Safety Board Recommendation 94-1 Implementation Plan would be implemented as appropriate. The Defense Nuclear Facilities Safety Board 94-1 Implementation Plan will be balanced with other factors such as budgetary constraints and public comments. Under all alternatives, DOE would consider ways to reduce costs for the management of SNF.

Some of the alternatives include references to transition periods. These can be defined as the periods of time needed to fully implement the alternative, if selected. Transition periods vary from 3 to 20 years depending on the time required to plan, design, procure, or construct equipment and facilities needed to fully implement the alternative. Activities taking place during transition periods would be similar to anticipated activities associated with one or more of the defined alternatives. Therefore, environmental impacts of transition period activities are bounded by the impacts assessment for the defined alternatives.

The DOE SNF Management Program is intended to (a) provide interim storage and management for SNF at specified locations until ultimate disposition, (b) stabilize the fuel as required for environmentally safe storage and protection of human health (for both workers and the public), (c) increase safe storage capacity, replacing facilities that cannot meet current standards and provide additional capacity for newly generated SNF, (d) conduct research and development initiatives to support safe storage and safe disposal, and (e) examine SNF generated by the Naval Nuclear Propulsion Program. The possible need to convert SNF into a form that meets the acceptance criteria of geologic repositories is beyond the scope of this EIS and will be the subject of future National Environmental Policy Act review.

The planning period for this EIS is 40 years, beginning with the issuance of the Record of Decision (that is, baseline conditions in June 1995) and extending through the year 2035. The 40-year timeframe may be required to make and implement decisions on the ultimate disposition of SNF. Detailed impact analyses are performed for the time period from 1995 to 2005. Normal operation impacts are then projected for the remaining 30 years.

Decisions as a result of this EIS apply to actions taken by DOE and the Navy from the date of the Record of Decision through the interim storage period. At the present time, intersite shipments of DOE SNF have been curtailed. However, limited shipments of SNF from Navy shipyards have occurred during the preparation of the EIS. Shipments from sources such as universities and foreign research reactors needing urgent relief have also occurred. These shipments are in accordance with existing court orders, Federal facility compliance agreements, and Council on Environmental Quality regulations. If the No Action alternative is selected in the Record of Decision, all such shipments would cease after an appropriate transition period.

After considering a number of elements, DOE has identified Regionalization 4A (management by fuel type) as the preferred alternative. DOE arrived at its preferred alternative through a formal decision management process, which included developing screening and performance criteria. Screening criteria are requirements that an alternative must satisfy to be further evaluated; performance criteria are desirable attributes or characteristics that help distinguish the relative merit of each alternative that satisfies the screening criteria. After applying the screening criteria, additional management considerations (technical and nontechnical), discussed below, were used to arrive at the final preferred alternative.

The screening and performance criteria were developed considering the following factors: (a) environmental impact, (b) environmental regulatory compliance, (c) DOE and SNF programmatic missions, (d) public comments, (e) national security mission, (f) cost, and (g) DOE policy.

Each alternative was first evaluated based on the following screening criteria:

- Resolving vulnerabilities consistent with DOE's Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities (DOE 1994a, b, c)
- Complying with all applicable Federal and state environmental laws and regulations, consent orders, and Federal facility agreements
- Maintaining backup capabilities for SNF management to limit interruptions of vital SNF program activities
- Providing the capability for 100 percent examination of naval SNF
- Providing technology development for SNF treatment, storage, and ultimate disposition.

Those alternatives that did not satisfy all of the screening criteria were not considered further, and these were No Action, Decentralization A and B, and Centralization. The remaining alternatives, 1992-93 Planning Basis, Decentralization C, and Regionalization 4A and 4B, met all of the screening criteria. These alternatives were then evaluated based on optimizing overall performance relative to the following performance criteria:

- Minimizing transport of SNF
- Minimizing environmental impact
- Assuring lowest cost consistent with mission accomplishment
- Maximizing support for DOE's National SNF Program to achieve safe storage and preparation for final disposition
- Maximizing DOE's ability to honor new and historical commitments and contracts.

Applying these performance criteria, two of the four remaining alternatives, 1992-93 Planning Basis and Regionalization 4A, rated the highest, so they were determined to be candidates for the preferred alternative. These candidate alternatives were then evaluated against a number of technical and nontechnical considerations, including environmental impact perception, indicated stakeholder preferences, implementation factors, regulatory risk, SNF processing potential, environmental justice, and fairness. This final evaluation resulted in Regionalization 4A being identified as the preferred alternative, because Regionalization 4A better supports a path forward for ultimate disposition of the SNF. Additional information on this alternative can be found in Section 3.1.4.

While the Nevada Test Site is analyzed in this EIS as an alternative site for SNF management activities, DOE did not consider it to be a preferred site for the management of SNF because of the State of Nevada's current role as the host site for the Yucca Mountain Site Characterization Project and the Nevada Test Site's lack of SNF management facilities and high-level waste infrastructure.

The DOE's preferred alternative is consistent with the Navy's preferred alternative to continue to conduct refueling and defueling of nuclear-powered vessels and prototypes, and to transport SNF to the Idaho National Engineering Laboratory for full examination and interim storage, using the same practices as in the past. Details and analyses supporting the Navy's preferred alternative can be found in Appendix D of Volume 1.

The remainder of this chapter is comprised of three sections. Section 3.1 summarizes the alternatives and the implications for each site. Section 3.2 discusses the alternatives eliminated from further evaluation. Section 3.3 provides a brief comparison of the potential environmental impacts associated with each alternative.

3.1 Overview of Alternatives Considered

Section 3.1 and Tables 3-1 through 3-5 discuss the potential actions at each site as a result of implementing each of the alternatives.

Table 3-1. Summary of the No Action alternative.

NO ACTION Take only the actions required for the safe storage and management of SNF at the site.							
Actions	Hanford Site	Idaho National Engineering Laboratory	Savannah River Site	Oak Ridge Reservation	Nevada Test Site	Naval sites	Other locations
Transportation— No shipment to or from site. Onsite movement limited to actions required for safe storage.	No shipment to or from the site. Fuel stored in 105-KE Basin may be transferred to 105-KW Basin. Fuel in PUREX, 308 Building Annex, 324 Building, 325 Building, and 327 Building to be relocated onsite.	No shipment to or from the site. Some naval SNF would be received during a 3-year transition period. After Expended Core Facility closure, onsite movement limited to needs for safe storage.	No shipments to or from the site. Limit onsite transfers to those required for safe storage.	No shipment to or from the site.	No shipment to or from the site.	Shipments to Idaho National Engineering Laboratory during 3-year transition period. Thereafter retained at refueling sites. SNF removed at Newport News, Virginia, transported to Norfolk Naval Shipyard.	No shipments onsite or offsite. Shut down reactors as storage capacity met.
Stabilization— Stabilization activities limited to those *minimum* actions required to store SNF safely.	Fuel in 105-KE to be canned.	Additional canning and characterization capabilities as needed.	Place aluminum-clad fuels that are badly corroded and in danger of cladding failure in containers and return them to wet storage.	Only as required for safe storage.	Not applicable.	None.	Only as required for safe storage at facilities not licensed by the Nuclear Regulatory Commission. As stipulated by license for facilities licensed by Nuclear Regulatory Commission.
Storage— Minimum facility modifications to support safe storage.	Fuel stored in 105-KE and 105-KW Basins Fast Flux Test Facility, T Plant, and 200 Area Low-Level Waste Burial Grounds. Fuel also stored near-term in 308 Building Annex, 324 Building, 325 Building, and 327 Building. No new facilities.	Replace Test Area North storage pool with dry storage facility.	Store fuels in Receiving Basin for Offsite Fuels and in an upgraded reactor basin. Requires no new facilities.	Continued use of existing onsite storage facilities.	Not applicable.	SNF stored in shipping containers at naval sites.	Continued use of existing onsite storage facilities for sites not licensed by Nuclear Regulatory Commission. As stipulated by license for sites licensed by the Nuclear Regulatory Commission.
Research and Development— Research and development underway for DOE SNF management will continue.	Characterization of defense production fuel to support canning.	Ongoing research and development for SNF management continues.	Continue existing SNF-related research and development.	Onsite continues as planned. High Flux Isotope Reactor may be required to shutdown.	Not applicable.	None.	High Flux Beam Reactor may be required to shutdown.
Naval Fuel Examination— Examination will cease.	Not applicable.	Close Expended Core Facility after a transition period.	Not applicable.	Not applicable.	Not applicable.	No examination at storage locations.	Not applicable.

Table 3-2. Summary of the Decentralization alternative.

DECENTRALIZATION Store most SNF close to existing locations with limited SNF shipments to DOE facilities.							
Actions	Hanford Site	Idaho National Engineering Laboratory	Savannah River Site	Oak Ridge Reservation	Nevada Test Site	Naval sites	Other locations
Transportation— Limited SNF shipments.	No shipments to or from the site. All fuel to be relocated onsite.	Some receipt of non-DOE domestic research SNF. Receipt of naval SNF for examination and return. (Option C for Navy). Some onsite transfer for consolidation.	Receive small quantities of aluminum-clad and stainless-steel clad fuels. Limit onsite transfers to those required for safe storage, consolidation, and research and development. Later relocate fuels to new wet or dry storage facility or move aluminum-clad fuels to F- and H-Canyons for processing.	No SNF shipment to or from the site except for research and development activities.	Not applicable.	Option A: Limited offsite shipment. Option B: Limited shipments to Puget Sound. Option C: All SNF transported to Idaho National Engineering Laboratory and returned.	Shipments as required for continued operation for Nuclear Regulatory Commission-licensed facilities. No offsite shipments from DOE facilities.
Stabilization— Stabilization activities.	Fuel in 105-KE to be canned. Defense fuels possibly stabilized by one of three methods.	Canning and characterization facility (Phase I of Dry Fuel Storage Facility).	Can aluminum-clad fuels and place them in wet or dry storage or process existing fuel through F- and H-Canyons. Place stainless steel and zircaloy fuels in wet or dry storage.	As required for safe storage.	Not applicable.	None.	As required for safe storage, by Nuclear Regulatory Commission license, or as planned.
Storage—Facility upgrade/replacement and onsite fuel transfers to support safe storage and to allow onsite consolidation.	Defense production fuel stored in new wet or dry facilities. Shippingport, Fast Flux Test Facility, and miscellaneous fuel stored in new dry facilities.	Upgrade/increase storage capacity. Replacement storage facility for SNF from Test Area North	Store in Receiving Basin for Offsite Fuels and in an upgraded reactor basin until new wet or dry storage facility is built. Requires new receiving and characterization facility, new wet or dry canning facility, and new wet or dry storage facility.	Continued use of existing onsite storage facilities. New interim storage capacity would be added.	Not applicable.	Storage at naval sites. New transport containers, dry storage, or water pools.	Continued use of existing onsite storage facilities New construction as planned.
Research and Development— Treatment technology and research and development activities for DOE SNF management, including stabilization technology.	Evaluation of dry storage for Shippingport, Fast Flux Test Facility, and miscellaneous fuels; research and development on defense production fuel stabilization; characterization of N-Reactor and Single-Pass reactor fuels to determine the feasibility of dry storage.	Electrometallurgical processing using limited quantities of commercial SNF. New technology development facility.	Develop technology (canning and storage design) to store Savannah River Site aluminum-clad fuels in dry storage vault.	Onsite continues as planned.	Not applicable.	None.	Not applicable.
Naval Fuel Examination	Not applicable.	Expended Core Facility phase out under Navy Options A and B.	Not applicable.	Not applicable.	Not applicable.	A: None. B: Limited examinations at Puget Sound Naval Shipyard under Navy Option B. C: Full.	Not applicable.

Table 3-3. Summary of the 1992/1993 Planning Basis alternative.

1992/1993 PLANNING BASIS Transport and store newly generated SNF at the Idaho National Engineering Laboratory or Savannah River Site. Consolidate some existing fuels at the Idaho National Engineering Laboratory.							
Actions	Hanford Site	Idaho National Engineering Laboratory	Savannah River Site	Oak Ridge Reservation	Nevada Test Site	Naval sites	Other locations
Transportation—1992/1993 planning basis implemented	Transport 0.04 MTHM of TRIGA fuel to the Idaho National Engineering Laboratory in four shipments. All other fuel to be relocated onsite.	Receipt of some foreign SNF. Receipt of Fort St. Vrain and West Valley SNF. Naval SNF to Idaho National Engineering Laboratory for examination and then storage at Idaho Chemical Processing Plant. Receipt of non-DOE SNF/domestic research SNF. Some onsite SNF movement.	Receive small quantities of aluminum-clad and stainless steel-clad fuels. Limit onsite transfers to those required for safe storage, consolidation, and research and development. Later relocate fuels to new wet or dry storage facility, or move aluminum-clad fuels to F- and H-Canyon for processing.	No SNF shipments to the site except for research and development activities. SNF shipments to other DOE facilities as planned.	Not applicable.	Transport all SNF to Idaho National Engineering Laboratory.	SNF shipments to DOE facilities as planned.
Stabilization—Stabilization activities as planned.	Fuel in 105-KE to be canned. Defense fuels possibly stabilized by one of three methods.	Canning and characterization facility.	Can aluminum-clad fuels and place them in wet or dry storage or process existing fuel through F- and H-Canyons. Place stainless steel and zircaloy fuels in wet or dry storage.	As required for safe storage or as planned.	Not applicable.	None.	As required for safe storage by Nuclear Regulatory Commission license or as planned.
Storage—Facility upgrade/replacement and increased storage capacity as planned.	Defense production fuel stored in new wet or dry facilities. Shippingport, Fast Flux Test Facility, and miscellaneous fuel stored in new dry facilities.	Upgrade/increase storage capacity. Replacement storage facility for SNF from Test Area North. Increased rack capacity in storage pools.	Store fuels in Receiving Basin for Offsite Fuels and in an upgraded reactor basin until new wet or dry storage facility is built. Requires new receiving and characterization facility, new wet or dry canning facility and new wet or dry storage facility.	Continued use of existing onsite storage facilities. New construction as planned. Maintain option for acquiring dry storage facilities.	Not applicable.	None.	Continued use of existing onsite storage facilities. New construction as planned.
Research and Development—Treatment technology and research and development activities for DOE SNF management and disposal as planned.	Evaluation of dry storage for Shippingport, Fast Flux Test Facility, and miscellaneous fuels; research and development on defense production fuel stabilization; characterization of N-Reactor and Single-Pass reactor fuels to determine the feasibility of dry storage.	Electrometallurgical processing using limited quantities of commercial SNF. New technology development facility.	Develop technology (canning and storage design) to store Savannah River Site aluminum-clad fuels in dry storage vault. Research and pilot-scale operations to determine best technology for ultimate disposition of aluminum-clad fuels.	Onsite continues as planned.	Not applicable.	None.	Not applicable.
Naval Fuel Examination	Not applicable.	Full examination at Idaho National Engineering Laboratory.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Not applicable.

Table 3-4. Summary of the Regionalization alternative.

REGIONALIZATION Distribute existing and projected SNF among DOE sites based on fuel type (Regionalization 4A) or geographic location (Regionalization 4B).							
Actions	Hanford Site	Idaho National Engineering Laboratory	Savannah River Site	Oak Ridge Reservation	Nevada Test Site	Naval sites	Other locations
Transportation— Distribute existing and projected SNF to three DOE sites (Regionalization 4A) or two DOE sites (Regionalization 4B).	Regionalization 4A: Defense production fuel to be relocated onsite. All fuel except defense production fuel transported offsite. Regionalization 4B: All fuel to be relocated onsite. Receive in a new facility all fuels from generators west of the Mississippi River (if Western Regional Site); transport all fuels to Western Regional Site (if not Western Regional Site).	Regionalization 4A: Receive naval, TRIGA, and nonaluminum fuels. Regionalization 4B: Receive all fuels from generators west of the Mississippi River (If Western Regional Site); transport all fuels to Western Regional Site (if not Western Regional Site); Receive naval SNF if selected for Expended Core Facility site.	Regionalization 4A: Receive aluminum-clad fuel from DOE and non-DOE sites. Transport stainless steel and zircaloy fuel to Idaho National Engineering Laboratory. Utilize new wet or dry storage facilities, or move aluminum-clad fuels to F- and H-Canyon for processing. Regionalization 4B: Receive all fuels from generators east of the Mississippi River (if Eastern Regional Site); transport all fuels to Oak Ridge Reservation (if not Eastern Regional Site); Receive naval SNF if selected for Expended Core Facility site.	Regionalization 4A: Transport all aluminum-clad SNF to Savannah River Site, and all other SNF to the Idaho National Engineering Laboratory. Regionalization 4B: Receive all fuel from generators east of the Mississippi River (if Eastern Regional Site) and naval SNF (if selected). Transport all SNF to designated site if not selected.	Regionalization 4A: Not applicable. Regionalization 4B: Receive all fuel from generators west of the Mississippi River (if Western Regional Site) and naval SNF (if selected).	Regionalization 4A: Transport all SNF to Idaho National Engineering Laboratory. Regionalization 4B: Transport all SNF to either Eastern or Western Regional Site depending on location for Expended Core Facility.	Regionalization 4A or 4B: Transport fuel to Eastern or Western Regional Site as appropriate.
Stabilization— Fuels to be retained at existing DOE sites would be stabilized as planned. For fuel to be transported to regional site, any stabilization beyond that required for transportation would be performed at the regional site.	Fuel in 105-KE to be canned. Defense fuels possibly stabilized by one of three methods or stabilized for transporting offsite.	Canning and characterization facility needed for stabilization. Regionalization 4A: Requires receipt facility. Regionalization 4B: Requires transporting facility (if not Western Regional Site).	Regionalization 4A: Can aluminum-clad fuels and place them in wet or dry storage; or process existing fuel through F- and H-Canyons. Regionalization 4B: Can aluminum-clad fuels and place them in wet or dry storage or process them through F- and H-Canyons. Place nonaluminum-clad fuels in wet or dry storage.	Regionalization 4A: As required for shipment. Regionalization 4B: As required for receipt and storage. Same as Regionalization 4A if not selected as Eastern Regional Site.	Regionalization 4A: Not applicable. Regionalization 4B: As required for receipt and storage. Same as Regionalization 4A if not selected as Western Regional Site.	None.	Regionalization 4A or 4B: As required for shipment.
Storage— Facility upgrade/ replacement and onsite fuel transfers to support safe storage and to allow onsite consolidation.	Regionalization 4A: Defense production fuel stored in new wet or dry facilities. Regionalization 4B: All fuel stored in new wet or dry facilities if Western Regional Site.	Upgrade/increase capacity, as required, as applicable for Regionalization 4A or 4B. Replacement storage facility for Test Area North SNF.	Regionalization 4A: Store fuel in Receiving Basin for Offsite Fuels and in an upgraded reactor basin. Requires new receiving and characterization facilities, and new canning facilities. Regionalization 4B: Store fuels in Receiving Basin for Offsite Fuel in a reactor basin until new storage facility is built.	Regionalization 4A: continued use of existing onsite storage facilities. Maintain option for acquiring dry storage facilities. Regionalization 4B: Construction of new facilities necessary for inventories. Same as Regionalization 4A if not selected as Eastern Regional Site.	Regionalization 4A: Not applicable. Regionalization 4B: Construction of new facilities necessary for inventories if selected as Western Regional Site.	None.	Regionalization 4A or 4B: Continued use of existing onsite storage facilities

Table 3-4. (continued).

REGIONALIZATION Distribute existing and projected SNF among DOE sites based on fuel type (Regionalization 4A) or geographic location (Regionalization 4B).							
Actions	Hanford Site	Idaho National Engineering Laboratory	Savannah River Site	Oak Ridge Reservation	Nevada Test Site	Naval sites	Other locations
Research and Development—Treatment technology and research and development activities for DOE SNF management, including stabilization technology.	Regionalization 4A: Research and development on defense production fuel stabilization; characterization of N-Reactor and Single-Pass reactor fuels to determine the feasibility of dry storage. Regionalization 4B: Activities listed above for Regionalization 4A, plus, if selected for the Western Regional Site: new technology development facility; additional research and development as needed for DOE SNF management and ultimate disposition of SNF.	Regionalization 4A and as applicable under Regionalization 4B: Electrometallurgical processing using limited quantities of commercial SNF. New technology development facility; additional research and development as needed for DOE SNF management and ultimate disposition of SNF. Regionalization 4B: If not, Western Regional Site, research and development activities phased-out.	Regionalization 4A: Develop technology (canning and storage design) to store aluminum-clad fuels in dry storage vault. Research to determine best technology for ultimate disposition of aluminum-clad fuels. Regionalization 4B: Develop technology (canning and storage design) to store aluminum-clad fuels in dry storage vault. Develop technology for storage of nonaluminum-clad fuels. Research to determine best technology for ultimate disposition of fuels.	Regionalization 4A: Onsite continues as planned. Regionalization 4B: Build research and development facility. Same as Regionalization 4A if not selected as Eastern Regional Site.	Regionalization 4A: Not applicable. Regionalization 4B: Build research and development facility. Same as Regionalization 4A if not selected as Western Regional Site.	None.	Not applicable.
Naval Fuel Examination	Regionalization 4A: Not applicable. Regionalization 4B: Full examination if selected as site for Expended Core Facility.	Regionalization 4A: Full examination. Regionalization 4B: Full examination if selected as site for Expended Core Facility.	Regionalization 4A: Not applicable. Regionalization 4B: Full examination if selected as site for Expended Core Facility.	Regionalization 4A: Not applicable. Regionalization 4B: Full examination if selected as site for Expended Core Facility.	Regionalization 4A: Not applicable. Regionalization 4B: Full examination if selected as site for Expended Core Facility.	Regionalization 4A or 4B: Not applicable.	Regionalization 4A or 4B: Not applicable.

Table 3-5. Summary of the Centralization alternative.

CENTRALIZATION
A.Hanford Site
B.Idaho National Engineering Laboratory
C.Savannah River Site
D.Oak Ridge Reservation
E.Nevada Test Site

Manage all existing and projected SNF inventories from DOE and the Navy at one site until ultimate disposition.

Actions	Hanford Site	Idaho National Engineering Laboratory	Savannah River Site	Oak Ridge Reservation	Nevada Test Site	Naval sites	Other locations
Transportation— Existing SNF transported to the centralized site.	Option A: Receive all SNF. Requires facility for receipt and handling of fuel. All Hanford Site fuel to be relocated onsite Options B, C, D, and E: Transport all Hanford Site SNF to the central site.	Option B: Receive all SNF. Options A, C, D, and E: Transport all Idaho National Engineering Laboratory SNF to the central site.	Option C: Receive all SNF. Options A, B, D, and E: Transport all Savannah River Site SNF to the central site.	Option D: Receive all SNF. Options A, B, C, E, F: Transport Oak Ridge Reservation SNF to the central site.	Option E: Receive all SNF. Options A, B, C, D: Not applicable	Transport all SNF to: Option A: Hanford Site Option B: Idaho National Engineering Laboratory Option C: Savannah River Site Option D: Oak Ridge Reservation Option E: Nevada Test Site	Options A through E: Transport all fuel to central site as appropriate.
Stabilization— Fuels at existing DOE sites would be stabilized before shipment. Other SNF would be stabilized as required at the centralization site.	Option A: Requires facility for handling and receipt of fuel. Fuel in 105-KE to be canned. Defense fuels possibly stabilized by one of three methods. Options B, C, D, and E: Requires facility for stabilizing and transporting fuel.	All Options: Canning and characterization facility needed for stabilization. Option B: Require facility for receipt and storage. Options A, C, D, and E: Require transporting facility.	Options A, B, D, and E: Can all SNF before shipment. Option C: Can aluminum-clad fuels and place them in wet or dry storage; or process existing fuel through F- and H-Canyons. Characterize fuel received from offsite.	Options A through C and E: As required for shipment. Option D: As required for receipt and storage.	Options A through D: As required for shipment. Option E: As required for receipt and storage.	None.	Options A through E: As required for shipment.
Storage— New facilities for SNF management.	Option A: Requires new storage facilities. Options B, C, D, and E: Phase out of storage facilities.	Option B: Requires new storage facilities. Options A, C, D, and E: Phase out storage facilities.	Options A, B, D, and E: Store existing aluminum-clad fuel in renovated Receiving Basin for Offsite Fuel and stainless-steel and zircaloy-fuel in an upgraded reactor basin until characterization and shipment offsite. Requires new fuel characterization facility. Option C: Store aluminum-clad fuel in Receiving Basin for Offsite Fuels and store zircaloy-clad and stainless steel-clad fuels in reactor basin until new storage facilities are available. Store fuel shipments in new storage facility. Requires new receiving, and characterization and canning facilities.	Option D: Construction of new facilities necessary for inventories. Options A through C and E: Use of existing onsite storage facilities. Maintain option for acquiring dry storage facilities.	Option E: Construction of new facilities necessary for inventories. Options A through D: Not applicable.	None.	Options A through E: Continued use of existing onsite storage facilities.

Table 3-5. (continued).

CENTRALIZATION A.Hanford Site B.Idaho National Engineering Laboratory C.Savannah River Site D.Oak Ridge Reservation E.Nevada Test Site Manage all existing and projected SNF inventories from DOE and the Navy at one site until ultimate disposition.							
Actions	**Hanford Site**	**Idaho National Engineering Laboratory**	**Savannah River Site**	**Oak Ridge Reservation**	**Nevada Test Site**	**Naval sites**	**Other locations**
Research and Development—Treatment technology and research and development activities for DOE SNF management and disposal occurs at the centralization site.	Option A: Research and development needed for DOE SNF management and ultimate disposition of SNF. New technology facility. Options B, C, D, and E: Research and development on defense production fuel stabilization and feasibility for canning and dry storage.	Option B: Electrometallurgical processing using limited quantities of commercial SNF. New technology facility. Research and development needed for DOE SNF management and disposal of SNF. Options A, C, D, and E: Research and development ceases	Option C: Develop technology (canning and storage design) to store Savannah River Site aluminum-clad fuels in dry storage vault. Research and development and pilot-scale operations to determine best technology for ultimate disposition of SNF. Options A, B, D, and E: Develop technology to stabilize and transport corroded aluminum-clad fuel.	Option D: Build research and development facility. Options A through C and E: Onsite continues as planned.	Option E: Build research and development facility. Options A through D: Not applicable.	None.	Not applicable.
Naval Fuel Examination	Option A: Expended Core Facility developed. Full examination. Options B, C, D, and E: Not applicable.	Option B: Expended Core Facility continues operation. Options A, C, D, and E: Expended Core Facility phased-out.	Option C: Expended Core Facility developed. Full examination. Options A, B, D, and E: Not applicable.	Option D: Build Expended Core Facility. Full examination. Options A through C and E: Not applicable.	Option E: Build Expended Core Facility. Full examination. Options A through D: Not applicable.	Not applicable.	Options A through E: Not applicable.

3.1.1 No Action

> **No Action Alternative**
>
> **Take minimum actions required for safe and secure management of SNF at or close to the generation site or current storage location.**
>
> - **After an approximate 3-year transition period, no transport of SNF to or from DOE facilities would occur.**
> - **Stabilization activities would be limited to the minimum actions required to safely store SNF.**
> - **Naval reactor SNF would be stored at naval sites.**
> - **Facility upgrade/replacement and onsite fuel transfers would be limited to those necessary for safe interim storage.**
> - **Existing research and development activities would continue.**

The No Action alternative is an alternative required under the Council on Environmental Quality regulations for implementing the National Environmental Policy Act of 1969. Under the No Action alternative, DOE would limit actions to the minimum necessary for safe and secure management of SNF at the generation site or current storage location. Under this alternative, small and large DOE sites, naval sites, university and other non-DOE domestic reactors, and foreign research reactors would all independently manage their SNF onsite. Generally, after an appropriate transition period SNF shipments between sites for management purposes would be discontinued, including those SNF shipments currently allowed by court orders and Federal facility compliance agreements. Figure 3-1 indicates SNF inventories. The technology development activities related to SNF management, limited to activities already approved, would continue within DOE. Figure 3-1 also shows the distribution of fuel from 1995 through 2035.

The following subsections highlight actions associated with the No Action alternative at the sites being considered for SNF management.

3.1.1.1 Hanford Site. Under the No Action alternative at the Hanford Site, only those actions deemed necessary for the continued safe and secure management of the SNF would be carried out. Thus, the existing SNF would be maintained close to its current storage locations and there would be minimal facility upgrades. Activities required to safely store SNF would continue.

Specific actions proposed for the near term include proceeding with the characterization of defense production reactor fuel to establish safe interim storage limits, containerizing the fuel in the 105-KE reactor basin by 1998, procuring the first 10 dry storage casks for the Fast Flux Test Facility, transferring SNF to dry cask storage if required for safety reasons (with emphasis on Fast Flux Test Facility fuel now stored in liquid sodium), and possibly consolidating SNF from defense production at the 105-KW reactor basin.

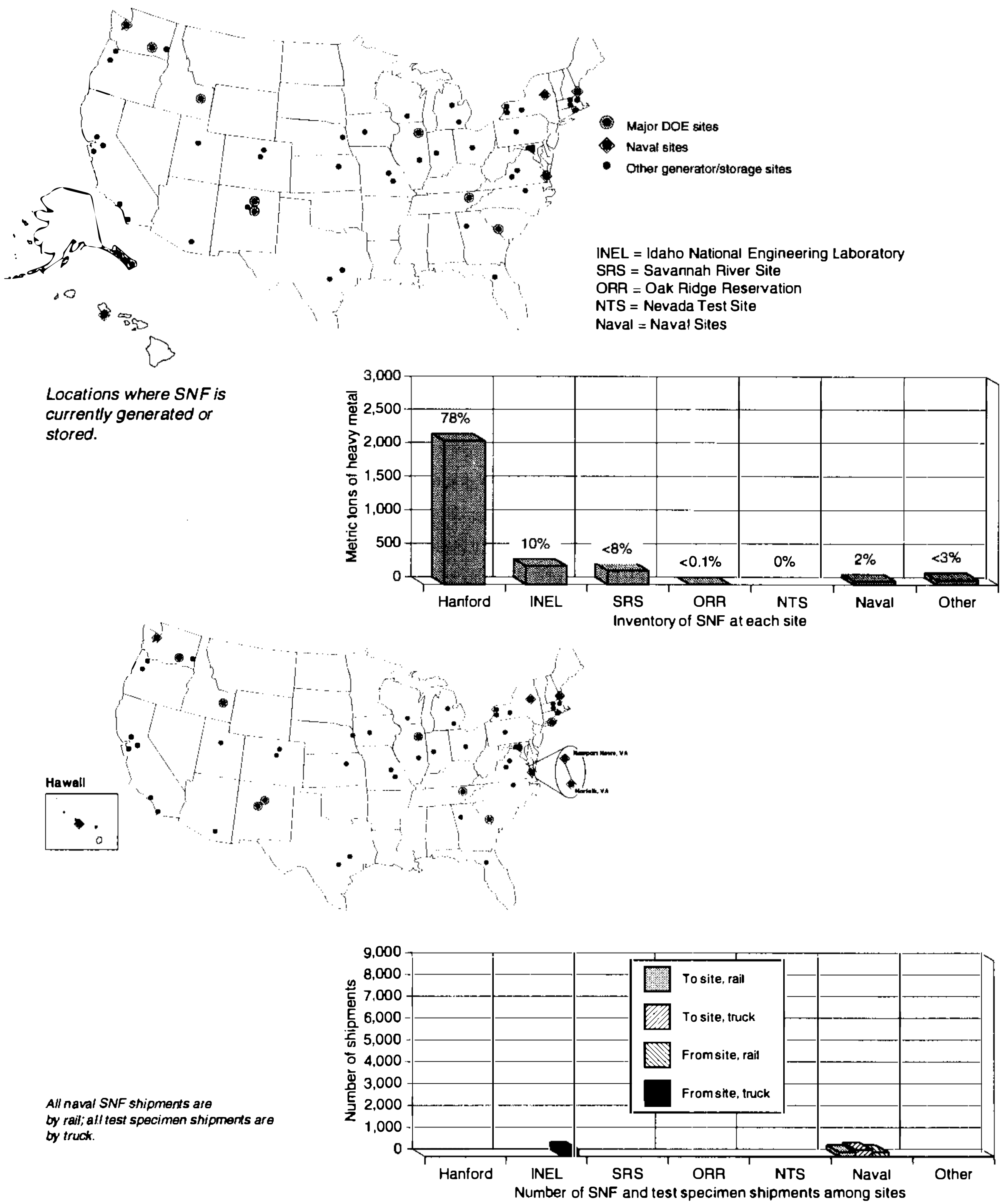


Figure 3-1. Spent nuclear fuel distribution, location, and inventory for the No Action alternative.

No new facilities are planned under the No Action alternative.

3.1.1.2 Idaho National Engineering Laboratory. For the No Action alternative, DOE would maintain SNF close to defueling or current storage locations with minimal facility upgrades or replacements. The Idaho National Engineering Laboratory would neither receive nor transport SNF except for naval SNF during a transition period of about 3 years (see Section 3.1.1.6). After the transition period, naval SNF would not be transferred to the Idaho National Engineering Laboratory, and the Expended Core Facility at the Idaho National Engineering Laboratory would be shut down. DOE would continue to transfer onsite SNF to the Idaho Chemical Processing Plant until the existing storage capacity is used.

DOE would continue operating existing SNF-related facilities at the Idaho National Engineering Laboratory. Because of the deteriorated condition of some of the fuel stored underwater in the CPP-603 Underwater Fuel Storage Facility, additional characterization and canning capabilities would be necessary to stabilize the fuel for safe transport and subsequent storage. DOE has scheduled the installation and operation of new fuel characterization and canning equipment in the Irradiated Fuel Storage Facility by late 1995 to provide these capabilities. DOE would perform other required stabilization of SNF at the Idaho National Engineering Laboratory in either the Remote Analytical Laboratory or the Fluorinel Dissolution Process Hot Cell. DOE would not start any new projects to increase SNF interim storage capacity.

SNF research and development would be limited. Existing SNF management research and development projects would continue, but the development of technology for the ultimate disposition of SNF would cease. Existing facilities, such as the Process Improvement Facility, the Remote Analytical Laboratory, and the Pilot Plant Facility, would support continuing research and development work.

3.1.1.3 Savannah River Site. For the No Action alternative, DOE would use the existing Savannah River Site facilities for extended wet storage of its current SNF inventories. The Savannah River Site would not transport any SNF offsite and would not receive any SNF. Only onsite consolidation and rearrangement would take place. DOE would temporarily move fuel currently on the Savannah River Site among facilities to accommodate facility upgrades.

Six Savannah River Site facilities are used for the storage of SNF: the Receiving Basin for Offsite Fuel, K-Reactor Disassembly Basin, L-Reactor Disassembly Basin, P-Reactor Disassembly Basin, F-Canyon, and H-Canyon. Most of the fuel is located in the Receiving Basin for Offsite Fuel, the L-Reactor Disassembly Basin, and the F-Canyon. DOE would accomplish onsite transfers as required to ensure the safety of aluminum-clad fuel. The Receiving Basin for Offsite Fuels and an upgraded reactor basin would be utilized for continued storage of this fuel. Additionally, DOE would place the aluminum-clad fuel, which is degrading because of corrosion, in containers to minimize the spread of radioactive material in the pools in case the cladding is breached. DOE would continue existing SNF-related research and development.

3.1.1.4 Oak Ridge Reservation. Under the No Action alternative, the Oak Ridge National Laboratory, which is on the Oak Ridge Reservation, would generate and store SNF as a result of reactor research activities. No SNF would be transported to the Oak Ridge Reservation, and no SNF would be transported offsite. SNF would be stabilized, as necessary, to ensure safe storage. Oak Ridge Reservation research and development activities would continue as planned except that the alternative could lead to the shutdown of the High Flux Isotope Reactor as a result of filling the existing SNF storage capacity. Additional SNF management planning is not expected to be required for the Bulk Shielding Reactor or the Oak Ridge Research Reactor through the year 2035. It is anticipated that the fuel now stored in the Tower Shielding Reactor No. II core would be moved to the Y-12 area at the Oak Ridge Reservation for interim storage. If this is not possible, additional storage space or cessation of reactor operations may be required after 2005. If the Advanced Neutron Source becomes operational in 2005, additional SNF interim storage space may be required.

3.1.1.5 Nevada Test Site. The Nevada Test Site does not generate or store any SNF and would not receive any SNF under the No Action alternative. Therefore, this alternative does not affect the Nevada Test Site.

3.1.1.6 Naval Nuclear Propulsion Program. Under the No Action alternative, naval reactors would continue to be defueled and refueled as planned. In accordance with normal practices, the spent fuel would be removed from the ships (or prototypes) and placed into shipping containers. No action would be needed to prepare the naval SNF for storage because of its corrosion resistance, high integrity, and strength. The SNF would be stored in this condition at a location near the defueling site. Naval SNF from ships defueled or refueled at Newport News Shipbuilding, a private shipyard located in Newport News, Virginia, would be transported to the Norfolk Naval Shipyard, in Portsmouth, Virginia, which is the nearest naval site.

Under this alternative, examination of naval SNF would ultimately cease. A transition period of approximately 3 years would be required to procure sufficient shipping containers to store naval SNF being removed by ongoing defueling or refueling. During this period, naval SNF would continue to be transported to the Idaho National Engineering Laboratory for detailed examination and storage. After the transition period, naval SNF would no longer be transported to the Idaho National Engineering Laboratory for examination and subsequent storage; the SNF removed from naval reactors would remain for storage at the naval sites. In addition, the Expended Core Facility at the Idaho National Engineering Laboratory would be shut down.

3.1.1.7 Other Generator/Storage Locations. Under the No Action alternative, the SNF generated and/or stored at DOE research and non-DOE research reactors and other locations would not be transported offsite. For the purposes of this analysis, it is assumed that SNF from foreign research reactors would not be transported to the United States under this alternative. DOE research reactors with adequate storage capacity could continue operating as planned. If the onsite storage capacity is inadequate or cannot be expanded, new plans would have to be considered, including potential cessation of reactor operations after storage capacity limits are reached.

The No Action alternative would also affect the management of SNF from nuclear power plants that DOE is obligated to store. For this alternative, the SNF would remain at these sites. Stabilization would be performed, as necessary, to ensure safe storage. Loss of access to the Idaho National Engineering Laboratory for storage of its SNF has already resulted in the construction of new onsite SNF storage at Fort St. Vrain. Therefore, implementation of the No Action alternative would have no additional impact on the management of SNF at Fort St. Vrain.

3.1.2 Decentralization

> **Decentralization Alternative**
>
> **Store most SNF at or close to the generation site or current storage location, with limited shipments to DOE facilities.**
>
> - DOE SNF shipments would be limited to the following:
>   - SNF stored or generated at universities and non-DOE facilities
>   - Potential foreign research reactor fuel.
> - SNF processing might need to be conducted. Other forms of stabilization might occur to provide for safe storage and/or transport.
> - Some facilities would be upgraded/replaced and additional storage capacity required by the alternative would be constructed.
> - Onsite fuel transfers would occur for improved safe storage.
> - Research and development activities would be undertaken for SNF management, including stabilization technology.
> - Three options for naval fuel
>   - No inspection—fuel remains close to refueling/defueling site
>   - Limited inspection at Puget Sound Naval Shipyard
>   - Full inspection at the Idaho National Engineering Laboratory followed by storage close to refueling/defueling site.

Under the Decentralization alternative, DOE would (a) maintain existing SNF in storage at current locations, and (b) store new SNF at or near the site of generation, thereby reducing the amount of fuel transported before a decision on ultimate disposition. This alternative differs from the No Action alternative by slightly increasing shipments to DOE sites and developing or upgrading facilities. Table 3-2 summarizes the basic actions at each site under this alternative. Actions that would improve management of SNF would be undertaken. SNF processing and research and development would be performed. Fuel may be transported for safety or research and development purposes. Figure 3-2 identifies the movement of fuel from 1995 through 2035 under this alternative. SNF from non-DOE locations would be transported to one of the major existing sites for management. SNF managed by DOE would remain at its current location until a decision on final disposition is made. The Navy has evaluated three options for SNF management under this alternative, based on the amount of examination that would be performed on the SNF. In general, naval SNF would be stored at the defueling site. SNF from Newport News Shipbuilding would be transferred to the Norfolk Naval Shipyard.

3.1.2.1 Hanford Site. Under the Decentralization alternative, the near-term activities at the Hanford Site include those activities identified under the No Action alternative, as well as substantial facility development and upgrades, and SNF processing research and development. In addition to the three principal activities identified for the No Action alternative (that is, fuel characterization, fuel canning, and cask procurement for Fast Flux Test Facility fuel), the following general activities would also occur: evaluating wet and dry storage methods for defense production N-Reactor and Single-Pass Reactor fuel; evaluating dry storage methods for other fuels (Shippingport Core II, Fast Flux Test Facility, miscellaneous); conducting extensive research and development on defense

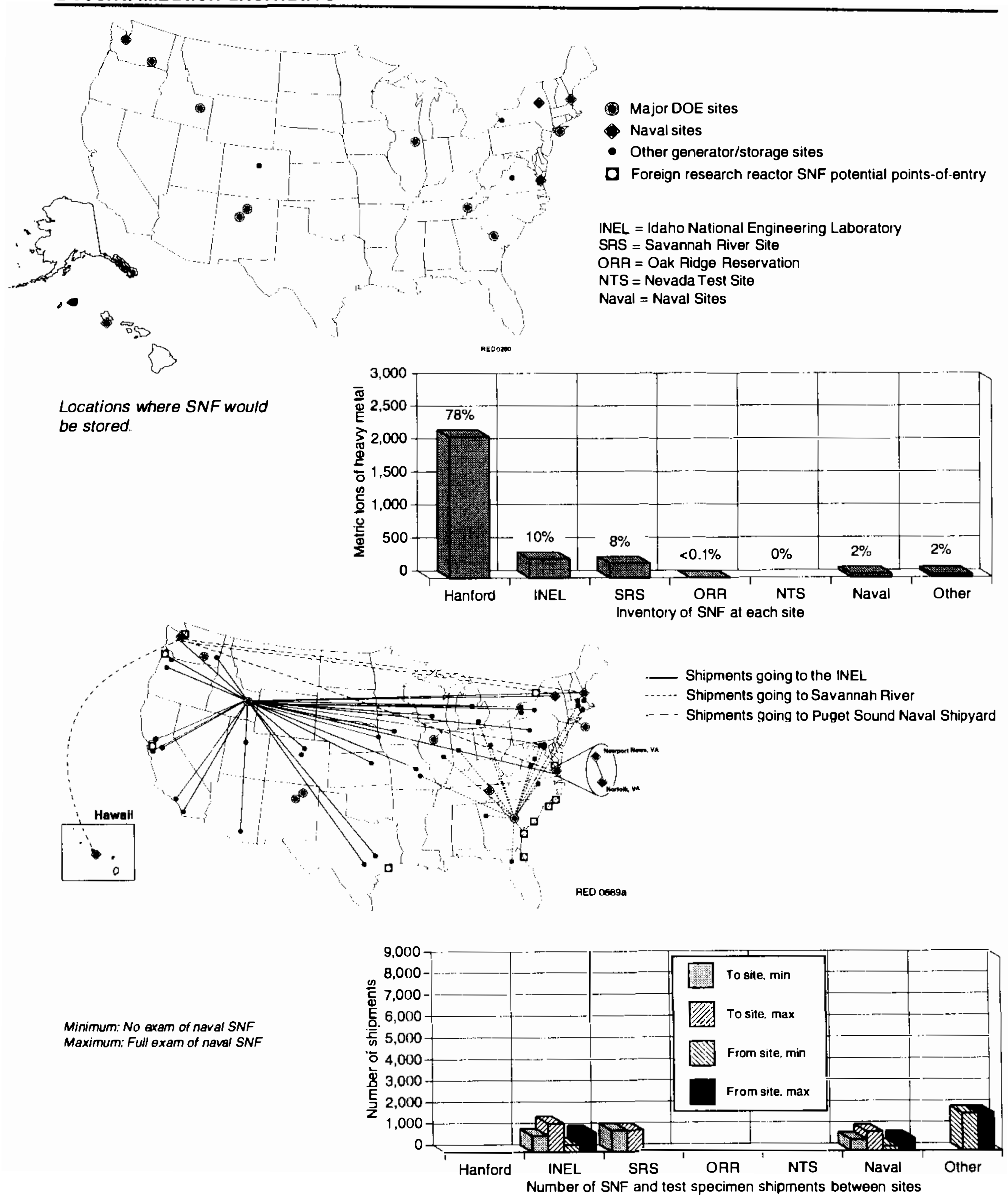


Figure 3-2. Spent nuclear fuel distribution, location, and inventory for the Decentralization alternative.

production SNF stabilization techniques; and constructing and using wet and/or dry storage facilities and possibly a stabilization facility. In response to public comment, this alternative also includes the option to process defense production SNF at an overseas facility. A discussion of this option is provided in Volume 1, Appendix A, Attachment B.

The Hanford Site would not transport SNF to or receive SNF from offsite locations, unless the option to process defense production SNF at an overseas facility is selected. Local transport of fuel would occur to support safety requirements, improved SNF management, and research and development activities.

Combinations of wet and dry storage would be considered. Either a new wet storage facility or dry casks or vault-type dry storage would be needed to replace existing facilities. Dry storage of defense production SNF would require a new stabilization facility. Because of substantial chemical and physical differences between defense production fuels and the nondefense fuels, it is possible that separate storage facilities would be built. Additional National Environmental Policy Act documentation would be prepared before selecting this option.

3.1.2.2 Idaho National Engineering Laboratory. Under the Decentralization alternative, the Idaho National Engineering Laboratory would accept limited shipments of SNF for storage, including SNF from some domestic research reactors and some foreign research reactors. Some onsite transfers would also be conducted. DOE would manage the existing SNF at the Idaho National Engineering Laboratory, such as the naval SNF at the Naval Reactors Facility and the SNF in underwater pools, to accomplish safe and secure interim storage until ultimate disposition.

DOE would use the characterization and canning equipment described for the No Action alternative to stabilize SNF removed from the CPP-603 Underwater Fuel Storage Facility for interim SNF storage. DOE would transfer the SNF in the CPP-603 Underwater Fuel Storage Facility to the Fuel Storage Area by the year 2000. DOE would continue to use the Underground Storage Facility and the Irradiated Fuel Storage Facility for existing SNF inventory and transfers of other SNF based on safety analyses. DOE would upgrade or increase fuel storage capacity at the Idaho National Engineering Laboratory, as required.

The Idaho National Engineering Laboratory would conduct various research and development activities, including laboratory and pilot-plant testing, continued repository performance assessments and acceptance criteria development, and the characterization of SNF.

The Idaho National Engineering Laboratory would examine different amounts of naval SNF, depending on the option selected for the Navy Nuclear Propulsion Program (see Section 3.1.2.6). Under two of the three options, the Expended Core Facility would ultimately be shut down. As with the No Action alternative, each of the options for naval fuel would require a transition period.

During this transition period, SNF would be transported in shipping containers to the Expended Core Facility for examination and then to the Idaho Chemical Processing Plant for storage.

3.1.2.3 Savannah River Site. The near-term fuel transfer and consolidation activities at the Savannah River Site for the Decentralization alternative would be similar to those under the No Action alternative, except that the site would receive limited SNF shipments from other locations. The Savannah River Site would receive research and test reactor fuel from some domestic and perhaps some foreign research reactors. This SNF would consist primarily of aluminum-clad fuel elements and some stainless steel and zircaloy fuel elements.

Fuel would continue to be stored in the Receiving Basin for Offsite Fuels and in an upgraded reactor basin until it is either canned, placed in wet or dry storage, or is processed. The processing option represented for evaluation in the EIS consists of processing existing Savannah River Site aluminum-clad fuel using existing chemical separations facilities (that is, F- and H-Canyons) and storing the current inventory of stainless-steel-clad and zirconium-clad fuel as well as future receipts of aluminum-clad SNF. This option is analyzed because DOE has data from past processing that can be used for analyses. The impacts from this technology are representative of other processing technology options that may be considered in the future. Other processing options, such as processing all SNF or processing coupled with vitrification, are also feasible and would be analyzed as part of the site-specific National Environmental Policy Act documentation needed to implement any option for this alternative.

The Decentralization alternative would require a new fuel characterization facility, a new wet or dry canning facility, and a new wet or dry storage facility. The Savannah River Site would evaluate wet and dry storage and processing options because (as in the No Action alternative) interim wet storage of the fuel elements without canning could cause corrosion and cladding failures. The Savannah River Site would initiate projects to design characterization, canning, and dry storage facilities for aluminum-clad fuels. Ongoing SNF research would continue at the site.

3.1.2.4 Oak Ridge Reservation. Under the Decentralization alternative, the Oak Ridge National Laboratory would generate and store SNF from reactor research activities. No SNF would be transported to the Oak Ridge Reservation except for small amounts associated with research and development activities (for example, from Sandia National Laboratories). No SNF would be transported offsite. SNF would be stabilized, as necessary, to provide safe storage. Research and development activities at the Oak Ridge Reservation would continue as planned. Because the interim storage capacity for SNF at the Oak Ridge Reservation is limited, new interim storage capacity would be added. The amount of SNF in interim storage would not increase substantially.

3.1.2.5 Nevada Test Site. Under the Decentralization alternative, the Nevada Test Site would not generate or store any SNF and would not receive any SNF. Therefore, this alternative is not applicable to the Nevada Test Site.

3.1.2.6 Naval Nuclear Propulsion Program. The Decentralization alternative at the naval sites is similar to the No Action alternative because naval reactors would continue to be defueled and refueled as planned, and the fuel would generally be stored at or near the defueling site. No action would be needed to prepare the naval SNF for storage because of its corrosion resistance, high integrity, and strength. A transition period would be required while the necessary interim storage capabilities could be procured and developed at the naval sites. During this period, naval SNF would continue to be transported to the Expended Core Facility for examination and subsequent interim storage at the Idaho National Engineering Laboratory. The principal difference from the No Action alternative is that the options for interim storage would be selected from shipping containers, dry storage casks, and wet storage in water pools. Another important difference is that examination of naval fuel would be possible.

Under this alternative, the Navy has three options, which vary by the amount of detailed examination that could be performed on the naval SNF:

- Option A, No Examination—Interim storage of naval SNF at the naval site of origin without any detailed examination, except during the 3-year transition period when naval SNF would continue to be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for detailed examination and preparation for storage at the Idaho Chemical Processing Plant.

- Option B, Limited Examination—Transport approximately 10 percent of the naval SNF to the Puget Sound Naval Shipyard where the existing water pool, designed to support aircraft carrier refuelings, would be modified to enable limited examination of certain high-priority SNF. Use of this water pool for examination would preclude the performance of aircraft carrier refueling work at the shipyard.

- Option C, Full Examination—Transport naval SNF to the Expended Core Facility for full examination and then return the fuel to the naval or DOE facility near the site of origin for storage.

For Option A, the Expended Core Facility at the Idaho National Engineering Laboratory would be shut down after the transition period. For Option B, the water pool facility at the Puget Sound Naval Shipyard would be modified to support SNF examinations and, upon completion, the Expended Core Facility would be shut down. It would not be possible to perform aircraft carrier refuelings at the Puget Sound Naval Shipyard if this option were selected. Under Options A and B, examinations of SNF would be either terminated or severely decreased. Under Option C, the Expended Core Facility would continue to operate, and planned Expended Core Facility improvements, including construction of the dry cell, would be completed.

3.1.2.7 Other Generator/Storage Locations. The Decentralization alternative for other generators and storage locations is similar to the No Action alternative because offsite transport of SNF would be allowed in limited amounts for continued operation. Thus, both DOE and non-DOE research reactors would be allowed to transport SNF offsite, as necessary. Additional SNF interim storage facilities at domestic research reactors would not be required. For this alternative, SNF currently stored at the West Valley Demonstration Project, Babcock & Wilcox Research Center, and the Fort St. Vrain power plant would remain at these sites. As identified in the No Action alternative, loss of access to the Idaho National Engineering Laboratory for storage of its SNF has already resulted in the construction of new onsite SNF storage at Fort St. Vrain. Therefore, implementation of the Decentralization alternative would have no additional impact on the management of SNF at Fort St. Vrain.

3.1.3 1992/1993 Planning Basis

The 1992/1993 Planning Basis alternative represents DOE's 1992/1993 plans for management of its SNF. Under this alternative, existing SNF located at major DOE sites would remain at those sites. This results in less intersite transportation of SNF compared with the other alternatives, except for the No Action alternative. Table 3-3 summarizes the basic actions at each site under this alternative.

1992/1993 Planning Basis Alternative

Transport to and store newly generated SNF at the Idaho National Engineering Laboratory or Savannah River Site. Consolidate some existing fuels at the Idaho National Engineering Laboratory or the Savannah River Site.

- Fuel would be transported as follows:
  - TRIGA fuel from the Hanford Site to the Idaho National Engineering Laboratory; Hanford Site receives limited fuel for research of storage and dispositioning technologies
  - Naval fuel to the Idaho National Engineering Laboratory for examination and storage
  - West Valley Demonstration Project and Fort St. Vrain fuel to the Idaho National Engineering Laboratory
  - Oak Ridge Reservation fuel to the Savannah River Site
  - Domestic research fuel, and foreign research reactor fuel as may yet be determined, divided between the Savannah River Site and the Idaho National Engineering Laboratory.
- Facilities upgrades and replacements that were planned would proceed, including increased storage capacity.
- Research and development for SNF management would be undertaken, including stabilization technology.
- SNF processing might need to be conducted. Other forms of stabilization might occur to provide for safe storage and/or transport.

Under this alternative, DOE would transport and store newly generated SNF at the Idaho National Engineering Laboratory or Savannah River Site. Some existing SNF currently at other sites would be consolidated at the Idaho National Engineering Laboratory or the Savannah River Site. Specifically, the Idaho National Engineering Laboratory would receive TRIGA fuel from the Hanford Site, SNF from naval sites, some test reactor SNF, SNF from the West Valley Demonstration Project and Fort St. Vrain, and some SNF from university and perhaps from foreign research reactors. The Savannah River Site would also receive some test reactor SNF and some SNF from university and perhaps from foreign research reactors. DOE sites would generally upgrade facilities and construct new facilities for the management of SNF.

Continued SNF transportation, receipt, processing, and storage are assumed for this alternative. The construction and operation of any new facilities required to accommodate current and project-specific SNF interim storage requirements would be implemented. Figure 3-3 identifies the movement of fuel from 1995 through 2035 under this alternative. Activities related to SNF processing would include research and development and pilot programs to support future decisions on the ultimate disposition of SNF.

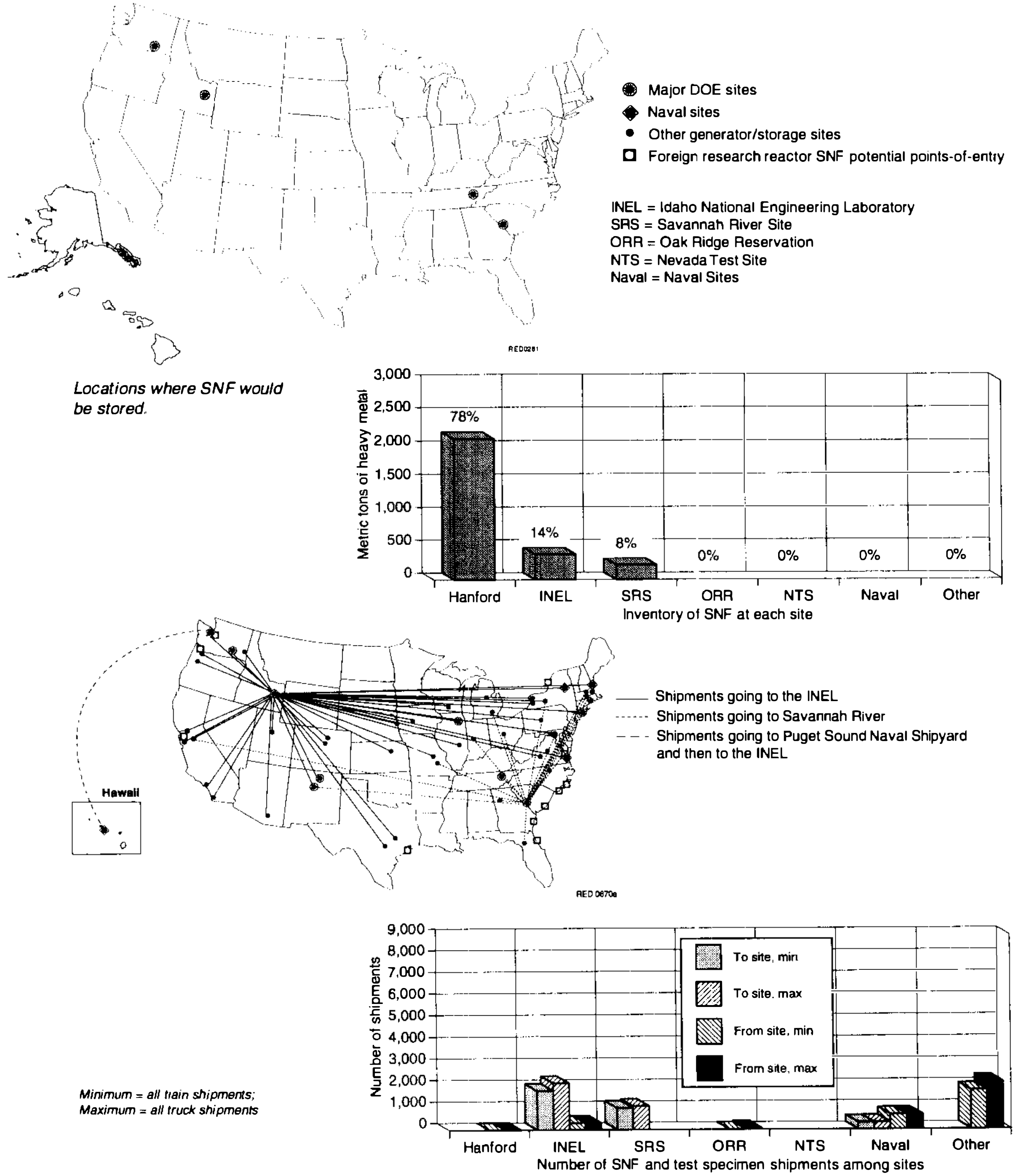


Figure 3-3. Spent nuclear fuel distribution, location, and inventory for the 1992/1993 Planning Basis alternative.

Naval SNF would continue to be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for examination. After examination, the SNF would be transferred to the Idaho Chemical Processing Plant for interim storage, pending ultimate disposition.

3.1.3.1 Hanford Site. The activities at the Hanford Site for the 1992/1993 Planning Basis alternative are the same as those identified for the Decentralization alternative, except that 191 TRIGA SNF elements currently stored in the 308 Building and the 200 Area low-level burial grounds would be transported to the Idaho National Engineering Laboratory. No new SNF would be transported to the Hanford Site except for limited quantities of materials for research in support of interim storage technologies for ultimate disposition. Thus, the overall inventory at the Hanford Site would decrease slightly.

3.1.3.2 Idaho National Engineering Laboratory. Under the 1992/1993 Planning Basis alternative, DOE would continue the maintenance and operation of existing SNF-related facilities in a manner similar to the No Action alternative; however, some consolidation of Idaho National Engineering Laboratory facilities could occur. Newly generated SNF would, with minor exceptions, be transported to either the Idaho National Engineering Laboratory or the Savannah River Site.

DOE would complete a new characterization and canning facility with appropriate inspection, conditioning, and packaging equipment to stabilize any new receipts of SNF and to prepare fuel currently in underwater storage for dry storage. DOE would upgrade or increase dry fuel storage capacity at the Idaho National Engineering Laboratory, as required.

SNF research and development, with the construction of a Technology Development Facility, would continue as planned. The Electrometallurgical Process Demonstration Project would continue at the Argonne National Laboratory-West Fuel Cycle Facility. The Dry Fuels Storage Facility would be used to demonstrate technology for the dry storage of selected DOE highly enriched uranium fuels.

Naval SNF would continue to be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for examination. After examination, the SNF would be transferred to the Idaho Chemical Processing Plant for interim storage, pending ultimate disposition.

3.1.3.3 Savannah River Site. The implementation of the 1992/1993 Planning Basis alternative at the Savannah River Site would involve the same actions and options as the Decentralization alternative, except that DOE would transfer about half of the newly generated domestic and foreign aluminum-clad research reactor SNF to the Savannah River Site.

The stabilization activities and options would be the same as those for the Decentralization alternative. The Savannah River Site would place the nonaluminum fuels and offsite aluminum-clad fuel receipts in interim storage and either process the aluminum-clad fuels currently at the Savannah River Site or place them in interim storage. The storage options and new facility requirements would also be the same as those for the Decentralization alternative. The Savannah River Site would undertake the same types of research and development programs as those described for the Decentralization alternative. Current ongoing activities would continue. The Savannah River Site would also conduct research and pilot-scale studies to determine the best technology for ultimate disposition of the aluminum-clad fuels.

3.1.3.4 Oak Ridge Reservation. Under the 1992/1993 Planning Basis alternative, the Oak Ridge Reservation would transport excess SNF to other DOE locations as necessary to permit continued operations of Oak Ridge reactors. The option for acquiring dry storage facilities would support continued High Flux Isotope Reactor operation during the transition period. The amount of SNF stored at the Oak Ridge Reservation would not increase. Research and development activities would continue, and SNF interim storage capacity would not increase.

3.1.3.5 Nevada Test Site. Under the 1992/1993 Planning Basis alternative, the Nevada Test Site would not generate or store any SNF and would not receive any SNF. Therefore, this alternative is not applicable to the Nevada Test Site.

3.1.3.6 Naval Nuclear Propulsion Program. Under this alternative, naval reactors would continue to be defueled and refueled as planned. Upon removal from the ship, the SNF would be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for examination. After examination, the fuel would be transported to the Idaho Chemical Processing Plant for interim storage, pending ultimate disposition. No action to prepare the SNF for storage would be necessary because of its corrosion resistance, high integrity, and strength. Planned improvements for the Expended Core Facility, including construction of the dry cell facility, would be completed.

3.1.3.7 Other Generator/Storage Locations. Under this alternative, SNF would continue to be transported to designated DOE sites. At Brookhaven National Laboratory, implementation of this alternative could require a transition period of several years and construction of temporary SNF storage facilities or acquisition of dry storage containers. DOE assumes that no additional SNF interim storage facilities would be constructed at the other generator/storage sites. For this alternative, SNF currently stored at the West Valley Demonstration Project, Babcock & Wilcox Research Center, and the Fort St. Vrain power plant would be transported to the Idaho National Engineering Laboratory.

3.1.4 Regionalization

The Regionalization alternative comprises Regionalization 4A, which would assign existing and projected SNF among DOE sites based primarily on fuel type, and Regionalization 4B, which would assign fuels geographically. This subsection briefly defines each one, provides a boxed summary, and discusses the implications of both on each site.

Table 3-4 summarizes actions at the sites being considered for the Regionalization alternative.

Regionalization 4A—Preferred Alternative

Distribute existing and projected SNF among DOE sites based primarily on fuel type.

- Naval fuel would be transported to, examined, and stored at the Idaho National Engineering Laboratory.
- Aluminum-clad fuel would be transported to the Savannah River Site; TRIGA and nonaluminum fuel would be transported to the Idaho National Engineering Laboratory; defense production fuel would be retained at the Hanford Site.
- SNF processing might need to be conducted. Other forms of stabilization might occur to provide for safe storage and/or transport.
- Facilities required to support SNF management would be upgraded or built as necessary.
- Research and development for SNF management would be undertaken, including stabilization technology.

Regionalization 4A is the management of SNF based on the specific fuel type. The DOE has identified Regionalization 4A as its preferred alternative (see Section 3.0). All SNF would be transported to and stored at either the Idaho National Engineering Laboratory or the Savannah River Site, depending upon the fuel type, with the exception of defense production fuel that would be retained at the Hanford Site. Regionalization 4A is similar to the 1992/1993 Planning Basis alternative but involves more intersite transportation of SNF to the sites, depending on the existing capabilities of the sites to manage the specific fuel types with respect to cladding material, physical and chemical composition, fuel condition, and adequate facilities to handle the increased quantity. Actions for this alternative would assign all but defense production SNF to either the Idaho National Engineering Laboratory or the Savannah River Site, depending on the fuel type.

Figure 3-4 shows the movement of SNF from 1995 through 2035 under Regionalization 4A. Facility upgrades, replacements, and additions would be undertaken to the extent required by this alternative. Activities related to the management of SNF, including research and development activities, would be included.

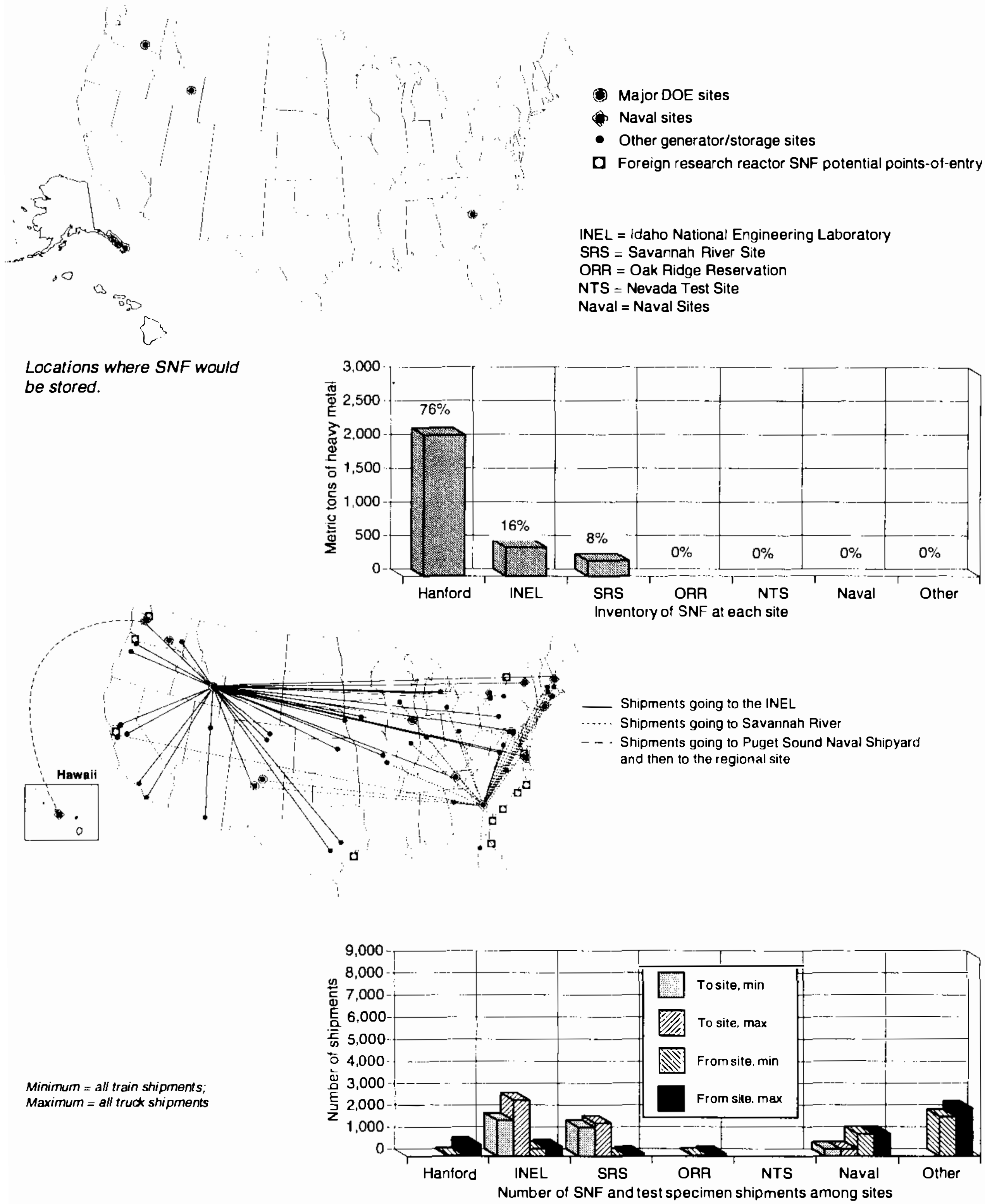


Figure 3-4. Spent nuclear fuel distribution, location, and inventory for Regionalization 4A (by fuel type).

> **Regionalization 4B**
>
> Distribute existing and projected SNF between an Eastern Regional Site (either Oak Ridge Reservation or Savannah River Site) and a Western Regional Site (either Hanford Site, Idaho National Eng neering Laboratory, or Nevada Test Site).
>
> - The Eastern Regional Site would receive fuel from east of the Mississippi River and the Western Regional Site would receive fuel from west of the Mississippi River.
> - Naval fuel would be transported to, examined, and stored at either the Western Regional Site or the Eastern Regional Site.
> - SNF processing might need to be conducted. Other fo ms of stabilization might occur to provide for safe storage and/or transport.
> - Facilities required to support SNF management would be upgraded or built as necessary.
> - Research and development would be undertaken for SNF management, ncluding stabilization technology.

Regionalization 4B is the management of SNF based on geography. In general, SNF from eastern locations (east of the Mississippi River) would be consolidated at the Eastern Regional Site (either the Oak Ridge Reservation or the Savannah River Site); SNF from western locations (west of the Mississippi River) would be consolidated at the Western Regional Site (either the Hanford Site, the Idaho National Engineering Laboratory, or the Nevada Test Site). All naval SNF would be transported to, examined, and stored at either the Eastern or the Western Regional Site. Regionalization 4B has 10 options, based on the combination of sites selected as the Eastern and Western Regional Site and the placement of the expended core facility at either the Eastern or the Western Regional Site. There are three potential Western and two potential Eastern Regional Sites that could be paired, with either supporting the expended core facility. Neither of the two possible combinations that include the Idaho National Engineering Laboratory as the Western Regional Site would consider constructing another expended core facility at the Eastern Site because of the estimated $1 billion cost to construct the expended core facility. Figure 3-5 shows the movement of SNF from 1995 through 2035 under Regionalization 4B with the Idaho National Engineering Laboratory as the Western Regional Site and the Savannah River Site as the Eastern Regional Site. Facility upgrades, replacements, and additions would be undertaken to the extent required by Regionalization 4B. Activities related to the management of SNF, including research and development, would be included.

3.1.4.1 Hanford Site.

Regionalization 4A—Under Regionalization 4A, activities at the Hanford Site would be intermediate to those of the Decentralization and the 1992/1993 Planning Basis alternatives. Hanford would continue to store its defense production fuel. The Hanford Site would not receive any shipments of SNF and would transport commercial remnants and stainless steel and nondefense production zircaloy-clad fuels to the Idaho National Engineering Laboratory. Facility upgrades,

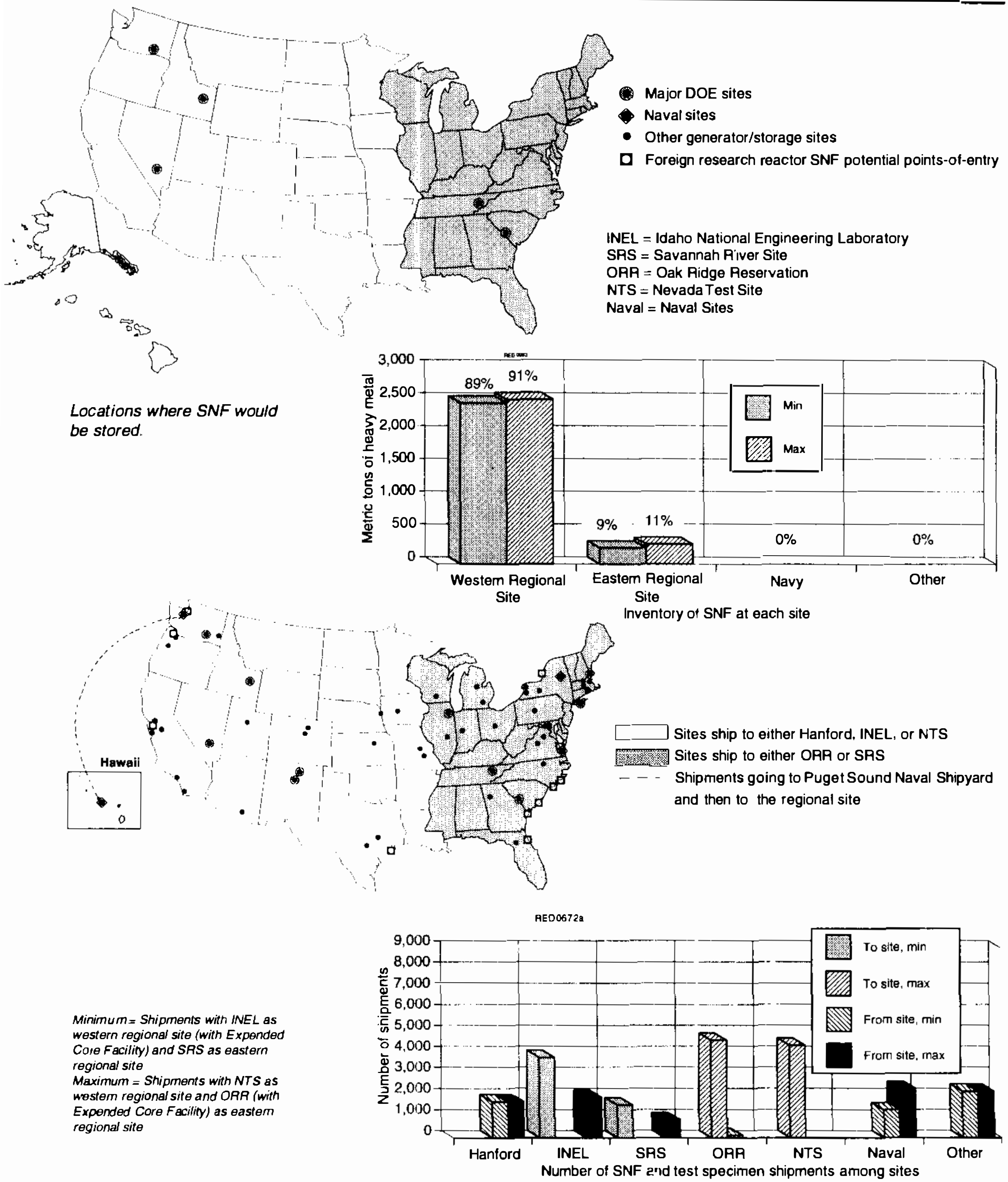


Figure 3-5. Spent nuclear fuel distribution, location, and inventory for Regionalization 4B (by geography).

replacements, and additions associated with defense production fuel would occur as for the Decentralization and 1992/1993 Planning Basis alternatives. Minor facility additions required to consolidate and prepare other onsite SNF for transport offsite would also occur.

Regionalization 4B—If the Hanford Site were selected as the Western Regional Site for implementation of Regionalization 4B, DOE SNF located or generated in the western United States and possibly naval SNF nationwide would be sent to the Hanford Site. This would require the completion of upgrades, increases, and replacements of storage capacity identified for the existing inventory under the Decentralization alternative, as well as additional capacity to accommodate DOE SNF and naval SNF within the existing or new facilities. A new stabilization facility may be required to accomplish safe interim storage of SNF.

New facilities would also be required to receive, handle, and store offsite fuel. In addition, a new facility for research and development and pilot programs would be required to support ultimate disposition. An expended core facility would be built on the Hanford Site, if the naval SNF were sent to the Hanford Site.

Implementation of Regionalization 4B at a site other than the Hanford Site would require the Hanford Site to consolidate and prepare onsite SNF for transport to the Western Regional Site. Because of the potential chemical reactivity of the defense production fuel at Hanford, it would require stabilization before offsite transport, which would require a new facility similar to the one described in the Decentralization alternative. Additional casks and associated handling equipment compatible with the receiving capabilities at the regional site may also be required. After the SNF is transported, related facilities at the Hanford Site would be closed.

3.1.4.2 Idaho National Engineering Laboratory.

Regionalization 4A—Under Regionalization A, stainless-steel- and zircaloy-clad, TRIGA, and naval SNF would be transported to the Idaho National Engineering Laboratory. The Idaho National Engineering Laboratory would transport aluminum-clad fuel to the Savannah River Site. Dry interim storage capacity would be increased and facility upgrades similar to those described for the 1992/1993 Planning Basis alternative would be undertaken, with replacements and additions as appropriate.

Regionalization 4B—If the Idaho National Engineering Laboratory were selected as the Western Regional Site for implementation of Regionalization 4B, SNF from western locations would be transported to the Idaho National Engineering Laboratory. The western facilities would characterize, stabilize, and can the SNF in containers compatible with dry storage at the Idaho Chemical Processing Plant at the Idaho National Engineering Laboratory. Naval SNF removed from naval reactors would be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for examination. Following examination, the SNF would be transferred to the Idaho Chemical Processing Plant for interim storage.

DOE would complete an expanded Dry Fuels Storage Facility, which would include a new characterization and canning facility similar to the one described for the 1992/1993 Planning Basis alternative. In addition, the same new facility projects described for the 1992/1993 Planning Basis alternative would be initiated.

DOE would conduct SNF research and development. Similar to the 1992/1993 Planning Basis alternative, the Electrometallurgical Process Demonstration Project would continue at Argonne National Laboratory-West.

If implementation of Regionalization 4B were to occur at a different site, DOE would construct a characterization and canning facility at the Idaho Chemical Processing Plant to assist in stabilizing the different types of Idaho National Engineering Laboratory SNF before placement in various shipping casks and storage containers before transport to the selected Western Regional Site.

Similar to the No Action alternative, DOE would complete the transfer of the CPP-603 Underwater Fuel Storage Facility pool inventory to existing dry storage facilities by the year 2000. DOE would not build the Dry Fuels Storage Facility. DOE would then close all SNF-related facilities at the Idaho National Engineering Laboratory, except for operating reactor support facilities, such as the Advanced Test Reactor canal or the Argonne National Laboratory-West Hot Fuel Examination Facility and Fuel Cycle Facility.

The SNF-related research and development activities would be phased out, although the Electrometallurgical Process Demonstration Project would continue at Argonne National Laboratory-West (but would only test processes for SNF currently on the site). Similar to the No Action alternative, shipments of naval SNF to the Idaho National Engineering Laboratory would cease, and the Expended Core Facility would be phased out.

3.1.4.3 Savannah River Site.

Regionalization 4A—Under Regionalization 4A, DOE would transport aluminum-clad fuels to the Savannah River Site. The same actions and options as the Decentralization alternative would be required. The Savannah River Site would transport nonaluminum-clad fuels to the Idaho National Engineering Laboratory.

The stabilization activities and options would be similar to those described for the Decentralization alternative. The principal differences are that, under this alternative, the Savannah River Site would can and store more aluminum-clad fuel and would not manage nonaluminum-clad fuels. The amount of fuel processed would remain the same. The storage options and new facility requirements would be similar to those described for the Decentralization alternative, except that storage space for stainless-steel-clad and zirconium-alloy-clad fuels would not be necessary. The Savannah River Site would undertake similar types of research and development programs as those described for the 1992/1993 Planning Basis alternative. The principal difference would be that nonaluminum-clad fuels would not be included under this alternative.

Regionalization 4B—If the Savannah River Site were selected as the Eastern Regional Site for implementation of Regionalization 4B, eastern locations would transport aluminum-clad and nonaluminum-clad fuels to the site. In addition, naval SNF might be transported to the Savannah River Site, if the Eastern Regional Site were selected for naval fuels. The stabilization activities and options required would be similar to those for the Decentralization alternative. The Savannah River Site would store the nonaluminum fuels and either store or process the aluminum-clad fuels. The storage options and new facility requirements would also be the same as those for the Decentralization alternative. The Savannah River Site would undertake the same types of research and development programs as those described for the Decentralization alternative. Current ongoing activities would continue. The Savannah River Site would also conduct research and pilot-scale studies to determine the best technology for ultimate disposition of aluminum-clad fuels.

If the Savannah River Site were not selected as the Eastern Regional Site, DOE would transport SNF to the Oak Ridge Reservation. Some fuel would have to be stabilized before transport.

3.1.4.4 Oak Ridge Reservation.

Regionalization 4A—Under Regionalization 4A , the Oak Ridge Reservation would not receive SNF and would transport its aluminum-clad SNF to the Savannah River Site. All other SNF would be transported to the Idaho National Engineering Laboratory.

Regionalization 4B—If the Oak Ridge Reservation were selected as the Eastern Regional Site for implementation of Regionalization 4B, the eastern locations would transport SNF to the Oak Ridge Reservation for storage. In addition, naval SNF might be transported to the Oak Ridge Reservation if the Eastern Regional Site were selected for naval fuel. SNF currently stored at other DOE facilities would arrive at the Oak Ridge Reservation fully stabilized. New non-DOE domestic, foreign research reactor, and naval SNF would arrive in a condition necessary for safe transportation but uncanned. This fuel would be stabilized, prepared, and canned at the Oak Ridge Reservation to ensure safe interim storage. Research and development activities at the Oak Ridge Reservation would increase from current levels. A new SNF management complex would be built, including (a) an SNF receiving and canning facility, (b) a technology development facility, (c) an interim dry storage area, and (d) an expended core facility similar to the one at the Idaho National Engineering Laboratory.

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before dry storage. The technology development facility would be used to investigate the applicability of dry storage technologies and pilot-scale technology development for disposition of the various types of SNF. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. Naval SNF would be examined at the new expended core facility at Oak Ridge before interim storage.

A small quantity of Molten Salt SNF is stored in tanks at the Oak Ridge Reservation. Currently, technology to stabilize this SNF for transport does not exist. Under this alternative, if the Oak Ridge Reservation were to transport SNF to the Savannah River Site, this Molten Salt SNF would continue to be stored at the Oak Ridge Reservation until it could be stabilized for safe transport.

If the Oak Ridge Reservation were not selected as the Eastern Regional Site, almost all SNF at the Oak Ridge Reservation would be transported to the Savannah River Site. Some SNF might not be transported until a stabilization process is developed because of the current inability to stabilize some SNF for transport. The option for acquiring dry storage facilities would support continued High Flux Isotope Reactor operation during the transition period.

3.1.4.5 Nevada Test Site. Regionalization 4A would not affect the Nevada Test Site because fuel is not currently stored onsite and fuel would not be transported to the site.

If the Nevada Test Site were selected as the Western Regional Site for implementation of Regionalization 4B, SNF from western locations would be transported to the Nevada Test Site for storage. In addition, naval SNF might be transported to the Nevada Test Site if the Western Site were selected for naval fuel. SNF currently stored at other DOE facilities would arrive at the Nevada Test Site fully stabilized. New non-DOE domestic, foreign research reactor, and naval SNF would arrive in a state necessary for safe transportation but uncanned. This fuel would be stabilized, prepared, and canned at the Nevada Test Site to ensure safe interim storage. A new SNF management complex would be built including (a) an SNF receiving and canning facility, (b) a technology development facility, (c) an interim dry storage area, and (d) an expended core facility similar to the one at the Idaho National Engineering Laboratory (if Nevada Test Site were selected for receipt of naval fuel).

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF, as necessary, before dry storage. The technology development facility would be used to investigate the applicability of dry storage technologies and pilot-scale technology development for disposal of the various types of SNF. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. Naval fuel would be examined at the new expended core facility at the Nevada Test Site before interim storage (if Nevada Test Site were selected for receipt of naval fuel).

If the Nevada Test Site were not selected as the Western Regional Site, then Regionalization 4B would not be applicable to the Nevada Test Site because it does not generate or store SNF.

3.1.4.6 Naval Nuclear Propulsion Program.

Regionalization 4A—Under Regionalization 4A, the management of naval SNF would be the same as for the 1992/1993 Planning Basis alternative. Naval SNF removed from naval reactors would continue to be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for examination. Following examination, the SNF would be transferred to the Idaho Chemical Processing Plant for interim storage. Planned improvements for the Expended Core Facility, including additions to the Dry Cell Facility, would be completed.

Regionalization 4B—Under Regionalization 4B, naval reactors would continue to be defueled and refueled, and the SNF would be sent to either the Western or the Eastern Regional Site for examination and storage.

If the Idaho National Engineering Laboratory were selected as the Western Regional Site, then naval SNF would continue to be transported to the Expended Core Facility for examination. After examination, the SNF would be transferred to the Idaho Chemical Processing Plant for storage. If another site were chosen for storage, naval SNF would continue to be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for examination until construction of a new nuclear fuel examination facility or modification of an existing facility to perform the examinations at the selected site. The new facility would provide capabilities equivalent to the Expended Core Facility at the Idaho National Engineering Laboratory.

3.1.4.7 Other Generator/Storage Locations. Under Regionalization 4A, the activities at the other generator and storage locations are the same as indicated for the 1992/1993 Planning Basis alternative. The exact destination of SNF transported would vary depending on the fuel type under Regionalization 4A and on the generation/storage location under Regionalization 4B.

3.1.5 Centralization

> **Centralization Alternative**
>
> **Manage all existing and projected SNF inventories at ne site until ultimate disposition.**
>
> - **Existing SNF would be transported to the centralized site.**
> - **Naval fuel would be transported to, examined, and stored at the centralized site.**
> - **Projected SNF receipts would be transported to the centralized site.**
> - **SNF processing might need to be conducted. Other forms of stabilization might occur to provide for safe storage and/or transport.**
> - **Facility upgrade/replacement and new storage capacity would be provided at the centralized site; stabi ization facilities would be provided at the transporting sites.**
> - **Research and development would be undertaken for SNF management, including stabilization technology.**

Under the Centralization alternative, the SNF that DOE is obligated to manage would be transported to a single location for management. Potential sites include the Hanford Site, Idabo National Engineering Laboratory, Savannab River Site, Oak Ridge Reservation, and Nevada Test Site. Table 3-5 summarizes the basic actions at each site under this alternative. Consequently, this alternative has five options (Options A through E)—centralization at each of the five potential sites. For the five sites designated under the Centralization alternative, the following discussion comprises two parts. The first part addresses the implications for the site if it were selected as the receiving site (that is, the centralization site). The second part presents the implications to the site if it were not selected as the centralization site, but currently managed SNF would be transported to the centralized site.

Regardless of the option selected, new facilities would be built at the selected site to accommodate the increased inventories. Some SNF would require stabilization, such as canning, before transport. SNF facilities at the transporting sites would then be closed. Activities related to the processing of SNF, including research and development and pilot programs, would also be centralized. Figure 3-6 shows the movement of fuel from 1995 through 2035 under this alternative.

For consolidation at sites other than the Idabo National Engineering Laboratory, a new expended core facility with capabilities comparable to the one in Idabo would be constructed, and the Idabo facility would be closed. Naval SNF would continue to be transported to the Expended Core Facility at the Idabo National Engineering Laboratory during a transition period, pending construction of storage and examination facilities at the central site.

3.1.5.1 Hanford Site. Under the Centralization alternative, Option A, DOE-controlled and naval reactor SNF would be transported to the Hanford Site. This would require the completion of

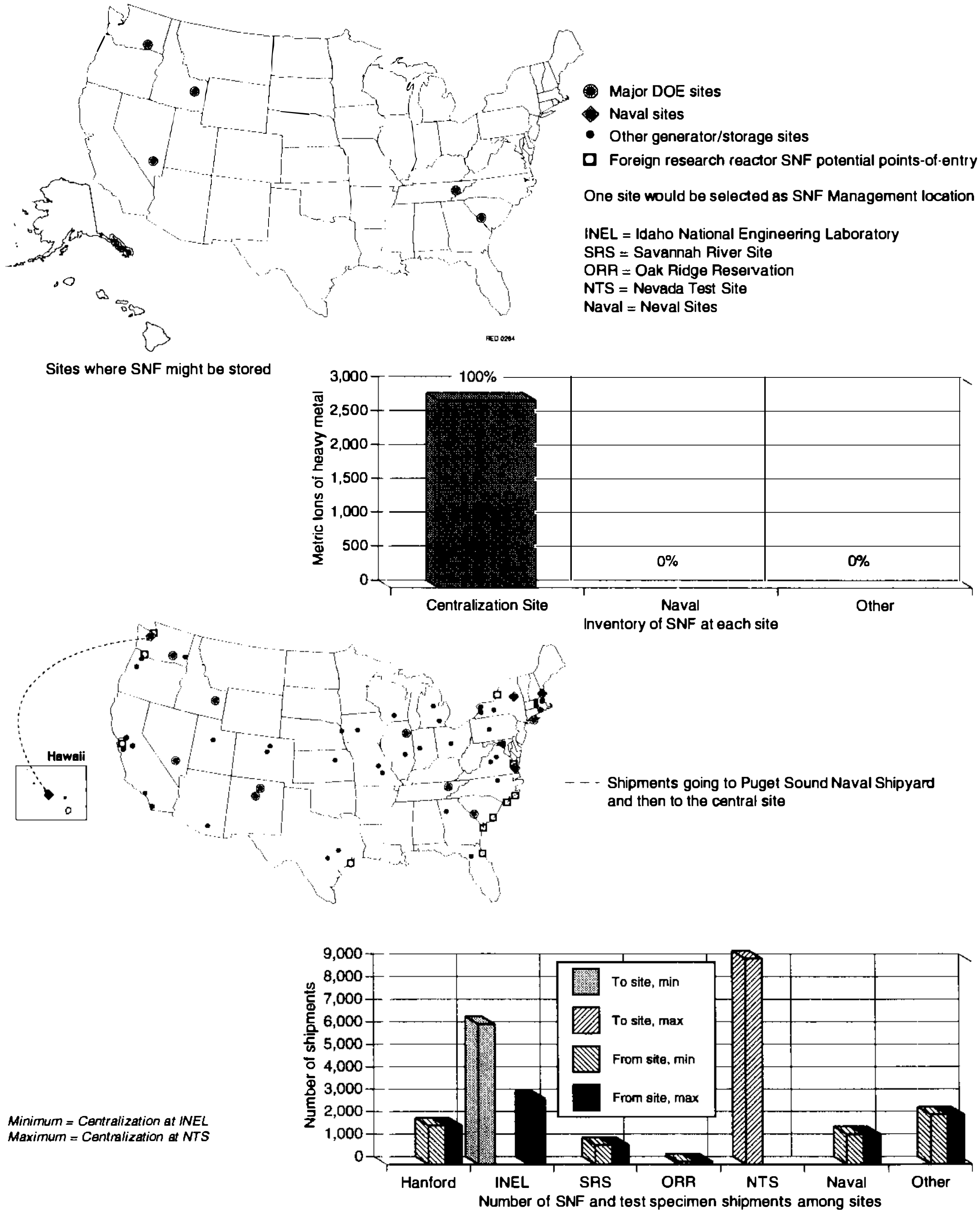


Figure 3-6. Spent nuclear fuel distribution, location, and inventory for the Centralization alternative.

the upgrades, increases, and replacements of storage capacity identified for the existing inventory under the Decentralization alternative, as well as of the additional capacity within those facilities or new facilities to accommodate the SNF from the other sites and possibly a stabilization facility.

New facilities would also be required to receive, handle, and store offsite fuel. In addition, a new facility for research and development and pilot programs would be required to support ultimate disposition. An expended core facility would also be built at the Hanford Site.

If the Hanford Site were not selected for storage, Hanford would have to consolidate and prepare onsite SNF for transport to the central site. Some of the SNF would require stabilization before offsite transport, which would require a new facility similar to the one described in the Decentralization alternative. Additional casks and associated handling equipment compatible with the receiving capabilities at the central site might also be required. After transport of the SNF, related facilities at the Hanford Site would be closed.

3.1.5.2 Idaho National Engineering Laboratory. If Option B were selected under the Centralization alternative, the Hanford Site, the Savannah River Site, and other DOE facilities would characterize, stabilize, and can the SNF in containers compatible with dry storage at the Idaho Chemical Processing Plant. Naval SNF removed from naval reactors would be transported to the Expended Core Facility at the Idaho National Engineering Laboratory.

Projects and activities for storage of SNF would be similar to those described for the 1992/1993 Planning Basis alternative, except that accelerated schedules for the Increased Rack Capacity and Additional Increased Rack Capacity projects would be necessary to accommodate the increased fuel receipts. In addition, the schedule for the Dry Fuel Storage Facility project would have to be accelerated and its scope expanded.

DOE would conduct maximum SNF research and development. Similar to the Regionalization alternative, the Electrometallurgical Process Demonstration Project would continue at Argonne National Laboratory-West.

If the Idaho National Engineering Laboratory were not selected as the storage site, a canning and characterization facility would be constructed at the Idaho Chemical Processing Plant to stabilize the different types of Idaho National Engineering Laboratory SNF in various shipping casks and storage containers before transport to the selected DOE facility.

Like the No Action alternative, the CPP-603 Underwater Fuel Storage Facility pool inventory would be transferred to existing dry storage facilities until it is transported offsite. The dry fuels storage facility would not be built. SNF-related facilities at the Idaho National Engineering Laboratory would be closed, except for facilities directly supporting operating reactors, such as the Advanced Test Reactor canal or the Argonne National Laboratory-West Fuel Cycle Facility.

SNF-related research and development activities would be phased out, although the Electrometallurgical Process Demonstration Project would continue at the Argonne National Laboratory-West Fuel Cycle Facility (but would process only SNF currently on the site). Similar to the No Action alternative, naval SNF would not be transported to the Idaho National Engineering Laboratory, and the Expended Core Facility would be shut down.

3.1.5.3 Savannah River Site. If Option C were selected under the Centralization alternative, the Savannah River Site would receive all DOE and naval SNF. Major new facilities, including an expended core facility for naval fuels, would have to be constructed. Near-term actions and options would be similar to those described for the Decentralization alternative.

The activities and options for management of the aluminum-clad fuel would be similar to those described for the Decentralization alternative. Fuels received from other sites would be stored.

The Receiving Basin for Offsite Fuels and reactor disassembly basins would be used to meet near-term storage requirements for the current inventory of Savannah River Site SNF in the same manner as described for the Decentralization alternative. The Savannah River Site would build large-capacity wet or dry storage facilities for the SNF received. In addition, SNF receiving, characterization, and canning facilities would be necessary, and an expended core facility would be built onsite for examination of naval SNF.

Projects would be initiated to design characterization, canning, and storage facilities for the fuel types that the Savannah River Site would manage. Additional research would be conducted to develop requirements for the ultimate disposition of the SNF.

If the Savannah River Site were not selected as the centralized storage site, it would have to transport onsite SNF to the central site after stabilizing any fuel that is not safe for transport. No new storage facilities would be necessary because the Savannah River Site would maintain the SNF in the existing pools (as described for the Decentralization alternative) until moving it to the characterization facility before transport. The Savannah River Site would construct new characterization and canning facilities to prepare the SNF for transport. In addition, research would be conducted on stabilization and transport of aluminum-clad fuel that is heavily corroded.

3.1.5.4 Oak Ridge Reservation. If Option D were selected under the Centralization alternative, the Oak Ridge Reservation would receive DOE SNF stabilized and canned to the extent necessary for safe transportation. The SNF might need to be uncanned, stabilized, prepared, and recanned at the Oak Ridge Reservation, however, to ensure safe interim storage. New non-DOE domestic, foreign research reactor, and naval SNF would arrive in a form suitable for safe transportation. If necessary, this fuel would be stabilized, prepared, and canned at the Oak Ridge Reservation to ensure safe interim storage. Research and development activities would increase from current levels. A new SNF management complex would be built, including (a) an SNF receiving and canning facility, (b) a technology development facility, (c) an interim dry storage area, and (d) an expended core facility similar to the one currently at the Idaho National Engineering Laboratory.

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before it is placed into dry storage, as necessary. The applicability of dry storage technologies and pilot-scale technology development for ultimate disposition of the various types of SNF would be investigated in the technology development facility. The interim dry storage area would consist of passive storage modules designed to safely store the SNF. Naval SNF would be examined at the expended core facility before storage.

A small quantity of Molten Salt SNF is stored in tanks at the Oak Ridge Reservation. Currently, technology to stabilize this SNF for transport does not exist. Under this alternative, if the Oak Ridge Reservation were to transport SNF to the Savannah River Site, this Molten Salt SNF would continue to be stored at the Oak Ridge Reservation until it could be stabilized for safe transport.

If the Oak Ridge Reservation were not selected as the centralization site, then almost all SNF at the Oak Ridge Reservation would be transported to the centralization site. The option for acquiring dry storage facilities would support continued High Flux Isotope Reactor operation during the transition period.

3.1.5.5 Nevada Test Site. If Option E were selected under the Centralization alternative, the Nevada Test Site would receive DOE SNF stabilized and canned to the extent necessary for safe transportation. (However, the SNF might need to be uncanned, stabilized, prepared, and recanned at the Nevada Test Site to ensure safe interim storage.) New non-DOE domestic, foreign research reactor, and naval SNF would arrive in a state necessary for safe transportation but uncanned. This fuel would be stabilized, prepared, and canned at the Nevada Test Site to ensure safe interim storage. A new SNF management complex would be built, including (a) an SNF receiving and canning facility, (b) a technology development facility, (c) an interim dry storage area, and (d) an expended core facility similar to the one currently at the Idaho National Engineering Laboratory.

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before it is placed into dry storage, as necessary. The applicability of dry storage technologies and pilot-scale technology development for disposal of the various types of SNF would be investigated in the technology development facility. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. Naval SNF would be examined at the expended core facility before interim storage.

If the Nevada Test Site were not selected as the centralization site, then this alternative would not be applicable to the Nevada Test Site because it neither generates nor stores SNF.

3.1.5.6 Naval Nuclear Propulsion Program. Under the Centralization alternative, naval SNF would be transported to the selected site for examination and storage. If a site other than the Idaho National Engineering Laboratory were selected, then a transition period would be required, during which naval SNF would be transported to the Expended Core Facility at the Idaho National Engineering Laboratory and a new expended core facility at the central site would be constructed. No actions would be needed to prepare the naval SNF for storage because of its corrosion resistance, high integrity, and strength.

3.1.5.7 Other Generator/Storage Locations. Under the Centralization alternative, SNF would be transferred from the other generator and storage locations to the central storage site. Although the shipment destination may vary, the impacts from SNF operations at these locations would be the same as those identified in the 1992/1993 Planning Basis alternative.

3.2 Alternatives Eliminated from Detailed Analysis

In the process of evaluating management alternatives available to the DOE, several other management concepts and technologies have been considered for incorporation into the programmatic alternatives described in Section 3.1. The following section describes the concepts and technologies considered and not carried forward and identifies why they have been eliminated from detailed analysis.

3.2.1 Examine or Store Spent Nuclear Fuel in Foreign Facilities

The design and operating characteristics of the fuel for naval reactors and certain portions of other SNF are classified. As such, they are not releasable to foreign interests without going through a complex procedure prescribed in the Atomic Energy Act and strict U.S. Nuclear Regulatory Commission licensing requirements. Some of these classified design details and characteristics are obvious from the physical form of the fuel, and others could be learned from detailed examination or analyses. The United States Nuclear Weapons Nonproliferation Policy is summarized in the White House Fact Sheet on Nonproliferation and Export Control Policy, dated September 27, 1993 (White House 1993). Under its nuclear nonproliferation policy, the United States seeks to reduce or eliminate, where possible, the accumulation of stockpiles of highly enriched uranium or plutonium. These factors, along with others such as the security required for foreign transport and storage, make this alternative impractical. Based on these considerations, this alternative was eliminated from detailed analysis.

3.2.2 Leave Naval Spent Nuclear Fuel In Nuclear-Powered Ships

It is physically possible to retain SNF in the reactors in nuclear-powered vessels and moor the ships at shipyards until a decision on the ultimate disposition of the SNF is determined and implemented, and the fuel could then be removed from the ships.

Implementing this alternative would require extensive modifications to facilities at shipyards, including increasing the number of piers and the availability of waterfront utilities to support the ships at their moorings. Other shipyard facilities also might have to be modified or replaced in order to moor the numbers of ships involved during the 40-year period. The construction of piers and other needed facilities would cause impacts on the waterfronts and harbors and could affect the local ecology. Shipyard facilities would become overloaded with the requirement to moor vessels retaining their SNF onboard and skilled shipyard staff would be unable to continue to work on the operational fleet.

In addition, the costs and impacts on national security resulting from such an approach would be large; it would affect the ability of the U.S. Navy to carry out its mission. The costs of maintaining the ships with SNF remaining installed under Navy operating procedures and of providing the additional piers, waterfront services, and utilities would be large, both for ships that are to be decommissioned and for ships that would normally be refueled and returned to duty. (Failure to remove the SNF from Navy ships that are still needed for service would result in these ships being unavailable once their currently installed reactor fuel reaches the end of useful life.)

3.2.3 Alternate Sites for the Management of Spent Nuclear Fuel

An alternative SNF site selection process was undertaken to identify alternatives to the three major DOE sites—Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The candidate sites evaluated, site selection screening process, and results are presented in the *Alternate Site Selection Decision Process Report* (DOE-ID 1994). This study concluded that the uncertainties regarding Department of Defense sites together with their lack of SNF facilities and expertise made these additional Department of Defense sites less attractive as site alternatives. The alternative SNF site selection process resulted in the addition of the Nevada Test Site and Oak Ridge Reservation as potential regionalization and centralization sites for SNF management. The Oak Ridge Reservation represented a reasonable alternative site to the Savannah River Site for regionalization of Eastern-based SNF and the Nevada Test Site represented a reasonable alternative site to the Idaho National Engineering Laboratory or Hanford sites for regionalization of Western-based SNF. These two sites also represented options for centralization of all SNF management activities. However, the DOE did not consider the Nevada Test Site to be a preferred site for the management of SNF because of the State of Nevada's current role as the host site for the Yucca Mountain Site Characterization Project and the Nevada Test Site's lack of SNF management facilities and high-level waste infrastructure. For purposes of conducting a thorough National Environmental Policy Act analysis, the Nevada Test Site provides a contrast to other potential sites because it represents a site that has no existing SNF infrastructure. Non-DOE sites were eliminated from further analysis.

3.2.4 Chemical Separation/Processing of Spent Nuclear Fuel

Three potential technical management options were evaluated for chemical separation/processing of DOE SNF. However, DOE will not select SNF technical management options on the basis of Volume 1 of this EIS. These technology-based decisions are most appropriately made after detailed analysis on a fuel type-specific or site-specific basis. The three options include (a) chemical separation/processing in DOE facilities at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site; (b) chemical separation/processing in foreign commercial facilities; and, (c) chemical separation/processing in domestic commercial facilities.

Chemical separation/processing at DOE sites was evaluated under certain alternatives as a reasonably foreseeable activity as a SNF stabilization technology. This activity is discussed in Section 3.1 of this EIS. However, the evaluation was limited to certain alternatives and certain fuel types based largely on historical technologies and capabilities. Future technology-based SNF management decisions would be made only after further National Environmental Policy Act reviews were completed.

Several foreign commercial facilities exist that have the capability to process certain types of DOE SNF. An analysis of processing DOE SNF at those facilities would have to consider United States nuclear nonproliferation policy (with regard to highly enriched uranium and plutonium), national security concerns (with regard to the classified nature of naval fuel), and other technical considerations (with regard to transportation of wet fuel, processing capability in foreign facilities, possible fuel instability, etc.). There are certain fuel types addressed in this EIS for which management by processing in a foreign facility may be considered appropriate. In such instances, final decisions on technology-based options would be made based on further analysis in other site-specific or fuel type-specific National Environmental Policy Act reviews tiered from this EIS. For example, in a separate EIS on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel, DOE addresses foreign processing of the foreign research reactor SNF included in this EIS as a potential management alternative.

In response to public comment, Appendix A, Volume 1 of this EIS includes an analysis of transporting N-Reactor and Single-Pass Reactor SNF currently stored at the Hanford Site to a site in England for processing. The impacts identified by this analysis are considered to be representative of the impacts of transporting and handling any specific DOE SNF that might be considered for foreign processing, because N-Reactor SNF is low-enriched SNF and is a large fraction (in MTHM) of the currently stored inventory. In addition, the analysis included transportation routes that maximize foreign and domestic distances. A summary of these transportation impacts is included in Appendix I, Volume 1 of this EIS.

Domestic commercial facilities are not available for SNF processing for interim storage and, therefore, were eliminated from further consideration.

3.2.5 Preparations for Disposal

DOE has not yet decided whether the ultimate disposition for DOE SNF is disposal in a repository or removal/recycle of the fissile material (primarily uranium). Disposal of SNF would require (a) development of the repository waste acceptance criteria, and (b) completion of the characterization of the various types of SNF that would allow a determination of the specific technology needed for SNF preparation (processing, canning, etc.) for each fuel type. Because of the large number of uncertainties at this time, it is considered too speculative to include in this EIS at this time. Therefore, preparation for disposal in a geologic repository was eliminated from further evaluation in this EIS.

3.3 Comparison of Alternatives

As discussed in Chapter 5 and the site-specific appendices, the environmental consequences and, therefore, differences among the five SNF management alternatives addressed in Section 3.1 would be small. The comparison of alternatives in this section concentrates on (a) the areas in which the public has expressed considerable interest, and (b) programmatic factors important to DOE decisionmaking. The following factors were selected for comparison:

- Number of SNF shipments among sites
- Public health effects
- SNF-related employment
- Generation of radioactive waste
- Impact on DOE or Navy missions
- Cost of implementation.

The alternatives that would cause the smallest impacts in these areas maximize the use of existing facilities, staff, and infrastructure.

3.3.1 Number of Shipments

Figure 3-7 shows the number of shipments that would occur under each alternative. Figure 3-7 also quantifies shipments of test specimens under each alternative. Shipments of naval test specimens are included here because of their contribution to cumulative impacts of naval SNF transportation. Details concerning naval test specimens and methodologies for calculating impacts of specimen shipments can be found in Appendix D. The No Action alternative would involve a limited number of naval spent fuel shipments (200) and test specimen shipments (320). The Decentralization alternative, 1992/1993 Planning Basis alternative, and Regionalization 4A alternative mostly involve shipments to DOE sites from the smaller reactor and storage sites and from the naval sites to DOE sites. These shipments range in number from approximately 2,300 shipments under Decentralization Options A or B to approximately 4,500 under the Regionalization 4A alternative. Decentralization Option C and the 1992/1993 Planning Basis alternative have approximately 3,200 and 3,700 shipments, respectively, over the 40-year period. For the Regionalization 4B alternative and the Centralization options, SNF is transported to one or two sites. For these alternatives and options, the number of shipments range from approximately 5,500 under the Regionalization 4B alternative (Idaho National Engineering Laboratory and Savannah River Site) to a high of about 9,200 under the Centralization Option E (centralization at the Nevada Test Site). The number of shipments is

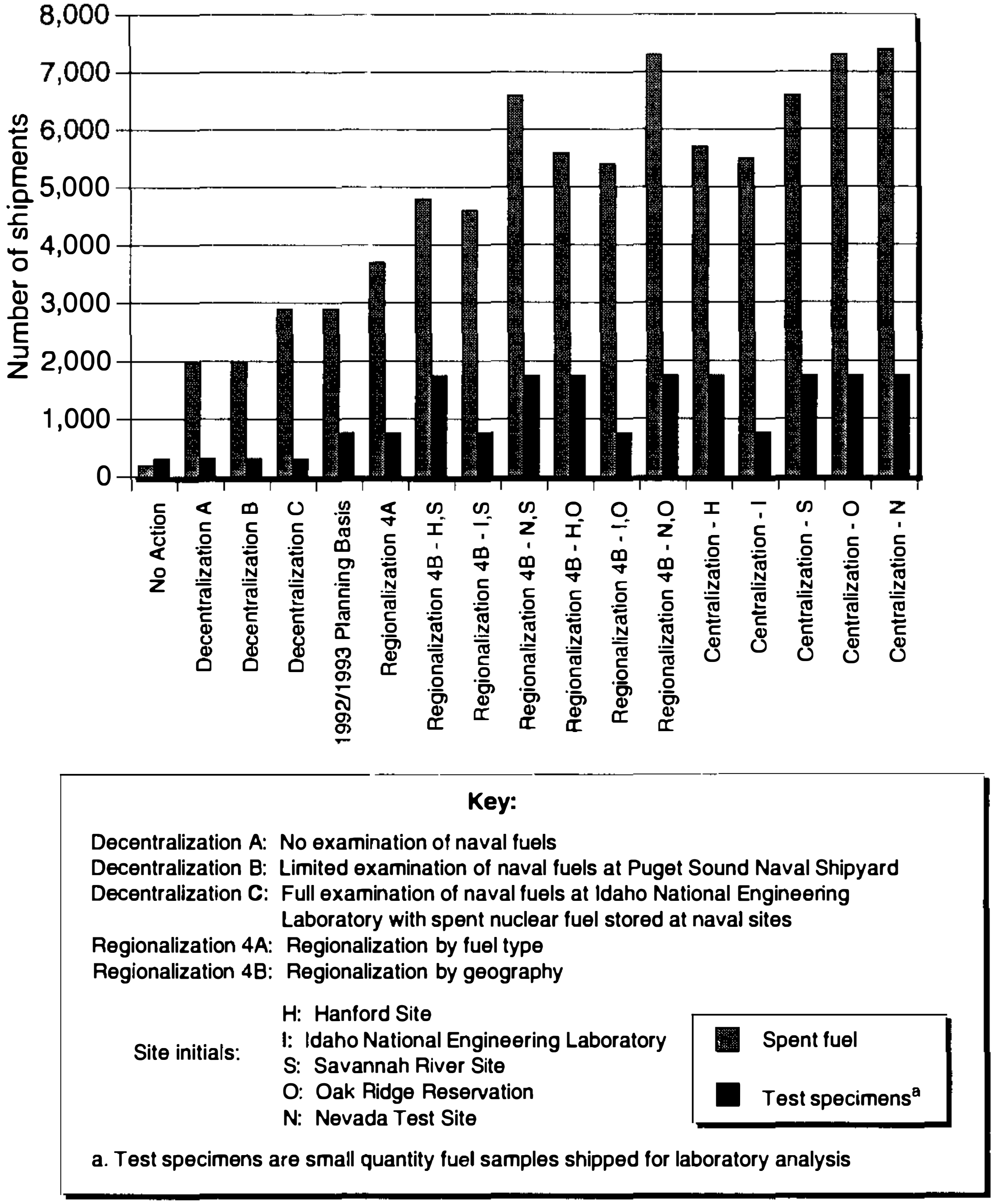


Figure 3-7. Number of spent nuclear fuel and test specimen shipments between the years 1995 and 2035.

summarized in Table 3-6. A more detailed discussion can be found in Appendices D and I of Volume 1. The public health effects from such shipments are discussed in the next section.

3.3.2 Public Health Effects

This section discusses the public health effects from radiation exposure and traffic accidents under DOE's SNF Management Program (see Section 5.1.1.4 for basic information regarding assessment methods). These effects are estimated to be small, as shown by Figures 3-8, 3-9, and 3-10. The three sources of radiation exposure are (a) normal site operations, (b) transportation, and (c) accidents. Under all alternatives, the estimated number of latent cancer fatalities from the operation of the entire DOE SNF management system over a 40-year period would range from approximately zero to about two latent cancer fatalities.

3.3.2.1 Normal Operations. In general, the greatest radiation exposure from normal SNF site activities and incident-free transportation results when large quantities of SNF are transported among sites, such as under the Regionalization 4B alternative or Centralization alternative. Under incident-free transportation, as noted in Table 3-7, the estimated total fatalities are less than two for all alternatives, with the highest estimates associated with the Centralization options. This reflects the higher number of shipments associated with these options.

In summary, estimated radiation impacts on public health are small for all alternatives (which include many different siting options), and it would, therefore, not be possible to materially reduce the impacts through a site selection process.

3.3.2.2 Accidents. Transportation accidents pose the lowest risk of cancer fatalities (although the consequences of some accidents can be high). The accident risks are presented in Table 3-8. The results indicated that the risks associated with traffic fatalities are greater than the risks associated with cancer caused by radiation exposure. Both normal site operations and incident-free transportation have greater risk than that expected from transportation accidents when the probability and the consequences of potential accidents are considered. The latent cancer fatalities associated with onsite accidents is small across alternatives. The transportation accident with the largest consequences would lead to 55 latent cancer fatalities; the probability of occurrence is 1.1×10^{-7} per year (1 in 10 million years) (see Appendix I).

In summary, for radiation-induced latent cancer fatalities to the public over 40 years of SNF management under all of the alternatives evaluated, the most likely outcome is as follows:

- Essentially zero latent cancer fatalities from normal facility operations and facility accidents

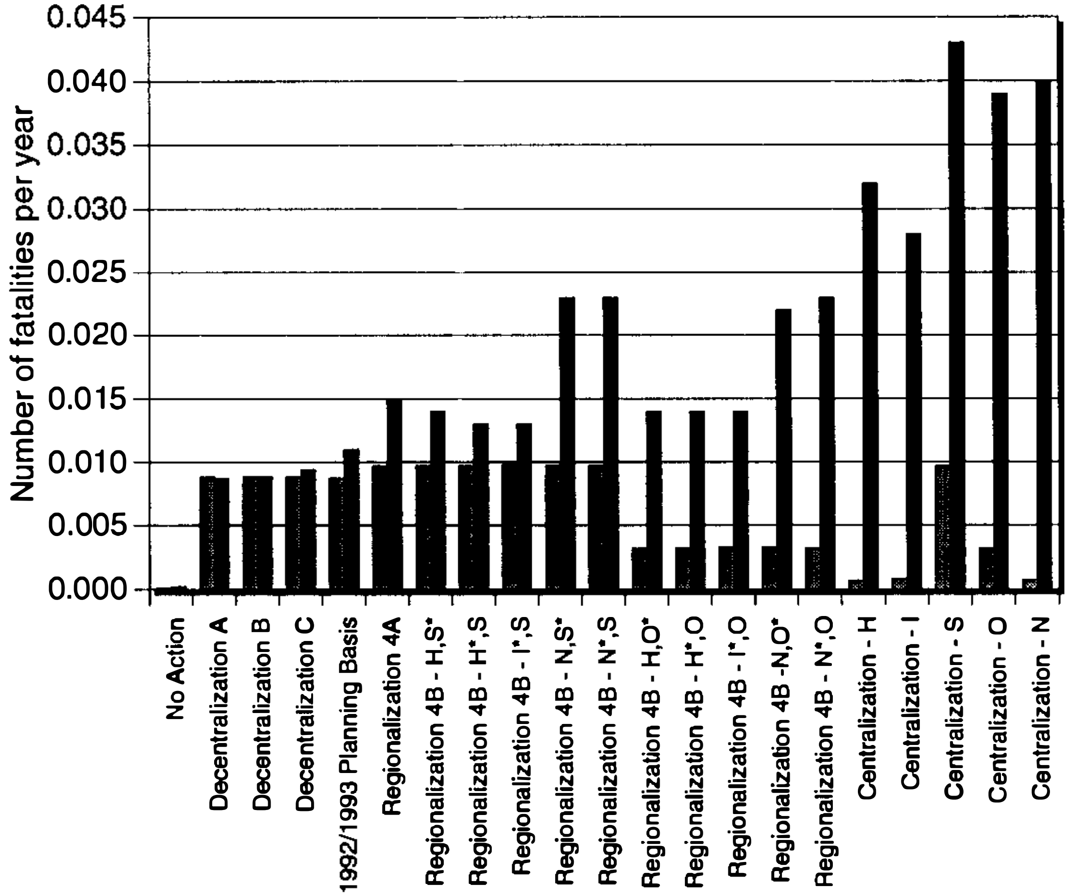
- Essentially zero latent cancer fatalities from transportation accidents

Table 3-6. Number of offsite spent nuclear fuel and test specimen shipments by alternative.

Alternative		Maximum number of shipments: Spent fuel shipments[a]	Maximum number of shipments: Test specimen shipments[b]
No Action		200	320
Decentralization	Option A	2,000	320
	Option B	2,000	320
	Option C	2,900	320
1992/1993 Planning Basis		2,900	760
Regionalization 4A		3,700	760
Regionalization 4B			
	Hanford Site/Savannah River Site	4,800	1,750
	Idaho National Engineering Laboratory/Savannah River Site	4,600	760
	Nevada Test Site/Savannah River Site	6,600	1,750
	Hanford Site/Oak Ridge Reservation	5,600	1,750
	Idaho National Engineering Laboratory/Oak Ridge Reservation	5,400	760
	Nevada Test Site/Oak Ridge Reservation	7,300	1,750
Centralization			
	Hanford Site	5,700	1,750
	Idaho National Engineering Laboratory	5,500	760
	Savannah River Site	6,600	1,750
	Oak Ridge Reservation	7,300	1,750
	Nevada Test Site	7,400	1,750

a. Assuming naval SNF shipments by rail and DOE SNF by truck.

b. Test specimens by truck.



Key:

Decentralization A: No examination of naval fuels
Decentralization B: Limited examination of naval fuels at Puget Sound Naval Shipyard
Decentralization C: Full examination of naval fuels at Idaho National Engineering Laboratory with spent nuclear fuel stored at naval sites
Regionalization 4A: Regionalization by fuel type
Regionalization 4B: Regionalization by geography

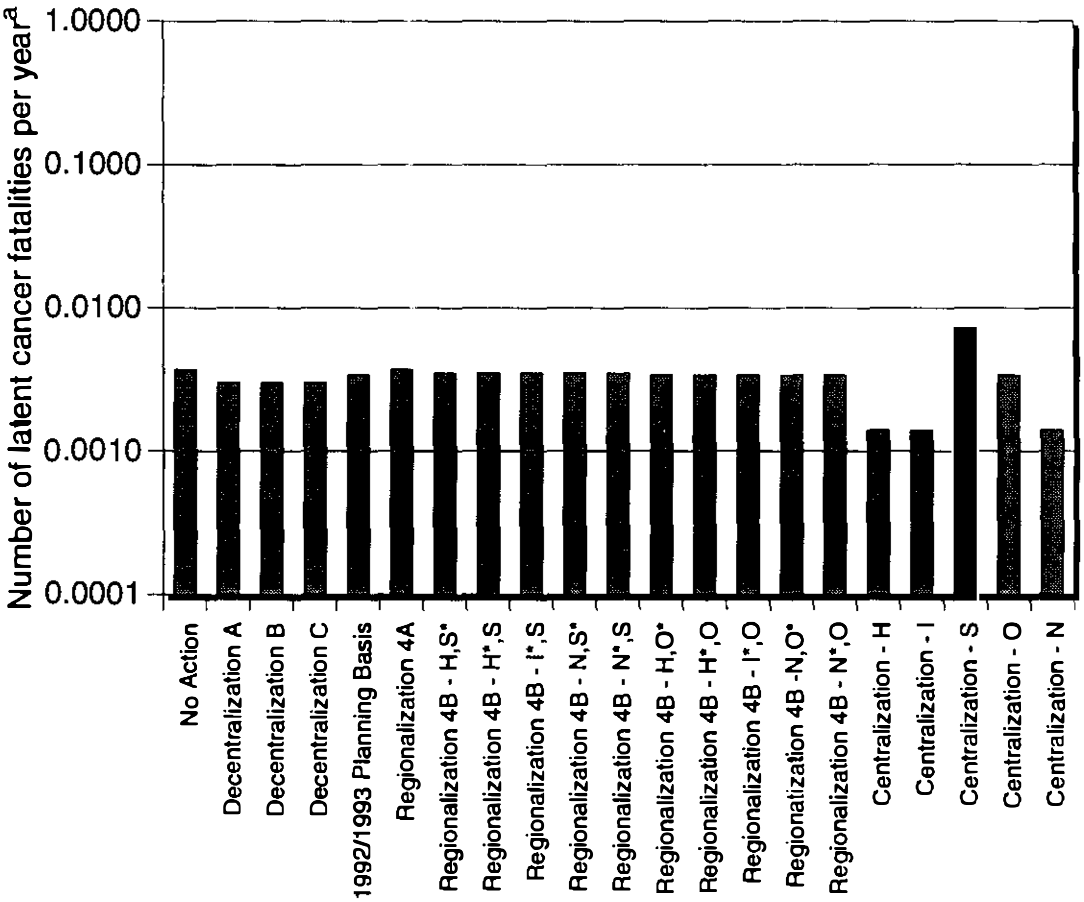
Site initials:
H: Hanford Site
I: Idaho National Engineering Laboratory
S: Savannah River Site
O: Oak Ridge Reservation
N: Nevada Test Site

■ Operations
■ Transportation[a]

* Location of Expended Core Facility

a. Total fatalities are the sum of the estimated number of radiation-related latent cancer fatalities for workers and the general population and the estimated number of nonradiological fatalities from vehicular emissions. Average annual risk for incident free transportation was determined by dividing the cumulative risks over the entire transportation campaign by the estimated duration of the transportation compaign. Cumulative risks are presented in Chapter 5 of EIS Volume 1.

Figure 3-8. Maximum estimated number of latent cancer fatalities per year in the general population from normal spent nuclear fuel site operations and total fatalities from incident-free transportation.



Key:

Decentralization A: No examination of naval fuels
Decentralization B: Limited examination of naval fuels at Puget Sound Naval Shipyard
Decentralization C: Full examination of naval fuels at Idaho National Engineering Laboratory with spent nuclear fuel stored at naval sites
Regionalization 4A: Regionalization by fuel type
Regionalization 4B: Regionalization by geography

Site initials:
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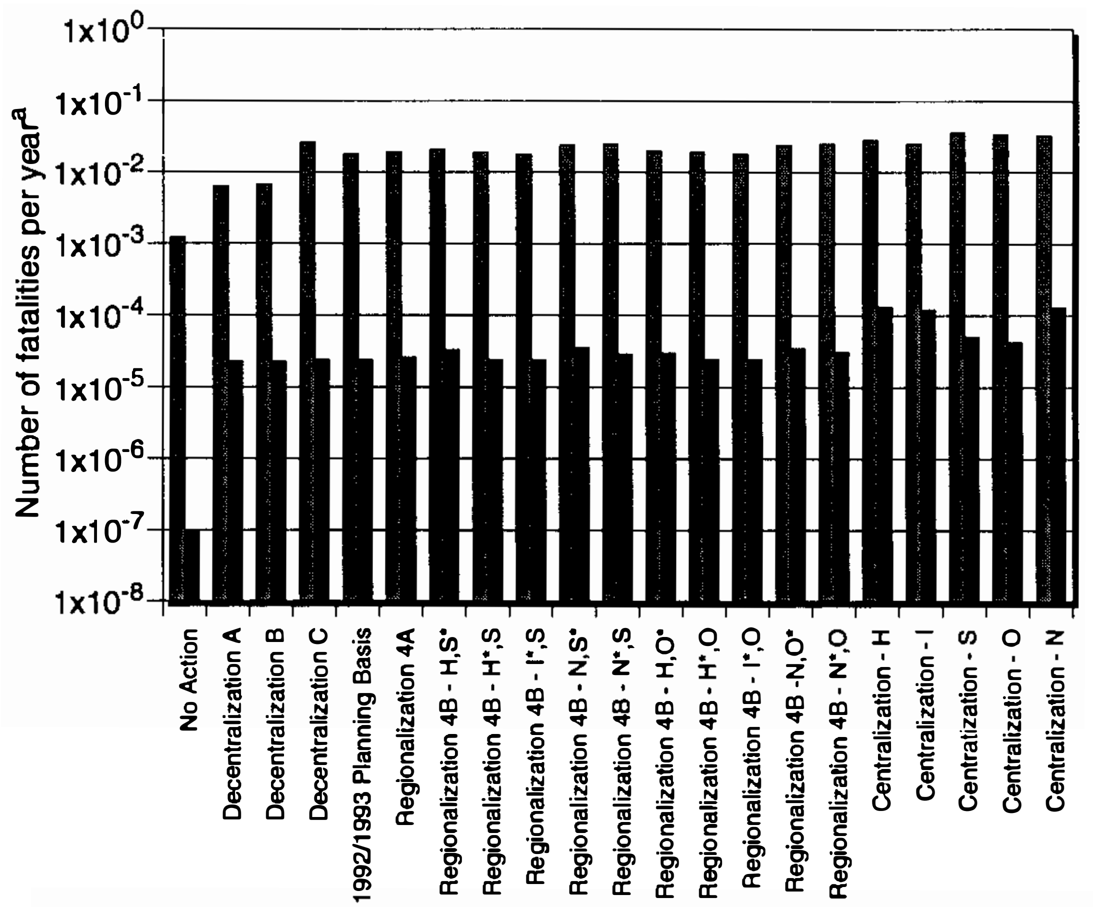
N: Nevada Test Site

* Location of Expended Core Facility

a. Facility risks are based on the product of the probability and consequences of the respective maximum foreseeable facility accident for each alternative and expressed in latent cancer fatalities per year.

Figure 3-9. Estimate of risk of latent cancer fatalities in general population from facility accidents for spent nuclear fuel management activities.



Key:

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Decentralization C: Full examination of naval fuels at Idaho National Engineering Laboratory with spent nuclear fuel stored at naval sites
Regionalization 4A: Regionalization by fuel type
Regionalization 4B: Regionalization by geography

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Traffic fatality risk
Radiological risk

* Location of Expended Core Facility

a. Radiological risk is in terms of latent cancer fatalities per year from spent nuclear fuel shipments; traffic fatality risk is in terms of estimated nonradiological traffic accident fatalities per year from spent nuclear fuel shipments.

b. Average annual risk was determined by dividing the cumulative accident risks over the entire transportation campaign by the estimated duration of the transportation campaign. Cumulative transportation accident risks are presented in Chapter 5 of EIS Volume 1.

Figure 3-10. Estimate of average annual risk[b] from transportation accidents for spent nuclear fuel management activities.

Table 3-7. Comparison of incident-free transportation total fatalities for alternatives over the 40-year period.

	Minimum[a,b] total fatalities	Maximum[b,c] total fatalities
No Action	0.0089	0.0089
Decentralization	0.12 to 0.15	0.35 to 0.38
1992/1993 Planning Basis	0.14	0.45
Regionalization 4A (fuel type)	0.17	0.61
Regionalization 4B (geography)		
Idaho National Engineering Laboratory and Savannah River Site	0.15 to 0.17	0.51 to 0.53
Idaho National Engineering Laboratory and Oak Ridge Reservation	0.14 to 0.15	0.53 to 0.54
Hanford Site and Savannah River Site	0.17	0.55 to 0.56
Hanford Site and Oak Ridge Reservation	0.15	0.57
Nevada Test Site and Savannah River Site	0.19	0.88
Nevada Test Site and Oak Ridge Reservation	0.17	0.90
Centralization		
Hanford Site	0.23	1.3
Idaho National Engineering Laboratory	0.21	1.1
Savannah River Site	0.26	1.7
Oak Ridge Reservation	0.21	1.6
Nevada Test Site	0.26	1.6

a. The minimum total fatalities are associated with transport of DOE fuel by rail; naval SNF shipments are by both truck (onsite) and rail (offsite).

b. Total fatalities are for the 40-year period 1995 through 2035 and were the sum of the estimated number of radiation-related latent cancer fatalities for workers and the general population and the estimated number of nonradiological fatalities from vehicle emissions.

c. The maximum total fatalities are associated with transport of DOE fuel by truck; naval SNF shipments are by both truck (onsite) and rail (offsite).

Table 3-8. Comparison of estimated transportation accident risks for alternatives over tbe 40-year period.

Alternative	Truck accident risks[a]		Rail accident risks[a]	
	Latent cancer fatalities	Traffic fatalities	Latent cancer fatalities	Traffic fatalities
No Action	4.1×10^{-6}	0.047	4.1×10^{-6}	0.047
Decentralization[b]	0.00085 to 0.00090	0.20 to 1.01	0.00029 to 0.00034	0.26 to 1.07
1992/1993 Planning Basis	0.0010	0.70	0.00035	0.73
Regionalization 4A (fuel type)	0.0011	0.77	0.00037	0.76
Regionalization 4B (geography)				
Idaho National Engineering Laboratory and Savannah River Site	0.00090	0.72	0.00034	0.73
Idaho National Engineering Laboratory and Oak Ridge Reservation	0.00095	0.73	0.00024	0.72
Hanford Site and Savannah River Site	0.0013	0.84	0.00075	0.82
Hanford Site and Oak Ridge Reservation	0.0013	0.81	0.00050	0.78
Nevada Test Site and Savannah River Site	0.0012	0.99	0.00045	0.91
Nevada Test Site and Oak Ridge Reservation	0.0012	1.00	0.00035	0.91
Centralization				
Hanford Site	0.0050	1.10	0.0013	1.05
Idaho National Engineering Laboratory	0.0048	1.00	0.0013	0.95
Savannah River Site	0.0020	1.44	0.00080	1.09
Oak Ridge Reservation	0.0017	1.35	0.00055	1.00
Nevada Test Site	0.0050	1.33	0.0014	1.19

a. Assumes SNF shipments are 100 percent by truck or 100 percent by rail, except for naval SNF shipments that are by both truck (onsite) and rail (offsite).

b. Range of values in each column for the Decentralization alternative reflects the different fuel examination options for naval SNF.

- Up to about one latent cancer fatality from most incident-free transportation scenarios; up to two latent cancer fatalities under the Centralization options

- Up to about two fatalities from nonradiological traffic accidents.

A more detailed discussion of accidents is found in Chapter 5, Volume 1 of this EIS.

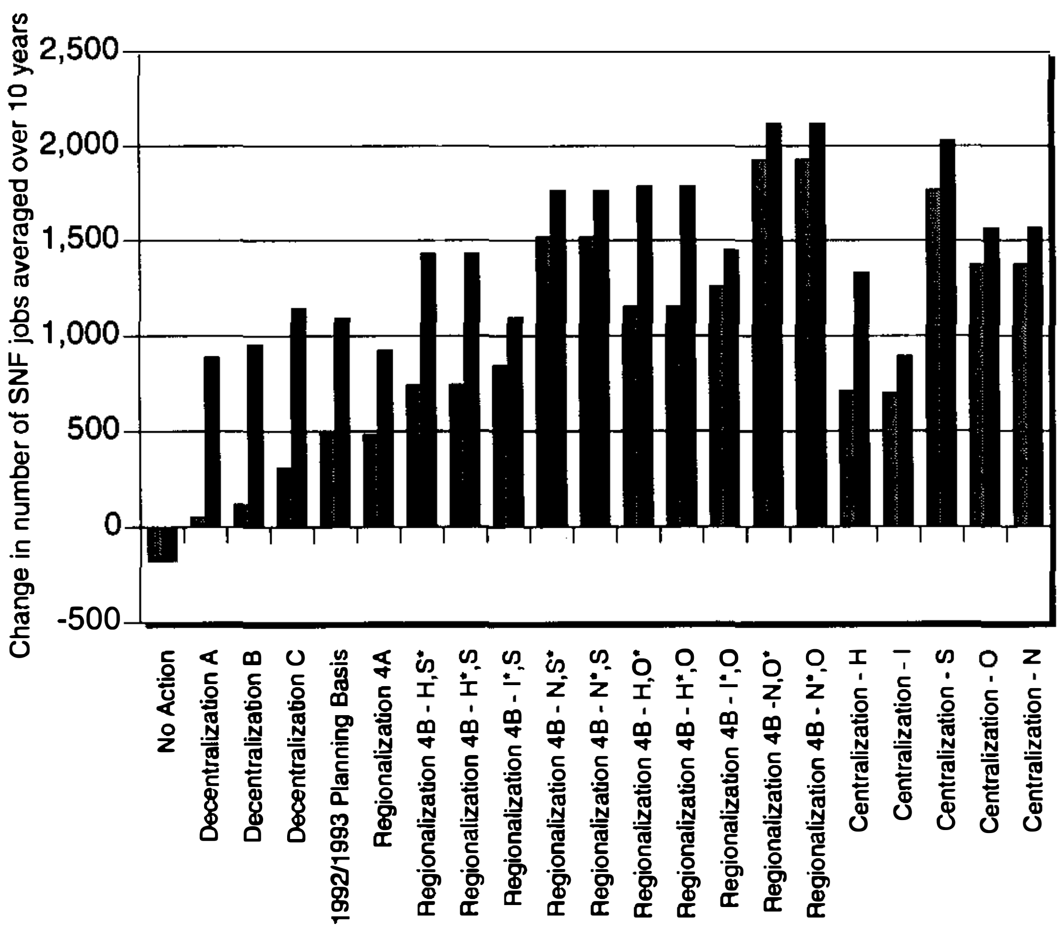
3.3.3 Employment Related to Spent Nuclear Fuel Management at DOE and Naval Sites

Under various alternatives, the total labor force involved in SNF management could decrease by 180 jobs or increase by more than 2,100 jobs averaged over the period 1995 to 2005, as compared to the 1995 baseline. This labor force is the sum of permanent employment in operating or maintaining new facilities and shorter term construction jobs. Figures 3-11 and 3-12 characterize the range of SNF jobs under each alternative. The number of jobs related to SNF management is small compared with the total number of jobs (2 to 4.5 percent) at the sites that would be involved in SNF management. SNF management-related jobs account for less than 4.5 percent of total employment at the sites and less than 8 percent of employment at any one site.

It is important to note that the relocation of large amounts of SNF under the Regionalization 4B alternative and the Centralization options would eventually result in closure of SNF management facilities at major DOE sites and, therefore, long-term job loss at the closed facilities. However, some of the job losses at closed facilities would be accompanied by job gains at the sites receiving the fuel shipments. In addition, from 1995 to 2005 several management actions already initiated at various sites to maintain a safe storage configuration for existing SNF will be completed, and much of the SNF would need to be stabilized before transport. In the near term, the combination of building facilities at some sites and stabilizing SNF before transport at other sites complicates estimating the near-term SNF employment situation.

Under the No Action alternative, employment would not increase substantially at any site, and the closure of the Expended Core Facility at the Idaho National Engineering Laboratory would result in a net loss of just over 500 jobs involved in SNF management following closure. The maximum number of jobs indicated in Figure 3-11 assumes processing for stabilization and reports the maximum number for options at each site.

For any of the alternatives, no more than an average additional 2,100 jobs over the period 1995 to 2005 would be required for implementation. Some of the larger SNF employment requirements (particularly those involving the Hanford Site) would be caused by the development and operation of processing facilities needed to stabilize stored SNF. If processing were not undertaken, less employment would be generated at those sites. In addition, the relocation of the Expended Core Facility to sites other than the Idaho National Engineering Laboratory would result in an increase of



Key:

Decentralization A: No examination of naval fuels
Decentralization B: Limited examination of naval fuels at Puget Sound Naval Shipyard
Decentralization C: Full examination of naval fuels at Idaho National Engineering Laboratory with spent nuclear fuel stored at naval sites
Regionalization 4A: Regionalization by fuel type
Regionalization 4B: Regionalization by geography

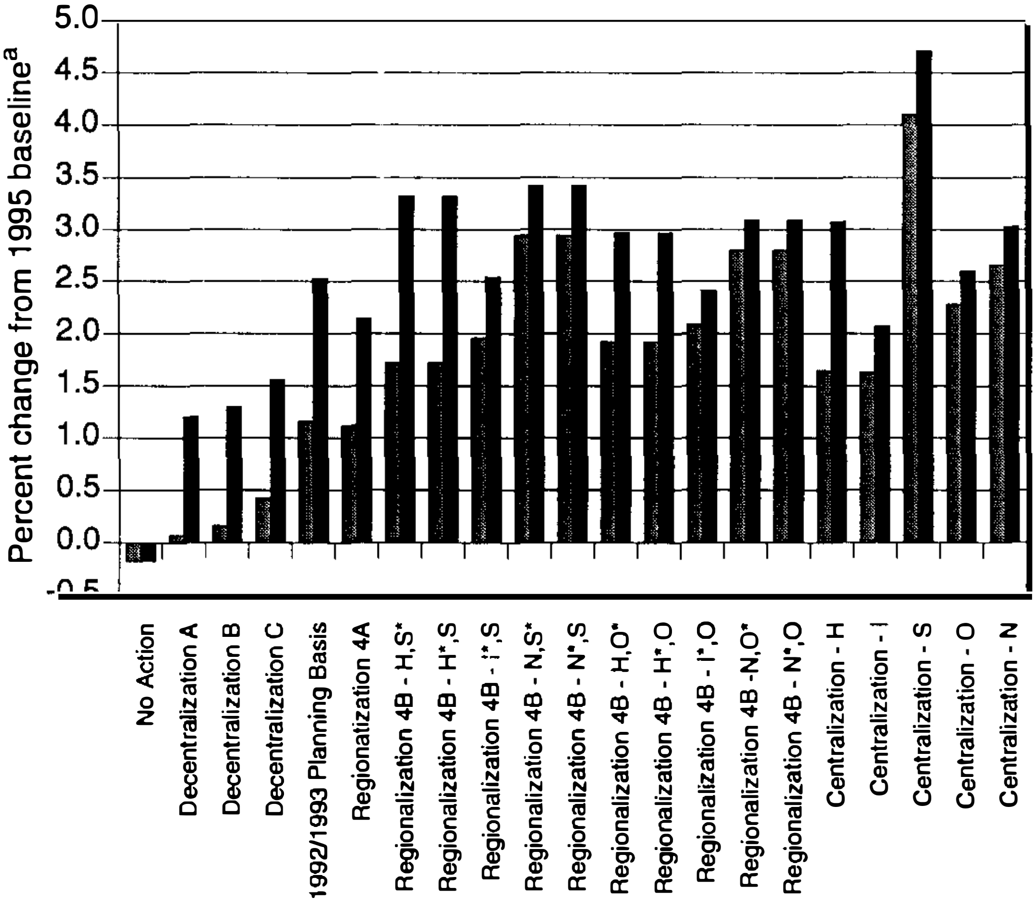
Site initials:
H: Hanford Site
I: Idaho National Engineering Laboratory
S: Savannah River Site
O: Oak Ridge Reservation
N: Nevada Test Site

Min[a]
Max[a]

* Location of Expended Core Facility

a. The maximum values occur with processing; the minimum values occur without processing.

Figure 3-11. Change in the number of jobs averaged over the years 1995 to 2005 for spent nuclear fuel management activities.



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Min[b]
Max[b]

* Location of Expended Core Facility

a. 1995 baseline is the sum of the employment at all sites involved in that alternative.

b. The maximum values occur with processing; the minimum values occur without processing.

Figure 3-12. Change in site employment between the years 1995 and 2005 for spent nuclear fuel management activities as a percent of 1995 baseline.

about 500 jobs per year in the support of naval SNF examinations at those sites and would result in a corresponding loss of approximately 500 jobs at the Idaho National Engineering Laboratory. However, regionalization with the Nevada Test Site as the Western Regional Site and the Oak Ridge Reservation as the Eastern Regional Site would result in the highest employment peak. The peak, estimated to be approximately 4,600 jobs in the year 2000, includes employment at sites preparing SNF for transport to the selected sites.

A more detailed discussion of socioeconomic impacts can be found in Chapter 5, Volume 1 of this EIS.

3.3.4 Generation of Radioactive Wastes

When SNF is stored onsite, very little high-level, transuranic, or mixed waste is generated (see Figure 3-13). These small quantities of radioactive wastes would usually be generated during stabilization activities. As a result, under the No Action alternative fewer than 20 cubic meters per year (26 cubic yards per year) of transuranic wastes would be generated from SNF management nationwide because SNF would not be stabilized. Under the other alternatives, where stabilization activities are assumed to occur, it is estimated that between 20 and 190 cubic meters (26 and 250 cubic yards) of high-level waste and between 20 and 90 cubic meters (26 and 120 cubic yards) of transuranic waste would be generated each year (Figure 3-13). The lower generation rates would occur in the Decentralization alternative, where small amounts of SNF would be transported among major DOE sites (and stabilization for transport would not be necessary). For other alternatives, greater amounts of SNF would be transported among sites; therefore, more SNF would require stabilization before transport and more waste would be generated. The difference between the minimum and maximum volume of waste generated results principally from the contribution attributable to processing for stabilization.

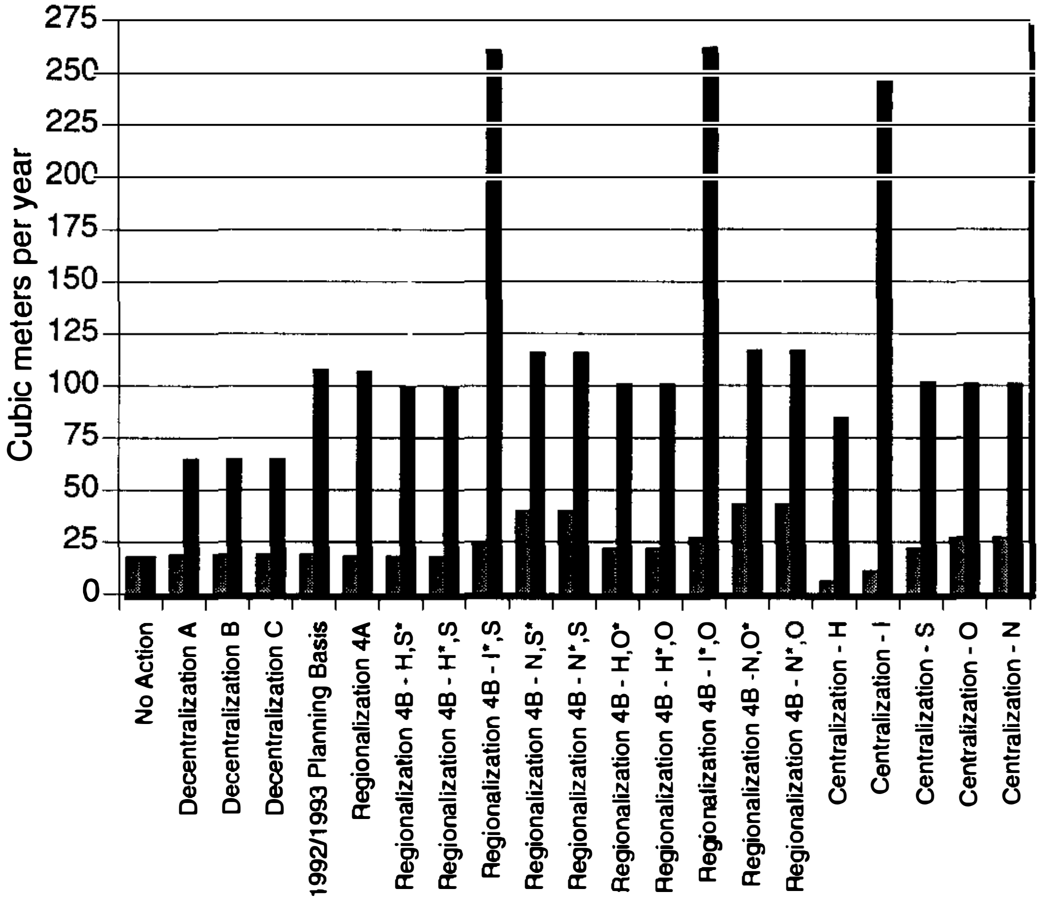
Low-level waste is also generated as a result of SNF management. Figure 3-14 indicates the estimated annual volume for each of the alternatives. As previously noted for high-level, transuranic, and mixed waste, the higher values are principally the result of processing for stabilization.

A more detailed discussion of radioactive waste generation under each alternative can be found in Chapter 5, Volume 1 of this EIS.

3.3.5 Impacts on DOE and Navy Missions

The concerns for the missions of DOE and the Navy relate to storing SNF safely, meeting obligations, preparing SNF for ultimate disposal, and examining naval SNF.

3.3.5.1 Impacts on DOE. The DOE mission regarding the safe storage of SNF is impacted in the No Action alternative. Under this alternative, DOE will initially suffer from a loss of margin



Key:

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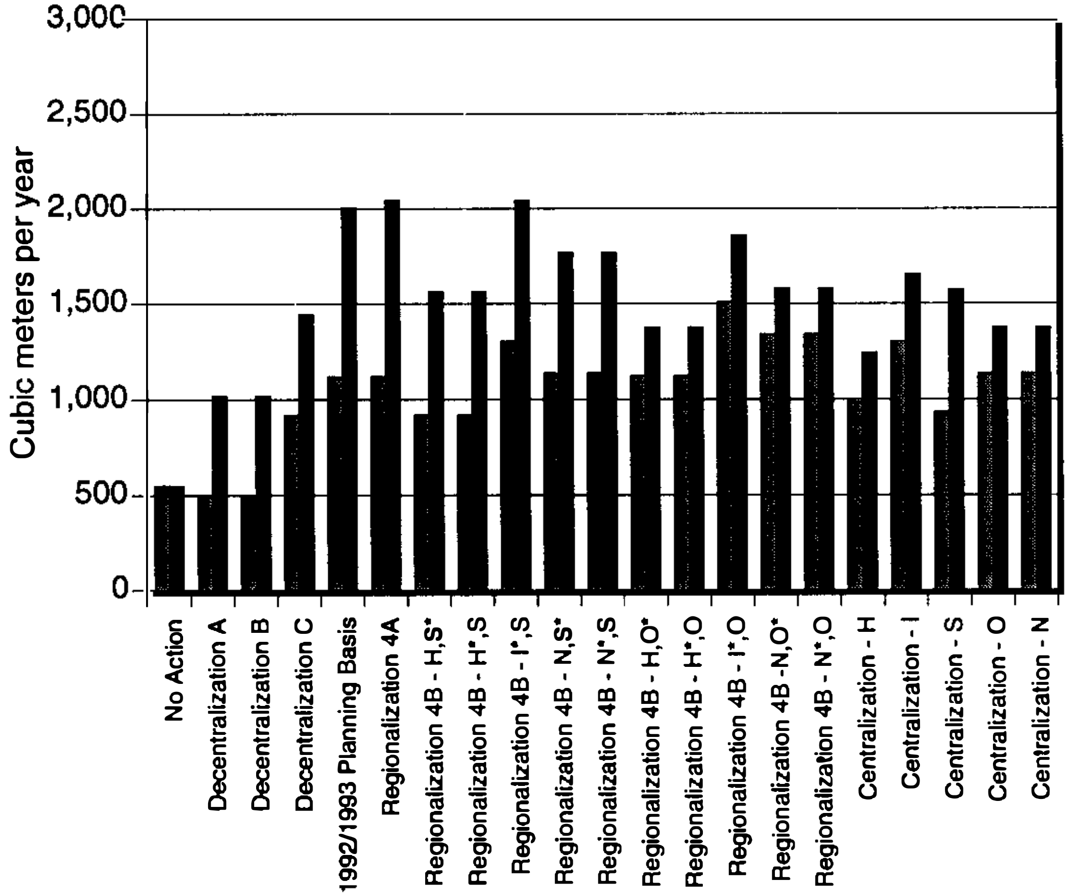
N: Nevada Test Site

Min[a]
Max[a]

* Location of Expended Core Facility

a. The maximum values occur with processing; the minimum values occur without processing.

Figure 3-13. Average volume of high-level, transuranic, and mixed waste generated per year over the years 1995 to 2005 for spent nuclear fuel management activities.



Key:

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N: Nevada Test Site

Min[a]
Max[a]

* Location of Expended Core Facility

a. The maximum values occur with processing; the minimum values occur without processing.

Figure 3-14. Average volume of low-level wastes generated per year over the years 1995 to 2005 for spent nuclear fuel management activities.

in storage capacity. In addition, DOE may be impacted by needing to make more frequent repairs to existing facilities (potentially losing the use of a facility because it is beyond repair). In time, there would be little or no flexibility for repairs under the No Action alternative.

Additionally, by limiting research and development to activities already approved, DOE's ability to safely store SNF would be impacted by being unable to conduct new research and development. The No Action alternative would not permit development of processing and other technologies except for those underway as of June 1995.

Under the No Action alternative, DOE would not satisfy its obligations associated with SNF from university reactors, other research reactors, and special-case commercial SNF. Also, under the No Action alternative, DOE might not be able to fulfill agreements with states or other Federal agencies that involve SNF, except those specific actions already in progress, unless the agreements are changed. Failure to meet the terms of these agreements would expose DOE to adverse legal actions. In addition, DOE would not proceed, as it has proposed, to establish a new policy for management of foreign research reactor fuel that contains United States origin uranium (see Section 1.2.4). These mission impacts could be avoided under any alternative but the No Action alternative.

The DOE recognizes a need, which is not yet well defined, to prepare SNF for its ultimate disposition. At this point, the processing and other technology required for ultimate disposition are not precisely known. Under the No Action alternative, no new facilities or new research and development would be allowed. The No Action alternative would not permit development of processing and other technologies except for those begun as of June 1995. Although the acceptance criteria for DOE-managed SNF have not yet been defined and repository disposal may permit canned SNF, alternative approaches for ultimate disposition must be developed. By not allowing this development under this alternative, DOE would be unable to meet one of the major goals of the SNF Management Program. For the No Action alternative, no facilities could be built for converting SNF to forms acceptable for disposition. In addition, with facilities storing SNF throughout the country, more canning or other processing facilities might be required than are currently planned. Building additional facilities at multiple locations would impede efficient disposition of SNF produced at small reactor sites. Other alternatives would allow research and development to proceed as deemed appropriate to support stabilization.

3.3.5.2 Impacts on the Navy. The Navy would incur large storage costs under the No Action and Decentralization alternatives. In addition, the Navy mission would be hindered if the full examination of fuels at an expended core facility were not possible. Full examination would not happen under the No Action alternative and Decentralization Options A and B. The examinations are a critical aspect of the Naval Nuclear Propulsion Program's ongoing advanced fuel research and development program. They provide engineering data on nuclear reactor environments, material behavior, and design performance. These data support

- The design of new reactors having extended lifetimes
- Continued safety of naval reactors
- Improvements in nuclear fuel performance and ship operational performance
- The operation of existing naval reactors by providing confirmation of their proper design and allowing maximum depletion of their fuel.
- The verification of engineering methods and models to design naval nuclear fuel.

Although it is difficult to quantify the benefits of an outstanding safety record and improved operational characteristics, increased core life yields an economic advantage—a reduction in the number of reactor cores that must be procured and in the number of refuelings that must be performed. It also results in less SNF being generated. Another advantage is the increased online availability of nuclear-powered ships with life-of-ship fuel, which would reduce the number of ships required. About $5 billion would be saved if life-of-ship fuels are developed, based on an assumed force structure of fewer than 100 nuclear-powered ships by 2005. Additional details can be found in Appendix D, Volume 1 of this EIS.

3.3.6 Cost of Implementation

The DOE prepared and issued in March 1995 a cost evaluation report (DOE 1995b) that provides insight for short- and long-term planning for DOE complex-wide SNF management. This report was also used to provide costs relevant to this EIS. This section provides potential costs associated with the management of DOE SNF for the 40-year period evaluated in this EIS.

3.3.6.1 Results. Table 3-9 provides a range of costs for interim storage. Because of the very broad scope associated with complex-wide SNF management and the uncertain nature of future actions, "best estimate" costs cannot be developed at this time. The degree to which existing facilities factor into a given alternative can vary. To account for this, each alternative was analyzed for two cost ranges to define the possible spread of cost for each alternative. The upper and lower cost ranges were defined as follows:

Upper Cost Range - Assumed construction of new facilities, except for a limited number judged adequate for 40 years.

Table 3-9. Cost results for storage only (billions of dollars).

Alternatives	Upper range	Lower range
No Action (1)	17.4	10.6
Decentralization—no examination (2A)	17.9	8.6
Decentralization—limited examination (2B)	18.1	8.9
Decentralization—full examination (2C)	20.1	10.8
1992/1993 Planning Basis (3)	18.0	9.4
Regionalization by fuel type (4A)	17.6	9.1
Regionalization by geography (4B)[a]	16.0	9.6
Centralization at Hanford (5A)	15.4	13.5
Centralization at Idaho National Engineering Laboratory (5B)	13.8	11.9
Centralization at Savannah River Site (5C)	15.1	9.5
Centralization at Oak Ridge Reservation (5D)	17.1	15.1
Centralization at Nevada Test Site (5E)	17.5	15.3

a. All options were considered, however, only Idaho National Engineering Laboratory and Savannah River Site costs are shown.

Lower Cost Range - Assumed existing facilities used at the Idaho National Engineering Laboratory and the Savannah River Site but no existing facilities used at Hanford. Facility upgrades were limited to Phase III vulnerability costs (DOE 1994c).

3.3.6.2 Discussion and Conclusions. Table 3-9 shows that Alternatives 1, 2A, 2B, 3, or 4A are roughly equivalent. This is because most of the SNF would be located at the same sites (Hanford, Idaho National Engineering Laboratory, and Savannah River Site) in each alternative. Alternative 4B costs less than Alternative 3 because all SNF would be moved to two sites (Idaho National Engineering Laboratory and Savannah River Site), which have existing infrastructures, and economies of scale (fewer sites cost less) dictate that two sites would be less costly than three. The table also shows that if new facilities are required, it would be least expensive to centralize SNF management at a site with existing SNF management infrastructure (that is, Alternatives 5A, 5B, or 5C). Transportation costs, which are typically 1 percent of total costs, would not be an overriding consideration in the selection of locations for SNF management.

In the lower cost range, if existing facilities can continue to be used, it would be least expensive to manage fuel under alternatives that maximize the use of sites with existing capabilities (that is, Alternatives 2A, 2B, 4A, or 4B). The centralization alternatives, which would require the construction of storage facilities, could cost up to $6.7 billion more that the least costly alternative (2A). Before drawing conclusions based on the lower cost range results, however, the reader should recognize that the selection of an approach using existing facilities, combined with a commitment to upgrade facilities [over and above correction of vulnerabilities (DOE 1994c)] may significantly change the cost comparisons. In this situation, cost would tend to increase toward the upper cost range.

Additional details can be found in DOE (1995b). This report is available in the DOE Public Reading rooms listed in the EIS, or upon request from the Office of Communications, DOE Idaho Operations Office at the address listed in the front of the EIS.

3.3.7 U.S. Nuclear Regulatory Commission Licensing Standards

DOE is proceeding with actions to implement safe, efficient, and cost-effective interim storage of its SNF before final disposition. The need for interim storage has led DOE to evaluate storage technologies and alternative management strategies to provide an optimum solution to storage challenges. Several commercial storage technologies under evaluation for DOE SNF have been licensed and regulated by the U.S. Nuclear Regulatory Commission. In addition, DOE SNF could eventually come under the jurisdiction of the U.S. Nuclear Regulatory Commission if it is to be disposed of in a geologic repository. Therefore, DOE is considering having any new interim storage facilities reviewed to determine whether they could meet U.S. Nuclear Regulatory Commission licensing standards. This approach, if implemented, would provide a testing ground for the development of the technical and administrative protocols between the U.S. Nuclear Regulatory Commission and DOE in the event that some type of U.S. Nuclear Regulatory Commission regulatory oversight occurs in the future.

4. AFFECTED ENVIRONMENT

This chapter contains overviews of the potentially affected environments at and around the existing and potential sites under consideration for management of SNF within the various alternatives addressed in the EIS. Because of the large amount of information necessary to adequately characterize the affected environments at these sites, the space available in this chapter limits the presentations to summaries of the relevant key site characterization information. Consequently, the detailed descriptions of the affected environments are presented under separate cover as self-contained appendices to Volume 1. This approach allows the reader to compare the relative similarities and differences among the sites without having to review thousands of pages of text. These separate site-specific appendices also contain the detailed analyses of environmental impacts associated with each alternative that are rolled up and summarized in Chapter 5.

The site-specific appendices under separate cover are organized as follows:

Appendix	Focus of appendix
A	Hanford Site
B	Idaho National Engineering Laboratory
C	Savannah River Site
D	Naval Nuclear Propulsion Program
E	Other Generator/Storage Locations
F	Nevada Test Site and Oak Ridge Reservation

This chapter focuses on details about resources most likely to be affected by the actions evaluated under the various alternatives. Consequently, not every category of information addressed in the site-specific appendices is rolled up for presentation here.

4.1 Hanford Site

This section summarizes the environmental characterization information on the Hanford Site, Richland, Washington. This information has been used in evaluating environmental impacts that might result from implementing the various alternatives for management of SNF at the Hanford Site. More detailed information characterizing the affected environment of the Hanford Site is presented in Appendix A, under separate cover.

The Hanford Site covers about 1,450 square kilometers (560 square miles) of the southeastern part of the State of Washington (see Figure 4-1). It is located in parts of Benton, Grant, and Franklin Counties. The nearest city is Richland, Washington, which borders the Hanford Site on its southeast corner. About 380,000 people live within an 80-kilometer (50-mile) radius of the Hanford Site.

The population within 80 kilometers (50 miles) of the Hanford Site has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Hanford Site is shown to be 20 percent minority and 18 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

Approximately 6 percent of the Hanford Site is occupied by operational facilities. Waste management and SNF processing activities and waste storage occur near the center of the Hanford Site. Eight retired plutonium production reactors and the N Reactor are located on the south side of the Columbia River, and the nuclear research and development laboratories are located in the southeastern part of the Hanford Site near the city of Richland. The majority of Hanford's SNF is stored in basins in 100-KW and 100-KE. The Fast Flux Test Facility is located in the east-central area of the Hanford Site. The remaining area is undeveloped land that provides for buffer zones for the operating areas. The Hanford Site is a Superfund site, listed on the National Priority List.

The land adjacent to the Hanford Site is either urbanized or agricultural. Agricultural areas include irrigated and dry-land farming and grazing.

In 1992, the Hanford Site employed 16,100 people, accounting for almost 25 percent of the nonagricultural employment in Benton and Franklin Counties. Other major employers include the Siemens Nuclear Power Corporation, Sandvik Special Metals, Iowa Beef Processors, Boise Cascade, and Burlington Northern Railroad.

As of 1992, 248 prehistoric archaeological sites were recorded by the Hanford Cultural Resources Laboratory of the Pacific Northwest Laboratory. Of the 48 sites on the *National Register of Historic Places*, two are single sites and the remainder are in seven archaeological districts. Archaeological sites include remains of numerous pithouse villages, campsites, cemeteries along the river banks, spirit quest monuments, hunting camps, game drive complexes, quarries in mountains and rock bluffs, hunting/kill sites in lowland stabilized dunes, and small temporary camps near perennial sources of water away from the river. Native Americans have inhabited the land around the Hanford Site since prehistoric times. The Wanapum and the Chamnapum bands of the Yakama tribe were the area's primary inhabitants, being joined by Palus people, Walla Walla people, and Umatilla people for fishing the Hanford Reach of the Columbia River. These people retain traditional secular and religious ties to the region. Some native plant and animal foods, which are used in religious ceremonies performed by members of the Washane or Seven Drums religion, can be found on the Hanford Site.

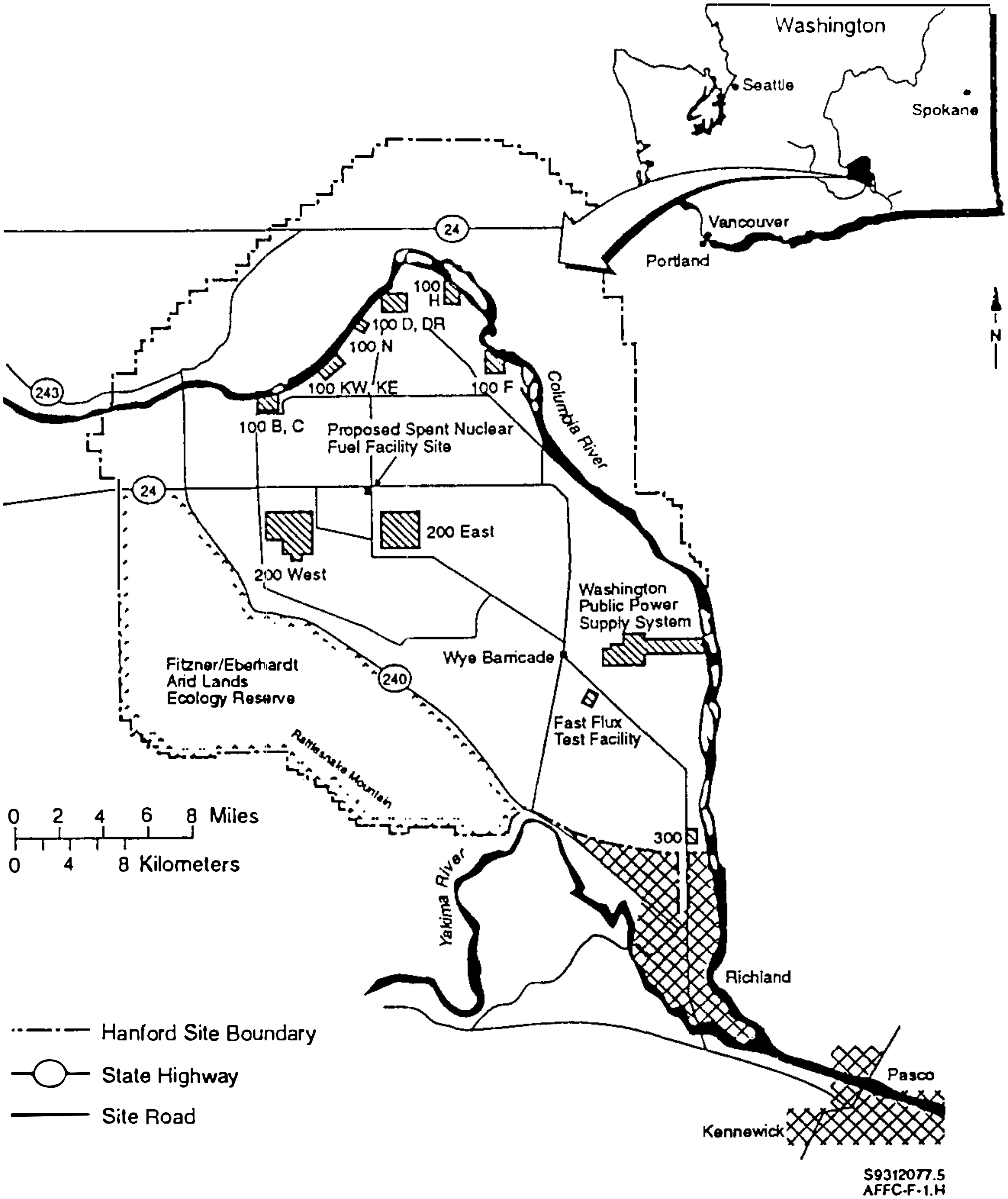


Figure 4-1. Hanford Site location and site map.

The Hanford Site is on a low-lying, modified alluvial plain of the Columbia River. Altitudes range from about 105 meters (345 feet) in the southeast part to about 245 meters (804 feet) in the northwest corner. The Hanford Site is bounded to the east by the Columbia River and the White Bluffs of the Ringold Formation, to the southeast by the city of Richland, to the west by the Rattlesnake Hills, and to the north by the Saddle Mountain.

The principal geologic features beneath the Hanford Site, listed from the oldest to the youngest, include the Columbia River Basalt Group (basaltic lava flows), the Ringold Formation (weakly cemented coarse sandy gravel to compacted silt and clay), and a series of deposits called the Hanford formation (coarse gravel and sand). These units are covered by a few meters or less of recent alluvial or windblown sands. Other than gravel, there are no geologic resources of economic value on the Hanford Site.

The area of the Hanford Site is historically of low-to-moderate seismicity. On a scale of 0 to 4, the Hanford Site is in a Uniform Building Code Seismic Risk Zone 2B. (Zone 0 represents little damage, and is subject to the greatest seismic risk.) The largest seismic shock near the Hanford Site on record was approximately 4.5 to 5 0 on the Richter scale and Modified Mercalli Intensity of V; it was recorded in Corfu, 35 kilometers (22 miles) north of the Hanford Site in 1918. A Modified Mercalli Intensity V quake occurred in 1973. Many lower intensity earthquakes have occurred in the Columbia Plateau and on the Hanford Site as part of "earthquake swarms," which are clusters of several small earthquakes occurring over a short period of time.

The Hanford Site is located approximately 160 kilometers (100 miles) to the east of the Cascade Range, which includes several volcanic vents. The great distance eliminates the potential for lava flows from these volcanoes reaching the Hanford Site. The foreseeable volcanic effects at the Hanford Site are limited to windborne volcanic ash.

The general climate of the Hanford Site is hot and dry in summer and cool in winter. The average annual precipitation is 16 centimeters (6.3 inches), most of which falls during the winter. On average, thunderstorms occur 11 days per year, mostly during the summer. Tornadoes are extremely rare, occurring within 160 kilometers (100 miles) of the Hanford Site about once in 3 years. Air quality in the Hanford region is well within the State of Washington and U.S. Environmental Protection Agency standards for criteria pollutants, except that short-term particulate concentrations occasionally exceed the PM-10 standard. (PM-10 is particulate matter defined as suspended particulates with an aerodynamic diameter less than 10 micrometers.) The Class I Area (areas where degradation of air quality is to be severely restricted) nearest to the Hanford Site is at Goat Rocks Wilderness Area, 145 kilometers (90 miles) away.

Two rivers pass through or near the Hanford Site. The Columbia River passes through the northern part of the Hanford Site and forms part of the eastern boundary. The average daily flow of this river is 3,400 cubic meters per second (120,100 cubic feet per second). The Yakima River, with an average flow of 104 cubic meters per second (3,673 cubic feet per second), is located near the southern portion of the Hanford Site. Wastewaters are discharged to several ponds on the Hanford Site and the Columbia River. In addition to these surface waters, there are two intermittent creeks that form the remainder of the surface waters on the Hanford Site. The flood areas of these rivers and streams include some areas where facilities are located, but flooding is well-controlled by upstream dams on the Columbia River. Minor flooding (away from facilities) occurs from other watercourses. While specific information on the 100-year floodplain has not been defined, the projected extent of the maximum probable flood, which is greater than the area of inundation expected from a 100-year flood, would not impact proposed SNF facilities. More details on flooding, including that induced by dam failures, are given in Section 4 of Appendix A of Volume 1.

The water quality of the Columbia River is high, with minor increases in constituents resulting from Hanford Site discharges. Radiological monitoring shows low levels of radionuclides in samples of Columbia River water. Tritium, iodine-129, and uranium are found in somewhat higher concentrations downstream of the Hanford Site than upstream, but are well below concentration guidelines established by the U.S. Environmental Protection Agency drinking water standards. Nonradiological water quality parameters measured during 1989 were similar to those reported in previous years and were within Washington State Water Quality Standards.

Part of the water supply at the Hanford Site and for the nearby Tri-Cities is the Columbia River. In 1991, the combined water use for Richland, Pasco, and Kennewick was 4.3×10^7 cubic meters (11.38 billion gallons). Richland and Kennewick derive a portion of their water used from nearby groundwater wells and rely on groundwater as a sole source of water from November through March each year. Additional references and more detailed information on groundwater are in Appendix A of Volume 1.

In 1993, several radionuclides and nonradioactive chemicals were present in unconfined aquifers located beneath the Hanford Site in some locations at levels exceeding U.S. Environmental Protection Agency drinking water standards and/or DOE Derived Concentration Guides. These constituents are listed, as follows: radiological constituents—tritium, strontium-90, cobalt-60, antimony-125, technetium-99, iodine-129, cesium-137, uranium, and plutonium; and nonradiological constituent—nitrate, chromium, trichloroethylene, cyanide, fluoride, carbon tetrachloride, and chloroform. Groundwater beneath the Hanford Site is not used for human consumption or food production with the exception of a well utilized for drinking at the Fast Flux Test Facility visitor center. Above-background levels of tritium and iodine-129 have been detected in this well; however, these levels are well below U.S. Environmental Protection Agency drinking water standards.

DOE asserts a federally reserved water withdrawal right with respect to the Hanford Site operations. Current withdrawals from the Columbia River occur under this assertion. Of the water consumed from surface waters in the vicinity of the Hanford Site, 13 percent is used for industrial purposes. The Hanford Site uses 41 percent of the water targeted for industrial use.

The Hanford Site is a shrub-steppe environment dominated by cheatgrass and sagebrush, but it includes 10 different types of plant communities. This plant environment supports 12 species of amphibians and reptiles, 39 species of mammals, and numerous bird and insect species. Deer and elk are the major large animals, and coyotes are the major mammalian predators. Wetlands of varying size exist along the Columbia River and support extensive stands of willows, grasses, aquatic plants, and other plants. In the Hanford Reach of the Columbia River, 44 species of fish have been identified. The Hanford Reach is also used by various salmon and trout species as a spawning area and a migration route to and from upstream spawning areas. Four threatened or endangered plants classified by the State of Washington exist on the Hanford Site, as well as seven species of threatened or endangered birds or mammals and one insect species. The insect species and three of the bird species are federally listed.

No federally listed threatened or endangered species have been observed at the proposed SNF site. However, two Federal and/or state candidate species, the loggerhead shrike (Federal and state candidate) and sage sparrow (state candidate), were observed during a survey of the proposed SNF site. The sagebrush habitat at the proposed site is considered priority habitat by the State of Washington for the loggerhead shrikes, sage sparrows, burrowing owls (state candidate), pygmy rabbits (Federal candidate and state threatened), sage thrashers (state candidate), western sage grouse (Federal and state candidate), and sagebrush voles (state monitored). Although burrowing owls were not observed at the site, ground squirrel burrows used by burrowing owls and owl pellets were observed during the survey. No evidence of the other species were found at the proposed site. The closest known ferruginous hawk (Federal candidate and state-threatened species) nest is approximately 8.9 kilometers (5.5 miles) northwest of the site. The proposed site should be considered as comprising a portion of the foraging range of this species.

The Tri-Cities (Richland, Kennewick, and Pasco) serve as a regional transportation center with major air, land, and river connections. The Tri-Cities area has four major highways: U.S. Routes 12 and 395, State Route 240, and Interstate 82. State Route 240 traverses the Hanford Site from southeast to northwest. The Burlington Northern and Union Pacific railroads connect the area to more than 35 states. Docking facilities exist at the ports of Benton, Kennewick, and Pasco. The Tri-Cities Airport, located in Pasco, provides daily passenger and freight services.

For the years 1991 to 1993, the potential collective dose to the population within 80 kilometers (50 miles) from all Hanford Site effluents was calculated to be 0.9, 0.8, and 0.4 person-rem, respectively. In 1993, the dose to the maximally exposed offsite individual was calculated to be 0.00003 rem (0.03 millirem) per year from all exposure pathways. For perspective, collective dose to the same population from natural background radiation was calculated to be about 100,000 person-rem from an average individual dose of 0.3 rem (300 millirem) per year.

In 1993, about 14,500 individuals were monitored at the Hanford Site. Of those monitored, 11,000 were classified as radiation workers with a collective dose of 200 person-rem and an average annual dose equivalent of 0.02 rem (20 millirem) per individual with measurable doses. A subset of Hanford radiation workers associated with SNF storage at 100 K Basins averaged doses of 0.4 rem (400 millirem) per year. These averages are well below the 10 CFR Part 835 radiation dose limit of 5 rem (5,000 millirem) per year and the DOE Administration Control Level of 2 rem (2,000 millirem) per year for occupational exposure.

Electricity in the region is provided by several different entities, but it is ultimately generated by the Bonneville Power Administration. About 74 percent of the region's installed generating capacity is hydroelectric. Power for the Hanford Site is purchased wholesale from the Bonneville Power Administration, amounting to greater than 550 megawatts in 1988. Because of the reliance on hydropower, annual production is variable, averaging 16,400 megawatts of capacity.

Major incorporated areas in Benton and Franklin Counties are served by municipal wastewater treatment systems. The unincorporated areas are served by onsite septic systems.

High-level radioactive waste has been accumulating at the Hanford Site since 1944 in 149 single-shell tanks—no new waste has been added to these tanks since 1980. Much of the liquid waste from single-shell tanks has been transferred to newer double-shell tanks for safer storage. Transuranic wastes were disposed of onsite before 1970 in unlined trenches. Since 1970, transuranic wastes have been stored in abovegrade storage facilities. As of 1991, there were about 120,000 cubic meters (157,000 cubic yards) of transuranic waste buried or in retrievable storage. Mixed low-level waste totaling 16,745 cubic meters (21,902 cubic yards) was buried at the Hanford Site from 1987 to 1991. Another 4,225 cubic meters (5,526 cubic yards) of mixed waste has accumulated in storage. In 1992, 56,245 kilograms (124,000 pounds) of mixed low-level waste was generated. From 1944 to 1991, approximately 558,916 cubic meters (731,030 cubic yards) of low-level waste was buried at the Hanford Site. In 1991, 5,300 cubic meters (6,932 cubic yards) of low-level waste was generated at the Hanford Site. In 1992, 619,268 kilograms (1,365,000 pounds) of hazardous waste was generated. Mixed wastes are 99 percent tank wastes at the Hanford Site resulting from 108 different waste streams. Hazardous wastes generated in 1995 from SNF are expected to total 2.2 cubic meters (2.9 cubic yards). In 1992, industrial solid waste totaled 22,213 cubic meters (29,054 cubic yards) and asbestos totaled 1,017 cubic meters (1,330 cubic yards). A total of 1,484 hazardous chemicals are reported at the Hanford Site at over 783 locations, and they are found in 2,926 different hazardous materials. In 1992, the Emergency Planning and Community Right-to-Know Act reporting threshold was exceeded for 53 hazardous chemicals.

4.2 Idaho National Engineering Laboratory

This section summarizes environmental characterization information on the Idaho National Engineering Laboratory. This information has been used to evaluate impacts at the Idaho National Engineering Laboratory under various alternatives for management of SNF. More detailed information characterizing this Idaho National Engineering Laboratory is presented in Appendix B, under separate cover.

The Idaho National Engineering Laboratory is located on approximately 2,300 square kilometers (890 square miles) of land in southeastern Idaho and contains nine major facility areas (see Figure 4-2). It is located primarily within Butte County, but portions of the Idaho National Engineering Laboratory are also located in Bingham, Jefferson, Bonneville, and Clark Counties. The Idaho National Engineering Laboratory is roughly equidistant from Salt Lake City, Utah, and Boise, Idaho. Cities near the Idaho National Engineering Laboratory include Idaho Falls to the east, Blackfoot to the southeast, Pocatello to the south-southeast, and Arco to the southwest. Yellowstone National Park is 149 kilometers (90 miles) to the east.

Categories of land use at the Idaho National Engineering Laboratory include facility operations, grazing, general open space, and infrastructure, such as roads. About 2 percent of the total Idaho National Engineering Laboratory area [4600 hectares (11,400 acres)] is used for facilities and operations. The Idaho National Engineering Laboratory is a Superfund site, listed on the National Priority List.

The region of influence for the Idaho National Engineering Laboratory is a seven-county area comprising Bingham, Butte, Bonneville, Clark, Jefferson, Bannock, and Madison counties. The region of influence had a 1990 population of 219,713. Historically, the regional economy has relied predominantly on farming and ranching. Mining is also an important component of the regional economy.

The population within an 80-kilometer (50-mile) circle centered at Argonne National Laboratory-West on the Idaho National Engineering Laboratory has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Idaho National Engineering Laboratory is shown to be 7 percent minority and 14 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

During fiscal year 1990, the Idaho National Engineering Laboratory directly employed approximately 11,100 personnel, accounting for almost 12 percent of the total regional employment. Approximately 38,000 persons, or 17 percent of the total regional population, were directly supported by employment associated with the operation of the Idaho National Engineering Laboratory. In 1992, the total direct Idaho National Engineering Laboratory employment was approximately 11,600 jobs. The total number of jobs at the Idaho National Engineering Laboratory is projected to decrease to approximately 8,620 in fiscal year 1995 and to approximately 7,250 in fiscal year 2004.

More than 1,500 prehistoric and historic archaeological resources have been identified in the Idaho National Engineering Laboratory area, but only 4 percent of the Idaho National Engineering

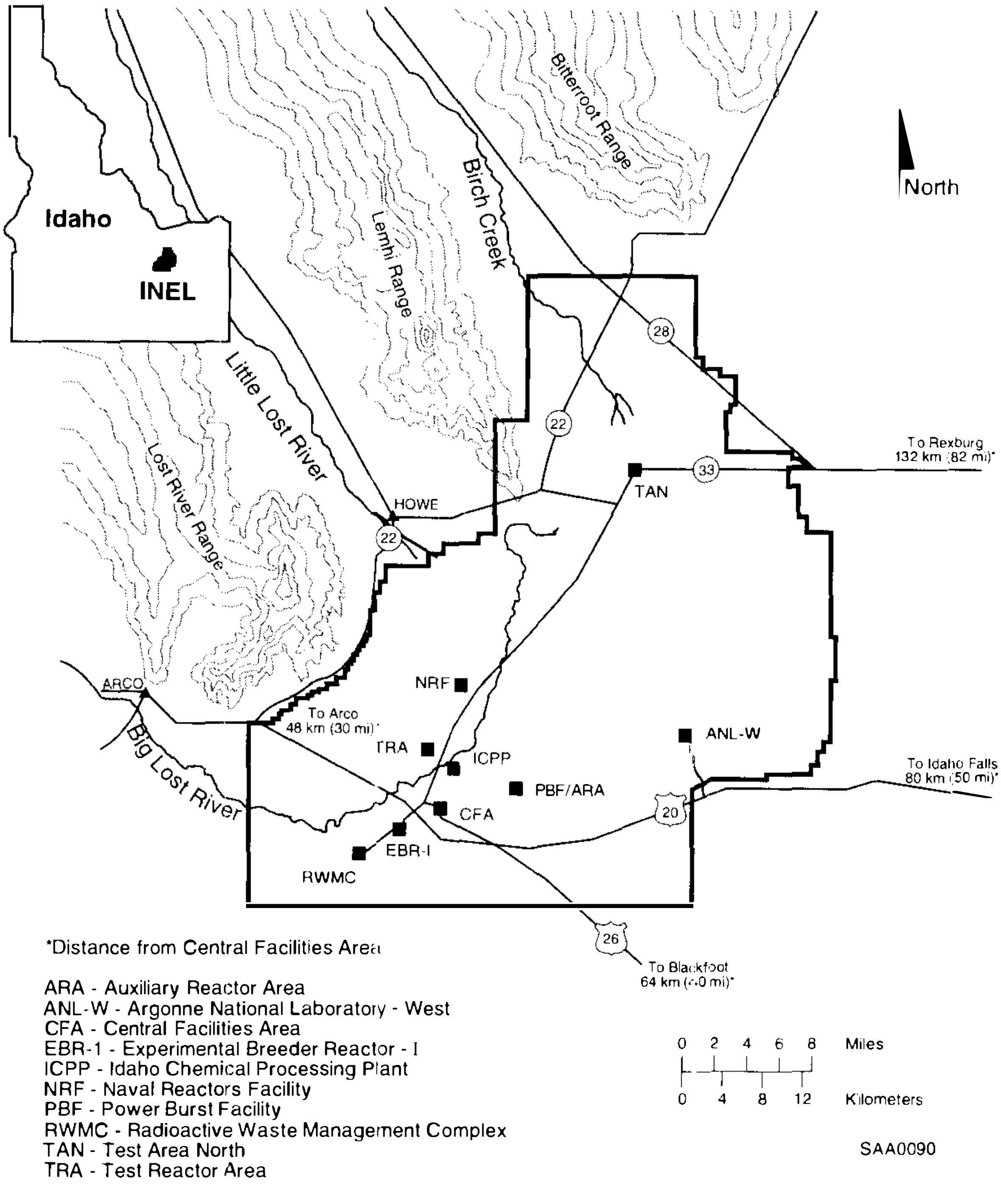


Figure 4-2. Idaho National Engineering Laboratory location and site map.

Laboratory has been surveyed, mostly near major facility areas. The resources identified include prehistoric and historic sites and isolates. Although not formally evaluated, these sites are considered potentially eligible for nomination to the *National Register of Historic Places*; the isolates have been categorized as unlikely to meet eligibility requirements. The Experimental Breeder Reactor-I is listed on the *National Register of Historic Places*, and other structures could potentially be listed. The Shoshone-Bannock Tribes are the region's primary Native American residents. Because they believe the land is sacred, the entire Idaho National Engineering Laboratory reserve is potentially culturally important to them. Cultural resources, to the Shoshone-Bannock peoples, include all forms of traditional lifeways and usage of all natural resources. This includes not only prehistoric archaeological sites, which are important in religious or cultural heritage context, but also features of the natural landscape, air, plant, water, or animal resources that might have special significance. DOE has committed to additional interaction and exchange of information with the Shoshone-Bannock Tribes at the Fort Hall Reservation.

The northwestern edge of the Eastern Snake River Plain, where the Idaho National Engineering Laboratory is located, is bordered on the north and west by the Bitterroot, Lemhi, and Lost River mountain ranges. A number of inactive volcanic buttes also form part of the Idaho National Engineering Laboratory landscape.

The Eastern Snake River Plain forms a broad, northeast-trending, crescent-shaped trough with low relief comprised primarily of basaltic lava flows. These flows at the surface range in age from 1.2 million to 2,100 years. The surface of the Eastern Snake River Plain is comprised primarily of basaltic lava flows with thin, discontinuous, interbedded deposits of wind-blown loess and sand, waterborne alluvial fan and floodplain alluvial sediments, and rhyolitic domes formed 1,200,000 to 300,000 years ago.

The Eastern Snake River Plain is on an area of low seismicity that is adjacent to the seismically active Intermountain Seismic Belt and Centennial Tectonic Belt and lies in Uniform Building Code Seismic Risk Zones 2B and 3. The largest recorded earthquake in the Centennial Tectonic Belt occurred on October 28, 1983, near Borah Peak, Idaho, and had a moment magnitude of 6.9 (surface wave magnitude of 7.3). The epicenter was about 90 to 100 kilometers (56 to 68 miles) from the Idaho National Engineering Laboratory. The largest recorded earthquake within the Intermountain Seismic Belt surface wave (Richter scale magnitude 7.5) occurred on August 17, 1959, near Hebgen Lake, Montana, with an epicenter 145 kilometers (90 miles) northeast of the Idaho National Engineering Laboratory. In addition to these earthquakes, a total of 29 earthquakes greater than magnitude 5.5 have occurred within 322 kilometers (200 miles) of the Idaho National Engineering Laboratory since 1884. The Idaho National Engineering Laboratory lies in a potentially active but long-time dormant volcanic area. The conditional probability of basaltic volcanism affecting a south-central area of the Idaho National Engineering Laboratory is one incident in 40,000 to 100,000 years. The probability of volcanic impact on Idaho National Engineering Laboratory facilities further north is estimated to be less than one incident in every million years or longer.

Within Idaho National Engineering Laboratory boundaries, the geologic resources found or produced are sand, gravel, and pumice. Several quarries or pits maintain supply material for various onsite construction projects.

The general climate of the Idaho National Engineering Laboratory is characterized by average seasonal temperatures that range from -7.3°C (18.8°F) in winter to 18.2°C (64.8°F) in summer, with an annual average temperature of about 5.6°C (42°F). Annual precipitation is light, averaging 221 millimeters (8.71 inches). Snowfall averages 701 millimeters (27.6 inches) per year.

Although the Idaho National Engineering Laboratory is in a belt of prevailing westerlies, these winds are normally channeled by the adjacent mountain ranges into southwest wind. The annual average windspeed measured at the 6.1-meter (20-foot) level at the Central Facilities Area weather station is 3.4 meters per second (7.5 miles per hour). Monthly average values range from 2.3 meters per second (5.1 miles per hour) in December to 4.2 meters per second (9.3 miles per hour) in April and May. The highest hourly average nearground windspeed measured at the Idaho National Engineering Laboratory is 22.8 meters per second (51 miles per hour).

Severe weather, other than thunderstorms, is uncommon. Five funnel clouds (that is, tornadoes not touching the ground) and no tornadoes have been reported between 1950 and 1988.

Neither the Idaho National Engineering Laboratory nor the surrounding counties is designated as a nonattainment area (40 CFR Part 81.313) with respect to any of the National Ambient Air Quality Standards (40 CFR Part 50). The Idaho National Engineering Laboratory is located in a Class II area. Three prevention of significant deterioration (40 CFR Part 52.21) Class I ambient air quality areas have been designated in the vicinity of the Idaho National Engineering Laboratory: Craters of the Moon Wilderness Area, Idaho, 53 kilometers (33 miles) west-southwest from the center of the Idaho National Engineering Laboratory; Yellowstone National Park, Idaho-Wyoming, 143 kilometers (89 miles) east northeast from the center of the Idaho National Engineering Laboratory; and Grand Teton National Park, Wyoming, approximately 145 kilometers (90 miles) east from the center of the Idaho National Engineering Laboratory.

The types and amounts of nonradiological emissions from Idaho National Engineering Laboratory facilities and activities are similar to those of other industrial complexes of similar size. Baseline concentrations from criteria and hazardous/toxic air pollutants are within applicable standards and guidelines. Radioactive emissions occur from Idaho National Engineering Laboratory facilities; the calculated annual dose to the maximally exposed offsite individual is 0.00005 rem (0.05 millirem).

Essentially no surface water bodies drain the Idaho National Engineering Laboratory—all creeks and streams arise in the mountains and much of their water is diverted for irrigation. There is little flow of water onsite. Water that does reach the Idaho National Engineering Laboratory through the Big Lost River flows past the Test Reactor Area/Idaho Chemical Processing Plant area before going below ground or may be diverted by an onsite dam during heavy flows onto the southern part of the Idaho National Engineering Laboratory. The remainder of the water infiltrates near Test Area North. All rivers and streams are intermittent. No surface water runs off of the Idaho National Engineering Laboratory.

The Idaho National Engineering Laboratory does not withdraw or use surface water for operations, nor does it discharge effluents to natural surface water. However, the three surface water bodies at or near the Idaho National Engineering Laboratory (Big and Little Lost Rivers and Birch Creek) have the following designated uses: agricultural water supply, cold-water biota, salmonid spawning, and primary and secondary contact recreation. In addition, waters in the Big Lost River and Birch Creek have been designated for domestic water supply and as special resource waters.

Depths to the water table at the Idaho National Engineering Laboratory range from 61 meters (200 feet) in the north to 274 meters (900 feet) in the south. Flows in the largely unconfined Snake River Plain Aquifer are generally to the southwest. Groundwater flows at speeds ranging from 1.5 to 6.1 meters per day (5 to 20 feet per day). The water quality of the aquifer is generally good, and it is designated a sole source aquifer. As of 1992, concentrations of iodine-129, cobalt-60, strontium-90, and cesium-137 had exceeded the U.S. Environmental Protection Agency's maximum contaminant levels for drinking water established for radionuclides in localized areas within the aquifer inside the Idaho National Engineering Laboratory boundary. However, concentrations of these radionuclides in groundwater are generally decreasing over time. This decrease is attributed to improved waste management practices, reduced discharges, adsorption, and radioactive decay. Individual maximum contaminant levels have not been established for plutonium-238, plutonium-239, plutonium-240, and americium-241. However, these radionuclides have not been detected above the established limits for gross alpha particle activity or the proposed adjusted gross alpha activity maximum contaminant levels for drinking water. Extremely low concentrations of iodine-129 and tritium have migrated offsite, but both concentrations are well below the current U.S. Environmental Protection Agency's maximum contaminant levels for drinking water.

Of the nonradioactive metals, only total chromium has exceeded maximum contaminant levels established by the Safe Drinking Water Act. Nitrates have exceeded the maximum contaminant levels in the past near the Idaho Chemical Processing Plant but have been below the maximum contaminant level since 1988. Carbon tetrachloride, chloroform, 1,1-dichloroethylene, cis-1,2-dichloroethylene, trans-1,2-dichloroethylene, tetrachloroethylene, trichlorethylene, and vinyl chloride have exceeded maximum contaminant levels at various times over the last 5 years.

Groundwater use on the Snake River Plain includes irrigation, food processing and aquaculture, and domestic, rural, public, and livestock supply. Water use for the upper Snake River drainage basin and the Snake River Plain Aquifer was 16.4×10^9 cubic meters (4.3×10^{12} gallons) per year in 1985. Most of this water is for agriculture. The aquifer is the source of all water used at the Idaho National Engineering Laboratory. Site activities withdraw an average of 7.4 million cubic meters (1.9 billion gallons) per year, with a substantial portion discharged to the surface or subsurface and eventually returned to the aquifer. This withdrawal represents approximately 0.4 percent of the water consumed from the Eastern Snake River Plain Aquifer, or 53 percent of the maximum yield of a single typical irrigation well.

Total consumption of water at the Idaho National Engineering Laboratory averages 0.25 cubic meters per second (8.8 cubic feet per second). DOE holds a Federal Reserved Water Right for the Idaho National Engineering Laboratory, which permits a groundwater pumping capacity of 2.3 cubic meters per second (80 cubic feet per second), though this capacity is not utilized. The DOE priority on water rights dates back to the establishment of the Idaho National Engineering Laboratory.

Localized flooding can occur at the Idaho National Engineering Laboratory when the ground is frozen and melting snow combines with heavy spring rains. Test Area North was flooded in 1969; and, also in 1969, extensive flooding caused by snowmelt occurred in the lower Birch Creek Valley. Studies have shown that both the 25- and 100-year, 24-hour rainfall/snowmelt storm event could cause flooding within the Radioactive Waste Management Complex. The drainage system, including dikes and erosion prevention features designed to mitigate potential surface water flooding, have been upgraded. The area inundated by a probable maximum flood in the vicinity of Mackay Dam, 75 kilometers (45 miles) northeast of the Idaho National Engineering Laboratory, coupled with a dam failure, probably exceeds the areas expected to be inundated by 100- and 500-year floods of the Big Lost River at the Idaho National Engineering Laboratory. Analyses indicate that the shallow depths and low flow velocities resulting from the Mackay probable maximum flood and dam failure would not have a significant impact on Idaho National Engineering Laboratory facilities.

Onsite vegetation is predominantly shrub-steppe. Communities range from shadscale-steppe vegetation at lower altitudes, through sagebrush and grass dominated communities, to juniper woodlands along the foothills of nearby mountains and buttes. Big sagebrush and rabbitbrush are the most common shrub species. Indian ricegrass, wheatgrasses, squirreltail, and cheatgrass are common grasses. Common forbs include phlox, mustards, and Russian thistle.

About 270 vertebrate species have been observed onsite. These include 46 mammal, 204 bird, 10 reptile, 2 amphibian, and 9 fish species. Major fur-bearing species include coyote, badger, and bobcat. Important big-game species include the prongborn, mule deer, and elk. Two federally endangered and nine candidate animal species potentially occur on the Idaho National Engineering Laboratory. The bald eagle is a winter resident and is locally common in the far north end and the western edge of the Idaho National Engineering Laboratory. Peregrine falcons are infrequently observed in the winter. Neither species is known to nest onsite, and neither is commonly observed near facilities. The candidate species include the white-faced ibis, northern goshawk, ferruginous hawk, burrowing owl, Townsend's big-eared bat, pygmy rabbit, long-eared myotis, small-footed myotis, and Idaho pointheaded grasshopper (occurs just north of the Idaho National Engineering Laboratory).

No Federal- or state-listed plant species occur at the Idaho National Engineering Laboratory, but eight plant species identified by the U.S. Bureau of Land Management, the U.S. Forest Service, or the Idaho Native Plant Society as sensitive, rare, or unique are known to occur there. These species are not generally located near any facilities and are uncommon on the Idaho National Engineering Laboratory because they require unique microhabitats.

Two interstate highways serve the general region: Interstate 15, a north-south route that connects several cities along the Snake River, approximately 40 kilometers (25 miles) east of the Idaho National Engineering Laboratory, and Interstate 86, an east-west route that intersects Interstate 15 about 64 kilometers (40 miles) south of the Idaho National Engineering Laboratory. U.S. Highways 20 and 26 are the main access routes to the southern portion of the Idaho National Engineering Laboratory. State Route 33 provides access to the northern portion of the Idaho National Engineering Laboratory from the east, State Routes 28 and 33 from the north, and State Route 22 from the west. These roads are complemented by an onsite (controlled access) system of about 140 kilometers (87 miles) of roads.

The Union Pacific Railroad provides rail service to the Idaho National Engineering Laboratory. Idaho Falls receives railroad freight service from Butte, Montana, to the north, and from Pocatello, Idaho, and Salt Lake City, Utah, to the south. The Union Pacific's Blackfoot-to-Arco route, which crosses the southern portion of the Idaho National Engineering Laboratory, provides rail service to the Idaho National Engineering Laboratory. This branch connects with a DOE spur line that links with developed areas. Most naval reactor SNF has been transported to the Idaho National Engineering Laboratory over these rail lines. Other shipments arrive by truck.

Several airlines provide Idaho Falls with aircraft passenger and cargo service.

Recorded doses from 1987 to 1991 were used as a baseline for comparison with SNF management operations for the next 40 years. The average annual occupational dose to individuals with measurable doses was 0.156 rem (156 millirem), giving an average collective dose of about 300 person-rem.

Industrial health and safety statistics from 1987 to 1991 are used as a baseline for comparison for the alternatives. There were 1,337 total recordable injury and illness cases at the Idaho National Engineering Laboratory from 1987 to 1991, for an average of 8,385 employees working a total of 79,654,000 hours. One fatality occurred at the Idaho National Engineering Laboratory between 1987 and 1991 when an employee was struck and killed by a forklift.

The water supply for the Idaho National Engineering Laboratory is provided by a system of about 30 wells, with pumps and storage tanks. The average combined pumpage from the Idaho National Engineering Laboratory wells from 1987 through 1991 was 7.4 billion liters per year

(1.9 billion gallons per year), calculated based on the cumulative volumes of water withdrawn from the wells.

Average annual wastewater discharge volume at the Idaho National Engineering Laboratory for 1989 through 1991 was 537 million liters (142 million gallons).

The rated capacity of the Idabo National Engineering Laboratory electric power transmission loop line is 124 megavolt-amperes. The peak demand on the system from 1990 through 1993 was about 40 megavolt-amperes, and the average usage was approximately 200,000 megawatt-hours per year.

No high-level liquid waste resulting from reprocessing activities has been generated at the Idabo National Engineering Laboratory since 1992; however, certain other processes generate waste classified and handled as high-level waste. These sources are estimated to generate 750 cubic meters in 1995. From 1989 through 1992, an average of approximately 48.5 cubic meters of mixed low-level waste was generated annually. From 1989 through 1992, an average of approximately 46.5 cubic meters of low-level waste was generated annually.

Burial of transuranic waste ended in 1970; since then all transuranic waste has been placed in retrievable storage. Receipt of offsite transuranic waste ended in 1988 (with minor case-by-case exceptions). After 1988, only minor amounts of transuranic waste have been generated onsite and placed into retrievable storage. About 127,000 cubic meters (166,000 cubic yards) are retrievably stored or buried at the Idaho National Engineering Laboratory. The average annual volume of hazardous waste transported offsite from 1988 through 1991 was approximately 180 cubic meters. The average annual volume of industrial and commercial solid waste disposed of at the Central Facilities Area landfill from 1988 through 1992 was approximately 52,000 cubic meters (68,000 cubic yards).

4.3 Savannah River Site

This section presents summary environmental characterization information on the Savannah River Site. This information has been used to evaluate impacts at the site under various alternatives for management of SNF. More detailed information characterizing the Savannab River Site is presented in Appendix C, under separate cover.

The Atomic Energy Commission established the Savannab River Site in 1950 as the Savannah River Project to produce nuclear materials for the national defense. The number of Savannab River Site facilities grew to include five nuclear production reactors (now inactive), two chemical separations areas, a fuel and target fabrication facility (inactive), and support facilities.

The Savannah River Site occupies an area of approximately 800 square kilometers (310 square miles) in western South Carolina, in a generally rural area about 40 kilometers (25 miles) southeast of Augusta, Georgia (see Figure 4-3). The Savannah River Site, which is bordered by the Savannah River to the southwest, includes portions of three South Carolina counties: Aiken, Barnwell, and Allendale.

Approximately 73,500 hectares (181,500 acres) of the Savannah River Site is undeveloped, and 90 percent of this area (more than 65,000 hectares) is forest land. The Savannah River Forest Station (a branch of the U.S. Forest Service) manages the forested areas, many of which are pine plantations, under a cooperative agreement with DOE. Facilities that previously produced defense nuclear materials occupy approximately 5 percent of the total Savannah River Site land area. The remaining area consists of wetlands, ponds, and reservoirs.

Approximately 90 percent of the Savannah River Site work force lives in six counties around the Savannah River Site (Aiken, Allendale, Bamberg, and Barnwell counties in South Carolina and Richmond and Columbia counties in Georgia). In 1990, employment at the Savannah River Site was 20,230, representing approximately 10 percent of the employment in the six-county region of influence. Employment at the Savannah River Site grew to 23,351 in Fiscal Year 1992, with a payroll of more than $1.1 billion. The total number of jobs at the Savannah River Site is projected to decrease to approximately 15,800 in Fiscal Year 1995.

Between 1980 and 1990, the population in the six-county region of influence increased 13 percent, from 376,058 to 425,607. More than 88 percent of the 1990 population lived in Aiken (120,940), Columbia (66,031), and Richmond (189,719) counties. According to census data, the estimated average number of persons per household in the six-county region was 2.72, and the median age of the population was 31.2 years.

The population within 80 kilometers (50 miles) of the Savannah River Site has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Savannah River Site is shown to be 38 percent minority and 17 percent low-income based on U.S. Bureau of Census information, and the definitions and approach presented in Appendix L.

As of the end of Fiscal Year 1992, archaeological surveys have covered about 60 percent of the Savannah River Site and recorded 858 archaeological sites. Of these 858 sites, more than 200 have been evaluated, and 53 have been determined to be eligible for the *National Register of Historic Places*.

Three Native American groups—the Yuchi Tribal Organization, the National Council of Muskogee Creek, and the Indian Peoples Muskogee Tribal Town Confederacy—have expressed

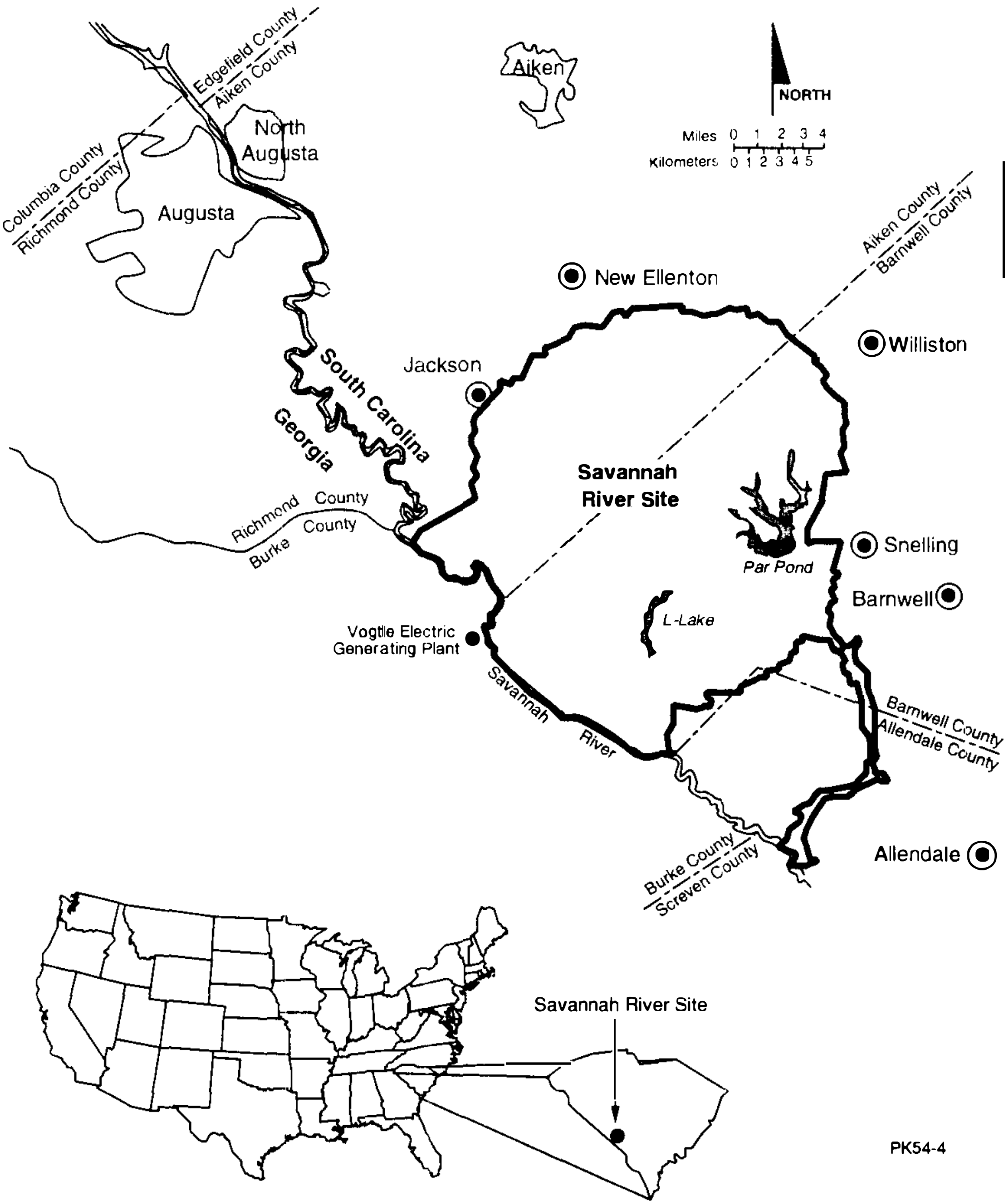


Figure 4-3. Savannah River Site location and site map.

concern over sites and items of religious significance on the Savannah River Site. DOE routinely notifies these organizations about major planned actions on the Savannah River Site and asks them to comment on the Savannah River Site documents prepared in accordance with the National Environmental Policy Act of 1969.

The Savannah River Site has gently rolling terrain and is heavily wooded. Facilities are scattered about the Savannah River Site, but major production facilities (for example, reactors and separations areas) are confined to its interior. As a result, the Savannah River Site facilities are generally not visible from outside of the Savannah River Site.

The Savannah River Site lies in the Coastal Plain physiographic province of South Carolina, approximately 32 kilometers (20 miles) southeast of the Fall Line, which separates the Atlantic Coastal Plain province from the Piedmont province. Onsite elevations range from 27 to 128 meters (89 to 420 feet) above mean sea level.

The Coastal Plain sediments underlying the Savannah River Site consist of sandy clays and clayey sands; however, occasional beds of clean sand, gravel, clay, and carbonate do occur. Underlying these sediments are dense crystalline igneous and metamorphic rock or younger consolidated sediments of the Triassic Period. A regional aquitard, the Appleton Confining System, hydrologically separates the Triassic formations and older igneous and metamorphic rocks from the overlying Coastal Plain sediments.

The area of the Savannah River Site is historically of low-to-moderate seismicity. On a scale of 0 to 4, the Savannah River Site is in a Uniform Building Code Seismic Risk Zone 2A. The partially mapped Pen Branch Fault, which spans the central portion of the Savannah River Site, is considered to be Cretaceous/Tertiary (140 million to 1.6 million years) reactivation of a northern boundary fault of the Triassic age Dunbarton basin. There is no evidence to indicate that the Pen Branch Fault is a capable fault as defined by the U.S. Nuclear Regulatory Commission. Surface mapping, subsurface boring, and geophysical investigations have not identified any faulting of the sedimentary strata at the Savannah River Site that would have an effect on facilities.

The closest offsite fault system of significance is the Augusta Fault Zone, approximately 40 kilometers (25 miles) from the Savannah River Site. In this fault zone, the Belair Fault has experienced the most recent movement, but it is not considered capable of generating major earthquakes. There is no conclusive evidence of recent displacement along any fault within 320 kilometers (200 miles) of the Savannah River Site, with the possible exception of the buried faults in the epicentral area of the 1886 Charleston, South Carolina, earthquake, approximately 145 kilometers (90 miles) away.

Two major earthquakes have occurred within 320 kilometers (200 miles) of the Savannah River Site: (a) the Charleston earthquake of 1886, which had an estimated Richter scale magnitude of

6.8, and (b) the Union County, South Carolina, earthquake of 1913, with an estimated Richter magnitude of 6.0, which occurred about 160 kilometers (100 miles) from the Savannah River Site. In June 1985, a minor earthquake with a local Richter scale magnitude of 2.6 and a focal depth of 1.0 kilometer (0.60 mile) occurred at the Savannah River Site. An earthquake with a local Richter scale magnitude of 2.0 occurred on the Savannah River Site on August 5, 1988, but was not felt by onsite workers.

The Savannah River Site is in a temperate region with mild winters and long humid summers. Average monthly temperatures range from 7.2°C (45°F) in January to 27.2°C (81°F) in July. The average annual precipitation at the Savannah River Site is approximately 122 centimeters (48 inches).

Prevailing winds are from the northeast and southwest, with an annual average windspeed of 3.8 meters per second (8.5 miles per hour). Windspeeds are typically highest in winter and lowest in summer.

On average, thunderstorms occur 56 days per year. The estimated probability of a tornado striking the Savannah River Site is 7.0×10^{-5} per year. Nine tornadoes have been confirmed on the Savannah River Site since 1953. Hurricane-strength winds have been recorded once at the Savannah River Site, from Hurricane Gracie in 1959.

Air quality at the Savannah River Site is generally good, meeting National Ambient Air Quality Standards for criteria pollutants. The nearest Class I Area, the Congaree National Monument, is more than 80 kilometers (50 miles) from the Savannah River Site. Tritium is the only radionuclide of Savannah River Site origin that is routinely detected in offsite air samples in concentrations above background.

Five streams drain the Savannah River Site: Upper Three Runs Creek, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs Creek. These streams originate on the Aiken Plateau and descend 15 to 60 meters (50 to 200 feet) before discharging to the Savannah River.

Surface-water quality in the Savannah River downstream of the Savannah River Site is generally good. In 1992, the South Carolina Department of Health and Environmental Control changed the classification of the river and its tributary streams to "freshwaters" from "Class B waters," imposing more stringent water quality standards. Two elements—iron and manganese (both naturally high constituents of local waters)—have historically exceeded maximum concentration limits.

Two distinct hydrogeologic systems underlie the Savannah River Site: (a) the southeastern Coastal Plain province, where a wedge of unconsolidated sediments of Late Cretaceous and Tertiary origin contains the major aquifer systems of the area, and (b) the Piedmont Province, where groundwater occurs in mudstones and sandstones within Paleozoic metamorphic and igneous basement rock. The vadose zone ranges in thickness from approximately 40 meters (130 feet) in the northernmost portion of the Savannah River Site to the surface in areas where the water table intersects wetlands or streams.

The sediments of the southeastern Coastal Plain hydrogeologic province are grouped into three major aquifer systems divided by two major confining systems, all underlain by the Appleton Confining System. These aquifer systems are known regionally as the Floridan, the Dublin, and the Midville systems. The local aquifers associated with these three aquifer systems are the Steed Pond, Crouch Branch, and McQueen Branch Aquifers.

The Crouch Branch and McQueen Branch hydrostratigraphic units are the most important aquifers in the vicinity of the Savannah River Site. The McQueen Branch Aquifer, in particular, is highly transmissive and serves as the main production aquifer for the Savannah River Site. The groundwater in the Crouch Branch and McQueen Branch Aquifers is suitable for most domestic and industrial purposes.

Industrial solvents, metals, tritium, or other constituents used or generated at the Savannah River Site have contaminated the groundwater over 5 to 10 percent of the Site. Contaminated groundwater generally underlies only a few facilities, and the contaminants detected reflect the material and processes used in these facilities. Contamination of groundwater in an aquifer supplying drinking water has occurred in one relatively small area in the northwest portion of the Savannah River Site: two wells in the Dublin-Midville Aquifer System (formerly known as the Tuscaloosa Formation) contain low concentrations of trichloroethylene and tetrachloroethylene.

The aquifers underlying the Savannah River Site sustain single-well yields of about 10.2 million liters per day (2.7 million gallons per day). The Savannah River Site withdraws approximately 14.0 billion liters per year (3.7 billion gallons per year) of groundwater for domestic and industrial uses. The Savannah River Site draws approximately 75.7 billion liters per year (20 billion gallons per year) of cooling water from the Savannah River. Water rights are not at issue at the Savannah River Site.

The Savannah River Site lies in the Upper Coastal Plain physiographic province. The Savannah River Site is near the transition area between the oak-hickory-pine forest and the southern mixed forest. As a consequence, species typical of both associations are present.

Plant communities adapted to dry conditions occur on more northern, upland areas of the Savannah River Site. (This area is sometimes referred to as the Aiken Plateau.) The most common community types on the northern half of the Savannah River Site are longleaf pine plantations and longleaf pine-turkey oak sandhills. Wetter areas along streams support different groups of plant species, including loblolly pine and bottomland hardwood forest communities. Other aquatic habitats, such as ponds, marshes, river swamps, and Carolina bays, add considerable botanical diversity to the Savannah River Site.

Four federally listed endangered animal species occur on the Savannah River Site or in the Savannah River upstream and downstream of the Savannah River Site: the red-cockaded woodpecker, the wood stork, the southern bald eagle, and the shortnose sturgeon. The U.S. Fish and Wildlife Service lists a fifth species, the American alligator, as "threatened due to similarity of appearance" (to the endangered American crocodile). Researchers have found one federally listed endangered plant species, the smooth coneflower, on the Savannah River Site.

In 1992, the Savannah River Site hunters (chosen by lottery from a large pool of applicants) harvested 1,519 deer and 168 feral hogs. The purpose of these hunts is to keep deer and feral hog populations in check and to reduce the number of animal-vehicle accidents on the Savannah River Site. The Savannah River Site measures each animal killed during the hunts for radioactivity. The maximum measurement of cesium-137 in a Savannah River Site deer was 22.4 picocuries per gram; the average was 6.4 picocuries per gram. For hogs, the maximum value was 22.9 picocuries per gram: and the average was 3.5 picocuries per gram. The estimated maximum dose received by a Savannah River Site hunter was 0.049 rem (49 millirem) per year. This estimate assumed a hunter whose entire meat consumption for the year consisted of the Savannah River Site deer.

The major sources of noise at the Savannah River Site are equipment and machinery (for example, cooling towers, transformers, engines, pumps, boilers, steam vents, and paging systems) in developed operational areas. Studies indicate that, because of the remote locations of the Savannah River Site operational areas, existing onsite noise sources do not adversely affect individuals offsite. Workplace noise limits established by the Occupational Safety and Health Administration protect onsite workers.

Interstate 20 is the primary east-west corridor in the general area of the Savannah River Site. U.S. Highways 1 and 25 are the principal north-south routes. Direct access to the Savannah River Site from the northwest is provided by South Carolina Highways 125 and 19; South Carolina Highway 125 is open to through traffic. South Carolina Highways 39 and 64 also provide access to the Savannah River Site. The CSX railroad line also serves the Savannah River Site.

Atmospheric releases of radioactive material to the environment from Savannah River Site operations from 1990 to 1992 resulted in an average dose of approximately 0.00002 rem (0.02 millirem) per year to individuals living within an 80-kilometer (50-mile) radius of the Savannah River Site. The collective dose equivalent due to atmospheric releases from the 1992 Savannah River Site operations to the population of 620,100 occupying the 80-kilometer (50-mile) radius was 6.4 person-rem. Atmospheric releases of tritium accounted for more than 90 percent of the estimated offsite population dose.

Similarly, liquid releases of tritium account for more than 99 percent of the total radioactivity discharged to the Savannah River from the Savannah River Site activities. The calculated average annual dose to the maximum exposed individual resulting from liquid releases from 1990 to 1992 was

0.00021 rem (0.21 millirem). This resulted in average doses of 0.00004 and 0.00005 rem (0.04 and 0.05 millirem) per year to consumers of drinking water from the downstream Beaufort-Jasper (South Carolina) and Port Wentworth (Georgia) water treatment plants, respectively.

The Savannah River Site purchases power from South Carolina Electric and Gas Company through three purchased power-line interconnects to the Savannah River Site transmission grid. Recent total annual power consumption for the Savannah River Site was approximately 659,000 megawatt hours. The average load was 75 megavolt-amperes, and the peak demand was about 130 megavolt-amperes.

Average annual wastewater discharge volume at the Savannah River Site is about 2 million liters per day (528,400 gallons per day), which is about 50 percent of capacity. Eighteen waste treatment plants currently process all Savannah River Site sanitary waste. A new centralized sanitary wastewater treatment facility, scheduled for completion in mid-1995, will replace 14 of these plants.

The Savannah River Site had 127.9 million liters (33.8 million gallons) of radioactive high-level waste onsite at the end of 1991, in 50 underground tanks, which is more than 90 percent of existing capacity. By 1993, the Savannah River Site had 9,900 cubic meters (350,000 cubic feet) of transuranic waste in storage. The current volume of mixed low-level waste at the Savannah River Site is 1,700 cubic meters (60,000 cubic feet). Low-level waste is packaged for disposal onsite in carbon steel boxes and deposited in trenches. Hazardous wastes in storage at the Savannah River Site total some 1.6 million kilograms (3.6 million pounds), with a volume of 2,430 cubic meters (86,000 cubic feet).

4.4 Nevada Test Site

This section presents summary environmental characterization information on the Nevada Test Site. This information has been used to evaluate impacts at the Nevada Test Site under various alternatives for management of SNF. More detailed information characterizing the Nevada Test Site is presented in Appendix F, under separate cover.

The Nevada Test Site is located in southwestern Nevada in southern Nye County. The Nevada Test Site is bordered on three sides by the Nellis Air Force Base Bombing and Gunnery Range (see Figure 4-4). The Nellis Range serves as a buffer zone between Nevada Test Site test areas and land open to the public. The Nevada Test Site comprises about 3,500 square kilometers (1,350 square miles), making this one of the largest contiguous, unpopulated land areas in the United States. The Nevada Test Site has been used for underground weapons testing and as a nonnuclear test area. Congress has mandated that the Federal Government pursue the development of mined geologic repositories for the permanent disposal of SNF and high-level waste and has directed DOE to study

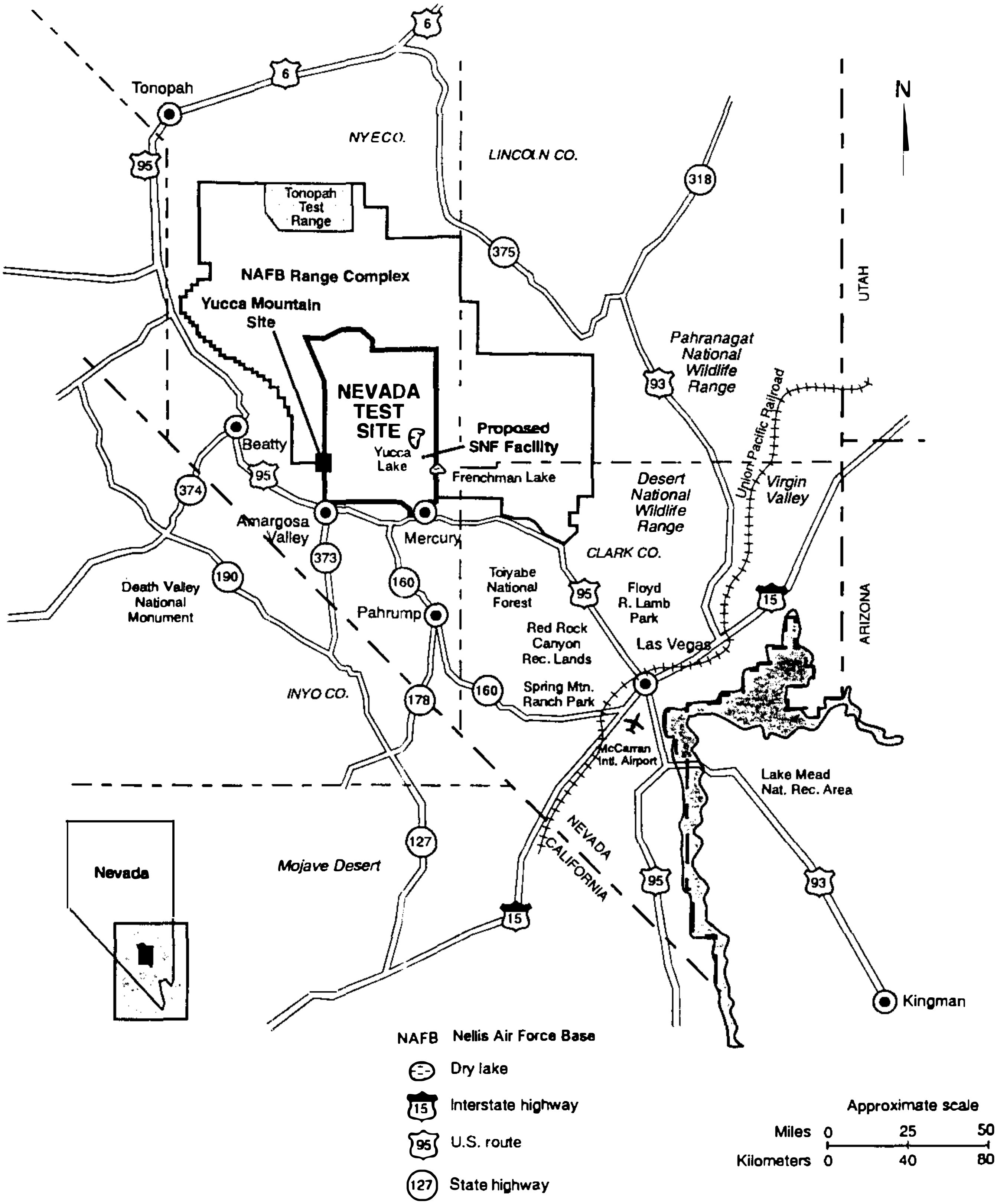


Figure 4-4. Nevada Test Site location and site map.

the Yucca Mountain, Nevada, site to determine whether it is a suitable site for the nation's first geologic repository.

The majority of the land near the Nevada Test Site is managed by the U.S. Bureau of Land Management and used for livestock grazing. The area is surrounded by recreational areas used for activities such as hunting, fishing, and camping.

The economy of the two-county area near the Nevada Test Site is dominated by support services for contractor personnel at the Nevada Test Site, with a direct link to Clark County and the Las Vegas area where most of the employees reside. Most of the offsite supporting contractors and the labor and capital supporting indirect economic activity connected to the Nevada Test Site are also located in Clark County. In 1990, the population of the Las Vegas Metropolitan Statistical area was 735,000, with a 4.7 percent annual growth rate since 1980. In contrast, Nye County is sparsely populated, with employment provided by service industries, some mining, and Government-sector jobs. As of January 1994, the work force totaled 8,563.

The population within 80 kilometers (50 miles) of the Nevada Test Site has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Nevada Test Site is shown to be 6 percent minority and 12 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

On the Nevada Test Site, numerous prehistoric sites and prehistoric/historic sites have been recorded and recommended as eligible for the *National Register of Historic Places*. However, none of them are located in the vicinity of the proposed SNF management facility. Historic activities began in 1849 with the Emigrant Trail, mining camps, and later the settlements of Bullfrog-Goldfield, Las Vegas, and Tonopah. Southern Nevada, including parts of what is now the Nevada Test Site, was inhabited by peoples of the Southern Paiute and Shoshone Tribes. Areas in the northern portion of the Nevada Test Site, including the Pahute and Rainier Mesas, contain sites of cultural affiliation to these peoples. However, no known Native American resources are located within the areas proposed for SNF facilities. Some late Pleistocene terrestrial vertebrate fossils also occur in the area, notably at Tule Springs.

The Nevada Test Site is in a visual setting of low-lying valleys and flats interspersed with mountains and the vegetation of the Mojave Desert and Great Basin. Because the public can be expected to have little concern about changes in the area's landscape and views are not regionally unique, the area may be considered to have low to moderate visual sensitivity.

The Nevada Test Site is located in the southern part of the Great Basin section of the Basin and Range Physiographic Province. Local geology is characterized by mountains of Precambrian and Paleozoic sedimentary rocks and Tertiary volcanic tuffs and lavas separated by alluvial, topographically closed valleys. Sedimentary rocks are complex, folded, and faulted carbonates in the upper and lower parts and shale and sandstone in the middle section. Volcanic rocks are predominantly Tertiary tuffs with some basalts and scattered granitic plutons. Potential geologic resources within the Nevada Test Site boundaries include silver, gold, tungsten, molybdenum, zeolites, barite, and fluorite.

The area of the Nevada Test Site is historically of low-to-moderate seismicity. On a scale of 0 to 4, the Nevada Test Site is in Uniform Building Code Seismic Risk Zones 2B and 3. Seismic activity in the Nevada Test Site area generally occurs as thrust faults, normal faults, and strike-slip faults. Recent displacements are thought to have occurred as a consequence of underground nuclear explosions. Recorded seismic activity before 1978 within 10 kilometers (6 miles) of Yucca Mountain shows seven earthquakes; two had magnitudes 3.6 and 3.4 on the Richter scale, and five had magnitudes that were smaller or could not be determined because of instrument problems. Two historical earthquakes with a magnitude of 6 (Richter scale) have been reported 110 kilometers (68 miles) southwest of Yucca Mountain and 210 kilometers (130 miles) to the northeast. Most earthquakes in the area are less than 10 kilometers (6.2 miles) in depth. Historic seismic events and the length of active faults can be used to infer a maximum magnitude of 7 to 8 for earthquakes in the Yucca Mountain region. Recurrence intervals for earthquakes with magnitudes greater than 7 are 25,000 years, greater than 6 are 2,500 years, and greater than 5 are 250 years.

The climate in the Nevada Test Site region is characterized by high solar radiation, limited precipitation, low humidity, and large diurnal temperature ranges. At Area 6, the mean daily minimum and maximum temperatures are -6.1 to 10.6°C (21 to 51°F) in January and 14 to 36°C (57 to 96°F) in July. Average precipitation at Area 6 is 15 centimeters (6 inches).

DOE maintains an extensive network of air sampling stations for radiological parameters such as particulates, reactive gases, tritium, and noble gases. Nonradiological air pollutants are within state and Federal standards. In recent years, the majority of radioactive effluents at the Nevada Test Site have resulted from underground nuclear tests. In addition, some of the radioactivity detected by onsite air monitors can be attributed to resuspension of radioactive particulate matter remaining from the atmospheric testing conducted from 1951 to 1962. Monitoring of airborne particulates, noble gases, and tritiated water vapor on the Nevada Test Site in 1992 indicated onsite concentrations that were generally not statistically different from background concentrations. External gamma exposure monitoring has indicated that the gamma environment has been consistent from year to year. Although airborne releases of radioactivity to offsite areas occurred during the years that atmospheric testing was performed, in recent years, no Nevada Test Site-related radioactivity has been detected offsite at any air sampling station.

Surface drainage in the Nevada Test Site area is epbemeral, and almost no streamflow data have been collected. Perennial surface waters occur as springs and in short reaches of the Amargosa River. Potential evaporation is 152 to 170 centimeters per year (60 to 67 inches per year). Run-off still occurs in response to infrequent storm events, which may cause local flooding, especially in Fortymile Canyon, the Amargosa River, and Jackass Flats drainage. There is the potential for a 100-year magnitude flood to transport radioactive contaminants released as a result of historic underground nuclear testing beyond the boundaries of the Nevada Test Site.

Six major aquifers occur in the area of the Nevada Test Site, including some perched groundwater. The hydrogeology is characterized by great depths to the groundwater table of 200 to 500 meters (660 to 1,640 feet) and slow velocity in the saturated and unsaturated zones. Flow velocities in these systems range from 1.8 to 183 meters (6 to 600 feet) per year. Regional groundwater flow is from the north and northeast toward the regional discharge area near Ash Meadows in the Amargosa Desert. Modeling studies for the Radioactive Waste Management Site at Area 5 indicate that the travel time from the surface to the regional water table is on the order of thousands of years.

Water in southern Nevada (excluding the Las Vegas area) is used chiefly for irrigation and to a lesser extent for livestock, municipal needs, and domestic supplies. Almost all water supplies are pumped from the groundwater aquifers, although some springs supply water to Death Valley and other areas south of the Nevada Test Site. The Nevada Test Site obtains its water supply from the aquifers underlying the Nevada Test Site in the Ash Meadows Subbasin and Alkali Flat-Furnace Creek Ranch Subbasin. Nevada Test Site water use is discussed in detail in Appendix F of Volume 1.

Groundwater meets U.S. Environmental Protection Agency secondary standards for major cations and anions and the primary standards for deleterious constituents. Contamination by radionuclides occurs below the water table as well as in the unsaturated zone above it as a result of underground nuclear testing. The extent of this contamination is currently being studied.

The Nevada Test Site lies in a transition area between the Mojave Desert and Great Basin, supporting flora and fauna from both areas. Less than 1 percent of the area has been developed. Natural vegetation occurs in nine plant communities identified as creosote bush; blackbrush; creosote-blackbrush, hopsage-desert thorn; sagebrush; saltbush; mountains, hills, and mesas; and two distinct desert thorn plant communities. Introduced weedy species, such as cheatgrass and Russian thistle, are common in disturbed areas.

Approximately 273 vertebrate wildlife species have been observed onsite, including over 30 species of reptiles, 190 species of birds, and 50 species of mammals. Common species include reptiles, rodents, raptors, and wild horses. A number of game and fur-bearing species are found on the Nevada Test Site, but hunting and trapping are not permitted.

National Wetland Inventory maps of the Nevada Test Site have not been prepared, nor have wetlands been delineated onsite. Available information indicates that wetlands on the Nevada Test

Site are limited in distribution and extent. Small riverine and palustrine wetlands may occur adjacent to surface drainages, springs, playas, and reservoirs on the Nevada Test Site. There are no perennial streams on the Nevada Test Site, and permanent surface water sources are limited to a few small springs and reservoirs. Springs do not support fish populations onsite, while reservoirs support introduced bluegill, goldfish, and golden shiner.

Twenty-five federally and state-listed threatened, endangered, and other special status species have been identified on and in the vicinity of the Nevada Test Site, including 9 birds, 2 reptiles, 1 fish, 2 mammals, and 11 plant species. Federally endangered species include the American peregrine falcon, bald eagle, and Devil's Hole pupfish. The federally threatened species is the desert tortoise.

The major noise sources at the Nevada Test Site occur primarily in developed operational areas and include various facilities; equipment and machines (for example, engines, pumps, boilers, steam vents, paging systems, construction equipment, and vehicles); aircraft operations; and testing. At the Nevada Test Site boundary away from most facilities, noise levels are barely distinguishable from background noise levels. Some wildlife disturbances may occur as a result of these activities.

Vehicular access to the Nevada Test Site is provided by U.S. Route 95 from the south and off-road access via State Route 375 from the northeast. No major improvements are scheduled for these segments providing immediate access to the Nevada Test Site.

The major railroad in the area is the Union Pacific, which runs through Las Vegas and is located approximately 80 kilometers (50 miles) east of the Nevada Test Site. A 15-kilometer (9-mile) railroad serves Area 25, but it does not connect with the Union Pacific line.

Background radiation exposure and releases of radionuclides to the environment from Nevada Test Site operations provide the sources of radiation exposure to people in the Nevada Test Site region. The estimated dose-equivalent during 1992 for the population within 80 kilometers (50 miles) of the Nevada Test Site was 5.2×10^{-3} person-rem. The average dose was 1.1×10^{-5} rem (1.1×10^{-2} millirem) in 1992 for a person at the Nevada Test Site boundary. This dose is well below the National Emission Standards for Hazardous Air Pollutants standard of 0.01 rem (10 millirem) per year and is a very small percentage of the background dose.

From 1988 to 1993, water use at the Nevada Test Site varied from a high of 134 liters per second (2,125 gallons per minute) in 1989 to a low of 60 liters per second (949 gallons per minute) in 1993. Significant changes in consumption are not anticipated.

From 1989 to 1993, Nevada Test Site electrical consumption ranged from 144,521 to 183,188 megawatt hours, with peak demands varying from 30.9 to 38.4 megavolt-amperes. In 1995, consumption is projected to be 176,440 megawatt hours, with a peak demand of 39.5 megavolt-amperes.

Nevada Test Site manages the following categories of waste: low-level waste, transuranic waste, hazardous waste, radioactive mixed waste, and nonhazardous waste. The Nevada Test Site does not currently manage high-level waste or SNF. Waste management activities include onsite treatment, onsite storage, onsite disposal, and preparation for appropriate offsite disposal. In addition, the Nevada Test Site uses and manages an onsite inventory of hazardous materials, including some managed in underground storage tanks.

Total nonradioactive waste generated at the Nevada Test Site in 1992 included approximately 90,000 kilograms (100 tons) of Resource Conservation and Recovery Act hazardous waste and 218,000 kilograms (240 tons) of hazardous non-Resource Conservation and Recovery Act waste.

4.5 Oak Ridge Reservation

This section presents summary environmental characterization information on the Oak Ridge Reservation. This information has been used to evaluate impacts at the Oak Ridge Reservation under various alternatives for management of SNF. More detailed information characterizing the Oak Ridge Reservation is presented in Appendix F, under separate cover.

The Oak Ridge Reservation is located on approximately 34,667 acres (140 square kilometers) of federally owned land. The reservation comprises forested lands, public lands, buffer zones and three operations areas: Y-12 Plant, Oak Ridge National Laboratories, and the K-25 Site (formerly the Oak Ridge Gaseous Diffusion Plant) (see Figure 4-5). The Oak Ridge Reservation is located within the incorporated city limits of Oak Ridge, Tennessee. Bordering land uses are predominantly rural, including residences, small farms, forest, and pasture.

Most of the industrial and commercial development, by energy-related companies in support of the Oak Ridge Reservation, has occurred in the City of Oak Ridge in Anderson and Roane counties. Regional economic linkages at the Oak Ridge Reservation occur primarily within Anderson, Knox, Roane, and Loudon counties, where most of the offsite contractors, labor, and capital are located. Employment at the Oak Ridge Reservation in 1990 was approximately 17,080 people, and it is projected to decrease to approximately 16,980 by the year 1999.

The population within 80 kilometers (50 miles) of the Oak Ridge Reservation has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Oak Ridge Reservation is shown to be 6 percent minority and 16 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

There are no identified archaeological sites or historic structures on the proposed site for the SNF management facilities on the Oak Ridge Reservation. Invertebrate fossils remains are found in early Cambrian to early Mississippian aged formations underlying the Oak Ridge Reservation. In the

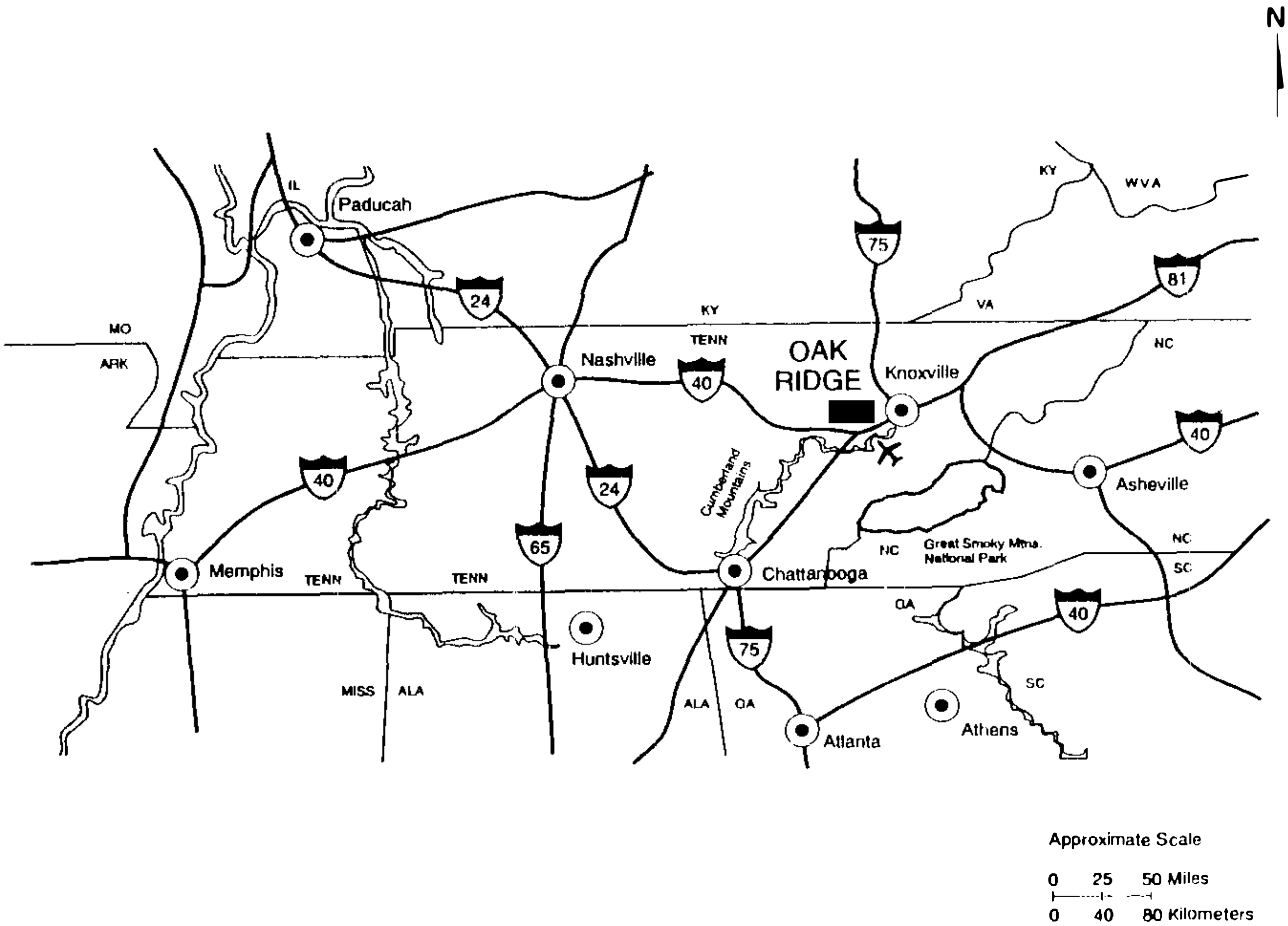


Figure 4-5. Oak Ridge Reservation location and site map.

early 1700s, the Overhill Cherokee lived in the area of the Oak Ridge Reservation. These Native Americans were forcibly moved to Oklahoma in 1838. While the Cherokee may retain cultural affiliation with their ancestral home, there are no known Native American resources on the proposed site for SNF facilities.

Visual resources are characterized by a series of low ridges and valleys trending northeast to southwest. Deciduous and coniferous forest covers about 80 percent of the Oak Ridge Reservation. The DOE facilities are brightly lit at night, making them highly visihle.

The area of the Oak Ridge Reservation is historically of low-to-moderate seismicity. On a scale of 0 to 4, the Oak Ridge Reservation is in a Uniform Building Code Seismic Risk Zone 2A. The Oak Ridge Reservation lies entirely within the western portion of the Valley and Ridge Province, near the boundary with the Cumberland Plateau. This province is characterized by numerous linear ridges and valleys. There are three regional thrust faults in the area. From 1811 to 1975, five major earthquakes have affected the Oak Ridge Reservation area, but none has been at an intensity that caused severe damage. There is no evidence of any volcanic activity in the area for more than one million years.

The climate of the region is characterized by moderate to high precipitation in all seasons, high humidity, low winds, and low diurnal temperature ranges. At Oak Ridge, mean annual precipitation was 54 inches (137 centimeters) from 1961 to 1990. Mean daily temperatures range from 2.6°C (36°F) in January to 24.8°C (76.7°F) in July. Daytime winds are usually southwesterly, while nighttime winds are northeasterly. In Tennessee, tornadoes are infrequent. The western half of the state has experienced three times as many tornadoes as the eastern half where the Oak Ridge Reservation is located. The Oak Ridge Reservation experienced a tornado from a severe thunderstorm on February 21, 1993.

A network of air monitoring stations at the Oak Ridge Reservation measures several types of uranium particulates, heavy metals, and several materials released by a Toxic Substances Control Act incinerator. The total dose of 0.0033 rem (3.3 millirem) per year to the maximally exposed individual is well within the 0.01 rem (10 millirem) per year National Emission Standards for Hazardous Air Pollutants standard. The estimated collective committed effective dose equivalent to the approximately 880,000 persons within 80 kilometers (50 miles) of the Oak Ridge Reservation was approximately 52 person-rem for 1992 This represents about 0.02 percent of the 280,000 person-rem that the surrounding population might receive from all sources of natural radiation. The Oak Ridge Reservation meets the state and Federal standards for all criteria pollutants.

The surface drainage of the Oak Ridge Reservation includes numerous creeks (such as White Oak, Poplar, and Bear Creeks) and the Clinch River, which subsequently flow to the Tennessee River. Melton Hill Dam, immediately south of the Oak Ridge Reservation, controls the flow of the Clinch River near the Oak Ridge Reservation. Average discharge from the dam was 150 cubic meters (5,300 cubic feet) per second from 1963 to 1979. The Clinch River supplies water for the Oak Ridge Reservation and for regional industrial uses.

Geologic units of the Oak Ridge Reservation comprise two hydrologic groups: (a) the Knox Aquifer, formed by the Knox Group and Maynardsville Limestone, and (b) the Oak Ridge Reservation aquitards, which include other geologic units of the area including sandstones, siltstones, and shales. The Knox Aquifer has solution conduits that store and transmit relatively large volumes of water, while the aquitards are controlled by fractures and transmit limited amounts of water. The aquifer is the primary source of sustained stream flow on the Oak Ridge Reservation. However, some flowpaths of the Knox Aquifer lead to discharge points outside the Oak Ridge Reservation boundary. Because of the abundance of surface water in the area, groundwater wells are not common. Groundwater quality is good above 300 meters (1,000 feet), but it has high total dissolved solids at depth.

Groundwater contamination has occurred in the general area of past-practice waste disposal sites, waste storage tanks, spill sites, and contaminated inactive facilities. Principal contaminants include volatile organics, nitrates, heavy metals, and radioactivity. Exact rates and extent of the contamination have not been quantified. However, data indicate that most contamination remains relatively close to the source. As an example of the maximum extent of groundwater contamination, nitrate has been detected in wells 3,000 feet (900 meters) southwest of the source. Nitrate is relatively mobile in groundwater and may therefore define the maximum horizontal migration of contamination. At Oak Ridge National Laboratory, 20 waste area groups have been identified and are being monitored for groundwater contamination. Monitoring data from each waste area group will direct further groundwater studies. At the K-25 Site, organics are the most commonly detected groundwater contaminants. Elevated levels of gross alpha and gross beta have been detected in a number of wells. Uranium and technetium-99, respectively, appear to be primarily responsible for the elevated gross alpha and gross beta levels. The metals chromium, lead, arsenic, and barium have been detected in a number of wells at concentrations exceeding drinking water standards. Elevated levels of fluoride and polychlorinated biphenyls have also been detected in some wells.

The offsite residential drinking water quality monitoring program has detected radionuclides and organics in some offsite monitoring wells; however, concentrations have been below drinking water standards. Fluoride has been detected at concentrations exceeding drinking water standards in one offsite well. The high fluoride concentration and accompanying pH are most likely from natural chemical reactions in the substrate.

The Clinch River supplies most of the water to the Oak Ridge Reservation, the City of Oak Ridge, and other cities along the river. Major surface water uses include withdrawals for industrial and public water supplies, commercial and recreational navigation, and other recreational water activities. Because of the abundance of surface water, most community and Oak Ridge Reservation water supplies come from surface supplies rather than groundwater. One supply well exists on the reservation for use as a supplemental water supply to a laboratory. Groundwater is used for some domestic, municipal, farm, irrigation, and industrial purposes. A typical well in the aquitard yields under 0.25 gallons per minute (0.02 liters per second), and in many places wells are incapable of producing enough water to support a typical household.

The Oak Ridge Reservation area was cleared by logging and agricultural practices in the past, but it is currently dominated by pine and pine hardwood, and oak hickory, as well as northern hardwood and hemlock-white pine-hardwood forest types.

Approximately 267 different vertebrate wildlife species have been recorded onsite, including 39 mammals, 169 birds, 33 reptiles, and 26 amphibians. Local habitats include wetlands, fields, pasture, and pine plantations in addition to forest. Undeveloped areas on the Oak Ridge Reservation support game and fur-bearing populations.

Wetlands have been identified on the Oak Ridge Reservation, based primarily on the National Wetland Inventory maps. Wetlands on the Oak Ridge Reservation include emergent, scrub/shrub, and forested wetland. These wetlands are located in embayments of the Melton Hill and Watts Bar Reservoir that border the reservation; along all major streams, including East Fork Poplar Creek, Bear Creek, and their tributaries; in old farm ponds; and around groundwater seeps. Commercial fishing occurs adjacent to the Oak Ridge Reservation for catfish and carp. Sport fishing for bass, catfish, and other fresh-water fish is also popular.

Forty-seven species of federally and state-listed threatened, endangered, and other special status species have been identified on and in the vicinity of the Oak Ridge Reservation, including 19 plants, 3 amphibians, 4 reptiles, 2 fish, 14 birds, and 5 mammals. Virginia spirea is a federally threatened plant species; bald eagle, peregrine falcon, gray bat, and Indiana bat are federally endangered species found in the area. The state-listed Tennessee dace has been recorded in Bear Creek and tributaries of East Fork Poplar Creek.

The major noise sources within the Oak Ridge Reservation occur primarily in developed operational areas and include facilities and equipment and machines, such as transformers, engines, pumps, boilers, and vehicles. Outside the operations area major sources of noise are vehicles and railroad operations. At the Oak Ridge Reservation boundary, away from most of these activities, noise from these sources is barely distinguishable from background noise levels. Some disturbances of wildlife may occur on the Oak Ridge Reservation as a result of operations and construction activities.

Bear Creek Valley Road provides vehicular access to the Oak Ridge Reservation. Tennessee State Routes 58, 62, 95, and 162 pass through the Oak Ridge Reservation and are open to the public. Road construction and modification are planned for segments of Bear Creek Valley Road, Scarboro Road, and State Routes 58, 62, and 95 in the near future. Interstate 40 is within 8 kilometers (5 miles) to the south. Railroad service on the Oak Ridge Reservation is provided by CSX Transportation and the Norfolk and Southern Corporation. Knoxville is the closest major airport, 64 kilometers (40 miles) away.

Low-level, hazardous, and mixed wastes are generated and managed at the Y-12 Plant, K-25 Site, and the Oak Ridge National Laboratory. Nonhazardous wastes are generated at all three sites and disposed of at the Y-12 Plant Sanitary Landfill. Oak Ridge Reservation generates and manages SNF and transuranic waste. Waste management at the Y-12 Plant and the Oak Ridge National Laboratory includes onsite waste treatment, onsite waste disposal, preparation for proper offsite waste disposal, and onsite waste storage. Liquid and solid hazardous wastes are disposed of offsite. Some low-level radioactive wastes are disposed of onsite.

4.6 Naval Sites

This section presents summary environmental characterization information on the naval sites that have been evaluated under various alternatives for management or examination of naval SNF. This information has been used to evaluate impacts at the sites under various alternatives for management of SNF. More detailed information characterizing these sites is presented in Appendix D, under separate cover.

The average annual radiation exposure for each naval shipyard radiation worker is 0.26 rem (260 millirem) (NNPP 1993). The average lifetime accumulated exposure for shipyard workers is 1.2 rem (1,200 millirem) (NNPP 1993).

4.6.1 Puget Sound Naval Shipyard

The Puget Sound Naval Shipyard is located in Bremerton, Washington, 23 kilometers (14 miles) west of Seattle and 32 kilometers (20 miles) northwest of Tacoma (Figure 4-6). The population within 80 kilometers (50 miles) of the shipyard is about 3 million people.

The population within 80 kilometers (50 miles) of the Puget Sound Naval Shipyard has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Puget Sound Naval Shipyard is shown to be 13 percent minority and 8 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

Puget Sound Naval Shipyard is on 132 hectares (327 acres) of highly developed land. The waterfront dry dock area is the high-security portion of the shipyard where most production activities take place. This area includes production shops, administration, and some public works and supply functions. The upland area of the shipyard provides services to military personnel, including housing, retail goods and services, recreation, counseling, dental care, and other support services. The industrial support area in the southwestern portion of the shipyard includes several piers for homeported ships and inactive fleet, the power plant, warehouses, a steel yard, public works shops, and parking.

There are about 10,200 civilians working at the shipyard. With other Government facilities in the area, the Federal payroll in Kitsap County, where the shipyard is located, provides about 45 percent of the total employment.

There are no prehistoric archaeological sites identified at the shipyard. There are four National Registered Historical Districts and one National Historic Landmark within the boundaries of the shipyard. Until the mid-1880s, Kitsap County was inhabited by several Native American tribes of the Salish language group who lived on the shores of Puget Sound. For about

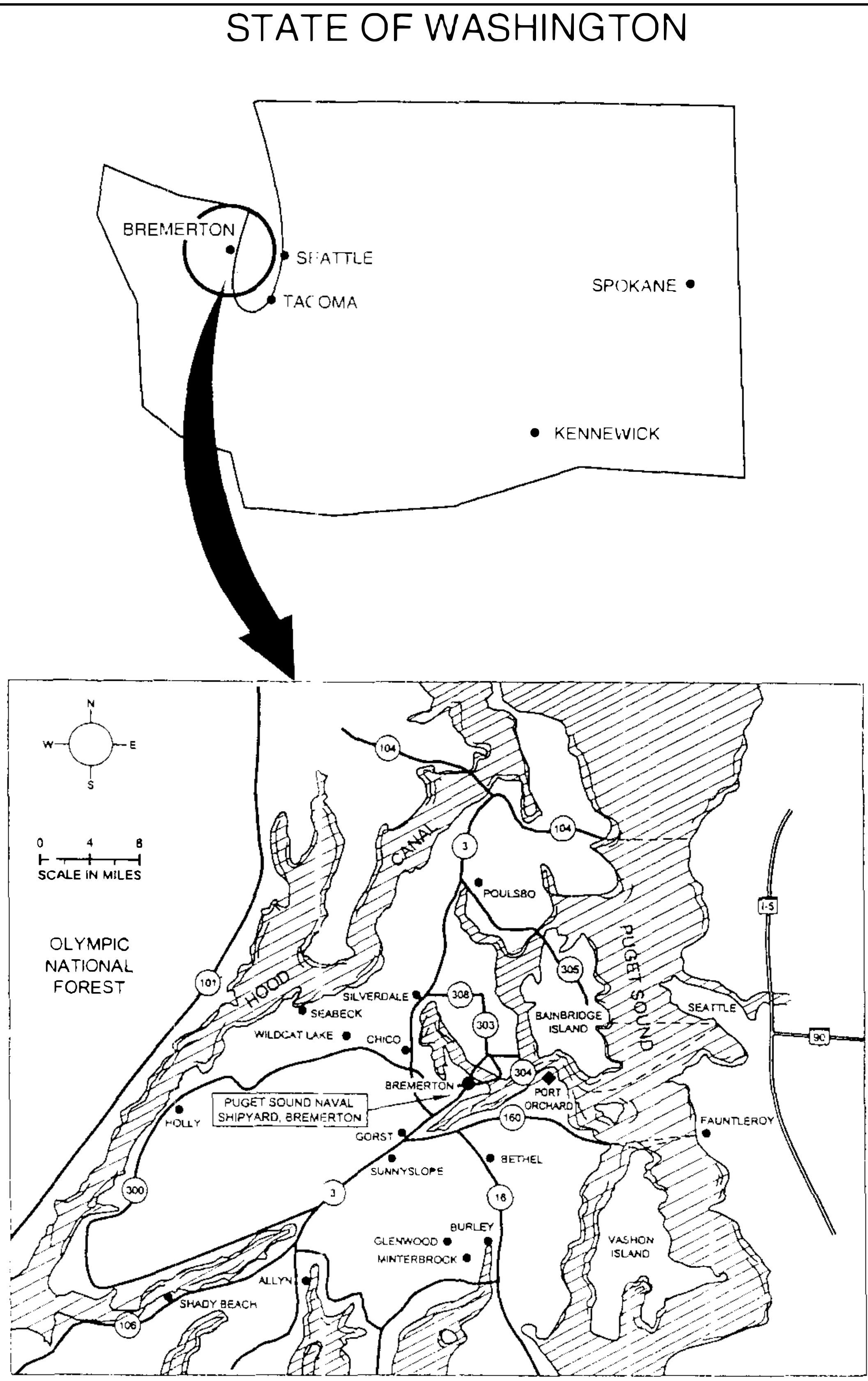


Figure 4-6. Puget Sound Naval Shipyard location and vicinity map.

100 years, the principal settlement of the Suquamish Tribe lay along the west shore of Agate Passage. There are no Native American properties or ceremonial sites in the shipyard areas where SNF activities would be conducted.

The natural topography of the shipyard has been altered significantly from its original condition. Portions of the upland areas of the complex were cut to fill marshes and create level land. The resulting fill material was predominantly a silty, gravelly sand with occasional pockets of silts and clays. The remaining areas of natural soils vary from dense glacial deposits to soft bay mud and peat. The upland soil is a stiff, hardpacked, clay soil with low permeability.

The site lies within Uniform Building Code Seismic Risk Zone 3. There have been approximately 200 earthquakes in the area since 1840, most of which caused little or no damage. The most recent earthquakes of high magnitude were near Olympia [64 kilometers (40 miles) from Bremerton] in 1949 (7.1 on the Richter scale) and near Seattle in 1965 (6.5 on the Richter scale). The central Puget Sound area could experience an earthquake of intensity 7.5 on the Richter scale. There has been no known surface faulting in conjunction with earthquakes in the shipyard region. Potential hazards from volcanism are minimal and limited to windborne volcanic ash.

The potential hazard from tsunamis and seiches is minimal because the system of straits and inlets that surround Puget Sound provides a natural barrier, effectively damping the propagation of distantly generated tsunamis.

The general area around Bremerton is damp, cool, and cloudy much of the year. Average windspeed at the Seattle-Tacoma Airport is 4 meters per second (9 miles per hour), with prevailing winds from the southwest.

The Code of Federal Regulations (40 CFR Part 81) states that the Air Quality Control Region for this site is better than national standards for total suspended particulate matter and sulfur dioxide. The area has no specific classification for ozone, carbon monoxide, and nitrogen dioxide. The nearest Class I Area is Olympic National Park, approximately 24 kilometers (15 miles) from the site.

Puget Sound Naval Shipyard has no important surface freshwaters. Groundwater is generally found within 30 meters (100 feet) of the ground surface in sand and gravel layers. The quality of most groundwater near Bremerton is good. Groundwater is used for approximately 35 percent of the public water supply. Current shipyard use is about 2.6 billion liters (676 million gallons) annually.

Vegetation and wildlife on the Puget Sound Naval Shipyard are limited to undeveloped areas that comprise approximately 19 hectares (46 acres) of the entire Bremerton Naval Complex. Most of these areas have been previously disturbed and are currently landscaped with native and ornamental trees and shrubs. No sensitive, threatened, or endangered aquatic or terrestrial species have been observed at the shipyard.

Land access to the Seattle/Tacoma area is over two interstate highways: Interstate 90 and Interstate 5. The major thoroughfare in south Kitsap County is State Route 16, which runs south from Bremerton to Tacoma where it connects with Interstate 5. Bremerton's primary access routes include State Routes 3, 303, and 304.

The Burlington Northern Railroad provides scheduled and on-demand freight service to southern and central Kitsap County. A Navy-owned spur line from Shelton, Washington, provides additional rail service to the shipyard. SNF originating at Bremerton and Pearl Harbor has historically been transported by rail from Bremerton to the Expended Core Facility at the Idaho National Engineering Laboratory. Since 1962, all 134 shipments of SNF have been sent from Bremerton to the Idaho National Engineering Laboratory by rail—114 originating from Puget Sound Naval Shipyard and 20 transported by ship from Hawaii to the Puget Sound Naval Shipyard, where the containers were transferred to railcars for the journey to the Idaho National Engineering Laboratory.

The annual airborne emissions from the site do not result in any measurable radiation exposure to the general public. Emissions of radionuclides from the site result in a calculated effective dose equivalent of less than 0.0001 rem (0.1 millirem) per year to any member of the general public.

In addition, normal activities associated with current naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site and independent U.S. Environmental Protection Agency monitoring of shipyard sites have shown that the operations at the site have had no adverse impacts on public health or safety. Additional discussion of these monitoring programs is found in Section 4.1.1 of Appendix D of Volume 1 of this EIS.

4.6.2 Norfolk Naval Shipyard

Norfolk Naval Shipyard is located in the Tidewater region of Virginia and is contiguous with the city of Portsmouth (see Figure 4-7). Newport News Shipyard, where some naval nuclear ships are defueled, is located in Newport News, Virginia (see Figure 4-8). Six city areas are within 24 kilometers (15 miles) of the Norfolk Naval Shipyard: Portsmouth, Chesapeake, Norfolk, Virginia Beach, Hampton and Newport News, and Suffolk. About 1.5 million people (USBC 1992) reside within an 80-kilometer (50-mile) radius of the shipyard, and about 8,500 shipyard workers are employed at the shipyard.

The population within 80 kilometers (50 miles) of the Norfolk Naval Shipyard has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Norfolk Naval

STATE OF VIRGINIA

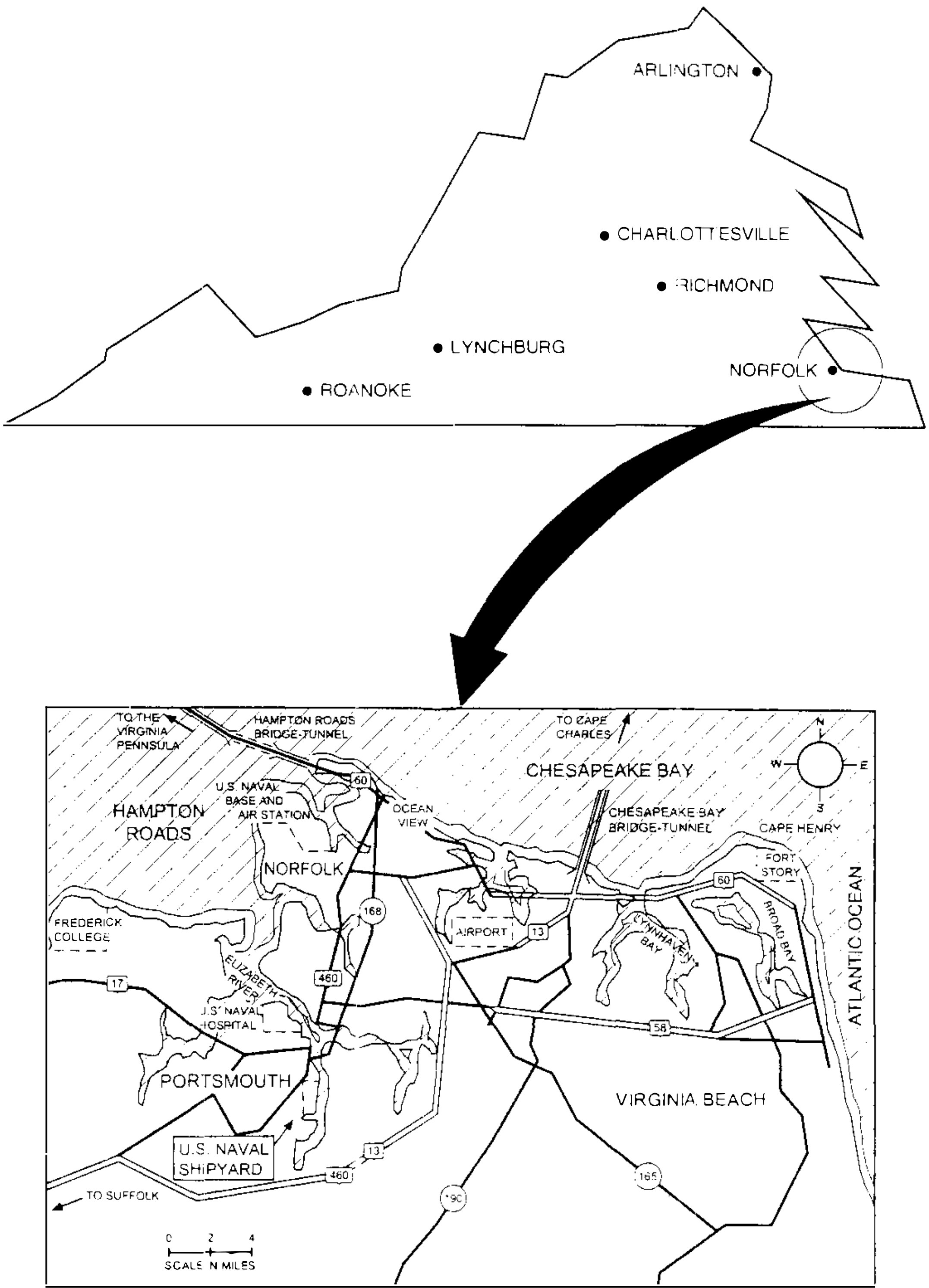


Figure 4-7. Norfolk Naval Shipyard location and vicinity map.

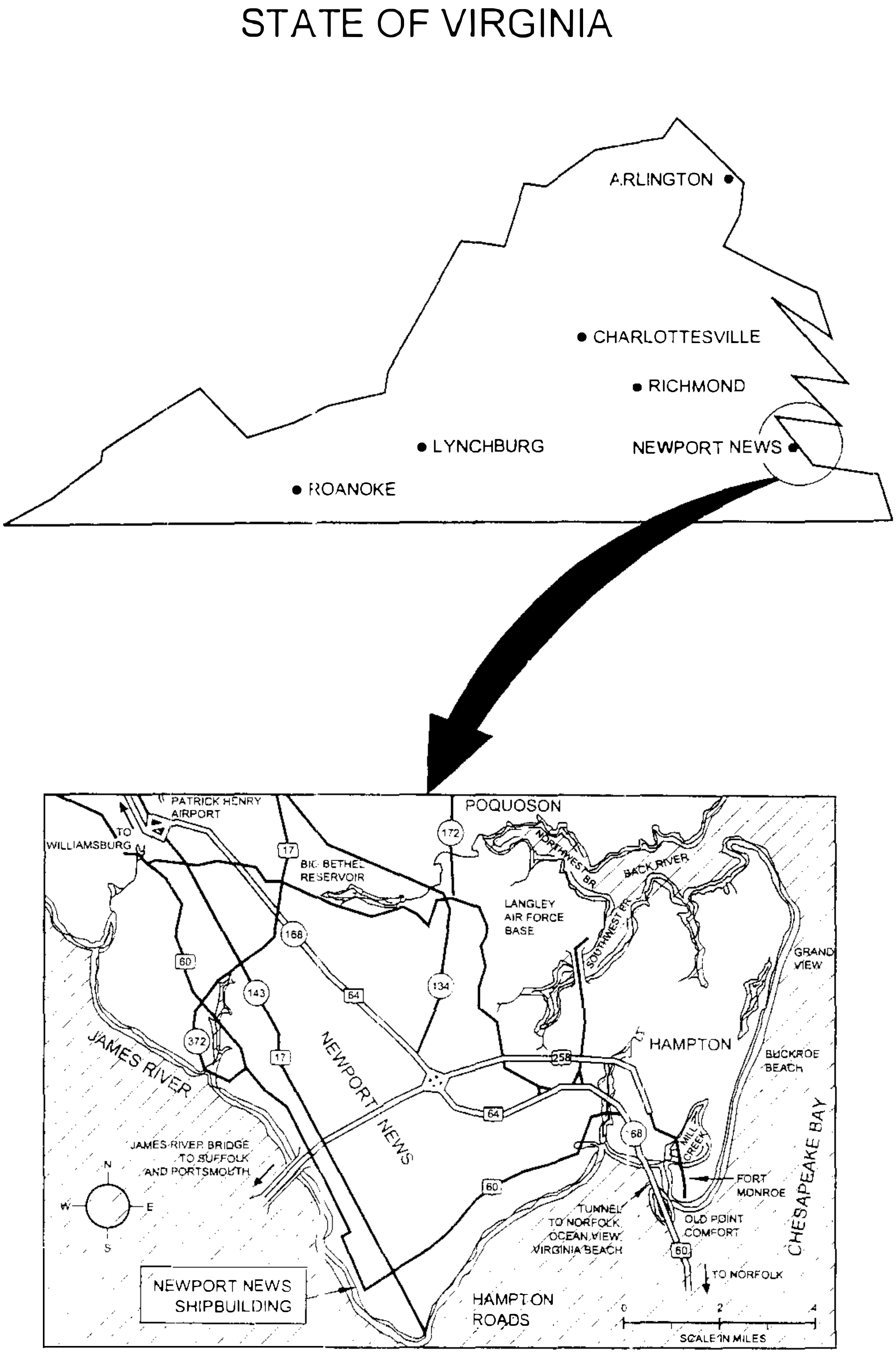


Figure 4-8. Newport News Shipyard location and vicinity map.

Shipyard is shown to be 33 percent minority and 11 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

Norfolk Naval Shipyard occupies over 486 hectares (1,200 acres) and includes over 500 administrative, industrial, and support structures along 4 miles of shoreline. Over 95 percent of the land within its boundaries is covered with structures or paved with concrete or asphalt. The facility is divided into a controlled industrial area and a nonindustrial area. All piers, dry docks, and work facilities involved with naval nuclear propulsion plant work are within the controlled industrial area.

No prehistoric archaeological sites or submerged cultural resources have been identified at the shipyard. Drydock I is a National Historic Landmark. There are no Native American properties or ceremonial sites in the areas where naval SNF activities would be conducted.

Norfolk Naval Shipyard is located in Uniform Building Code Seismic Risk Zone 1, which is the second lowest of four risk categories No volcanic hazards exist.

The general climate of the area is mild and moist, with predominant winds from the south to southwest. In summer, afternoon thunderstorms are very common. Thunderstorms occasionally spawn isolated tornadoes throughout the region, but they move through the area rapidly along with storm centers. Hurricanes and tidal flooding are not uncommon; tornados are infrequent. The Code of Federal Regulations (40 CFR Part 81) states that the Air Quality Control Region that includes this site is in marginal nonattainment for ozone and is better than national standards for total suspended particulate matter and sulfur dioxide. The area has no specific classification for carbon monoxide and nitrogen dioxide. The nearest Class I Area is the Swanquarter National Wilderness Area, which is approximately 160 kilometers (100 miles) from the site.

Norfolk Naval Shipyard is located on the Southern Branch of the Elizabeth River in a highly industrialized area of the city of Portsmouth, Virginia, 13 kilometers (8 miles) upstream from the confluence of the James and Elizabeth Rivers. The Southern Branch is a deep water river that provides access to heavy industry in the vicinity of the shipyard. The Southern Branch is brackish and is not a source of drinking water.

Shallow groundwater underlies the whole region. Designated as the Columbia Aquifer, the aquifer is comprised of interbedded gravel, sand, silt, and clay and is unconfined throughout the region. Underneath the Columbia Aquifer is the Yorktown Aquifer, which is a major source of domestic, commercial, and light industrial water. This aquifer is the usual source of drinking and domestic consumption water for those localities within the region not served by municipal water systems.

The shipyard area is highly developed, and its surface is about 95 percent covered with impervious materials. Several federally designated threatened or endangered species exist in the region; however, habitats have not been identified on shipyard property. No state-listed rare, threatened, or endangered species exist within the 24-kilometer (15-mile) tidal influence zone.

There are three main road corridors within the city of Portsmouth. These roads are High Street, Portsmouth Boulevard, and George Washington Highway, and they provide access to suburban commercial and residential areas. The Downtown and Midtown Tunnels link Portsmouth and Norfolk and join via connecting arteries to the regional interstate highway network consisting of Interstates 64, 262, 464, and 664. Interstate 64 crosses Hampton Roads and Interstate 664 crosses the lower James River, linking the south-side cities to Newport News and Hampton on the peninsula.

Norfolk Southern and CSX operate extensive rail transportation networks for freight and bulk cargo. Norfolk and Newport News are the Nation's largest terminals for coal exports, and, along with Portsmouth, have a large capacity for containerized and bulk cargos. Lines operated by CSX and Norfolk Southern subsidiaries serve the shipyard at the north and south ends and at Southgate and St. Juliens Creek annexes. Since 1965, all 10 shipments of naval SNF originating at the Norfolk Naval Shipyard have been made by rail to the Expended Core Facility at the Idaho National Engineering Laboratory.

The annual airborne emissions from the site do not result in any measurable radiation exposure to the general public. Emissions of radionuclides from the site result in a calculated effective dose equivalent of less than 0.0001 rem (0.1 millirem) per year to any member of the general public.

In addition, normal activities associated with current naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site and independent U.S. Environmental Protection Agency monitoring of shipyard sites have shown that the operations at the site have had no adverse impacts on public health or safety. Additional discussion of these monitoring programs is found in Section 4.1.2 of Appendix D of Volume 1 of this EIS.

4.6.3 Portsmouth Naval Shipyard

Portsmouth Naval Shipyard is located in York County, in the southeast corner of Maine. It is on Seavey Island, near the mouth of the Piscataqua River (see Figure 4-9). Seavey Island has an area of 113 hectares (278 acres). To the north lies the low-density residential community of Kittery, Maine. South of the shipyard, across the river, is the city of Portsmouth (population 22,300) and the town of New Castle in New Hampshire. The population within an 80-kilometer (50-mile) radius of the site is approximately 2.4 million. The shipyard is the region's largest employer, with 5,000 employees.

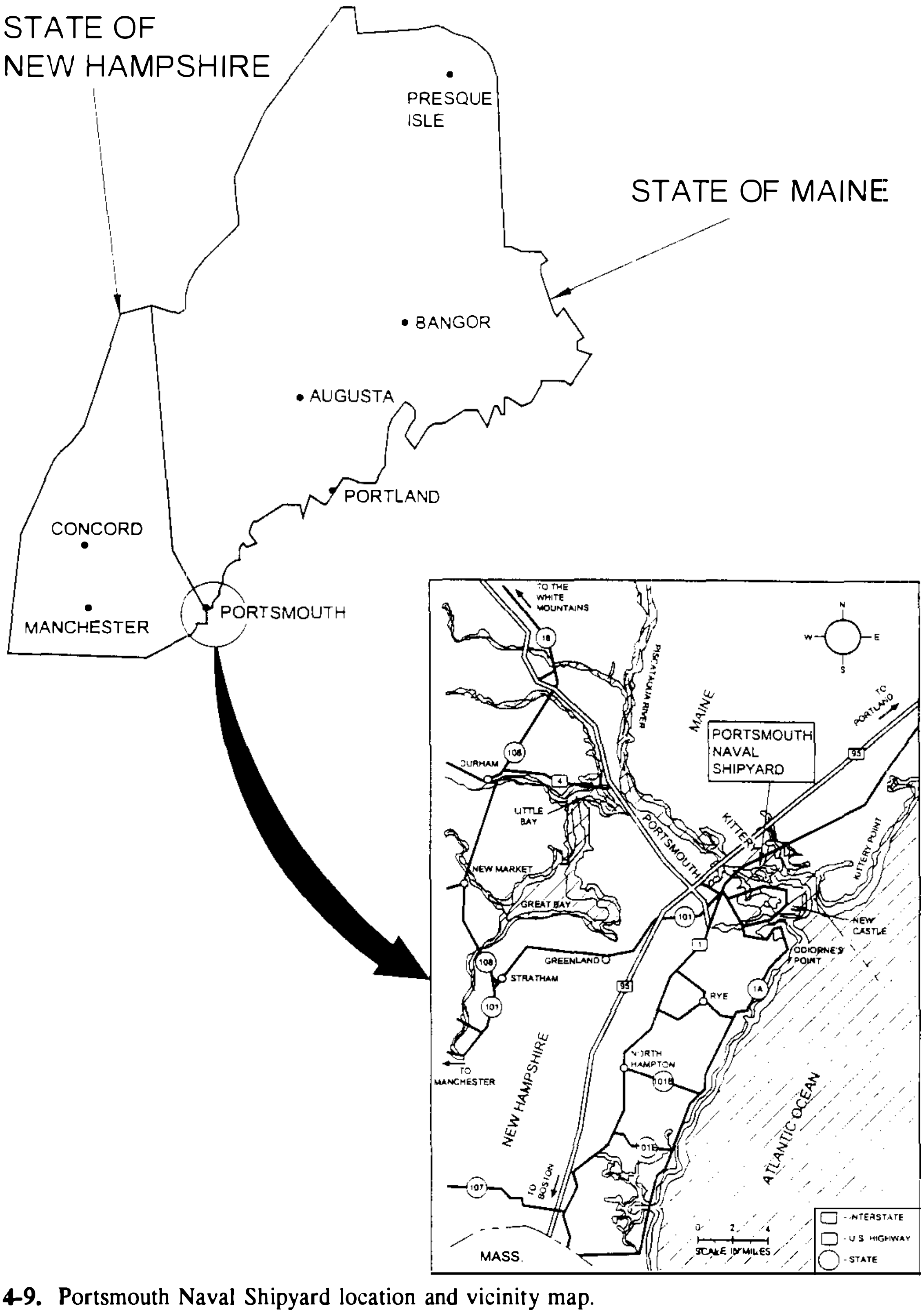


Figure 4-9. Portsmouth Naval Shipyard location and vicinity map.

The population within 80 kilometers (50 miles) of the Portsmouth Naval Shipyard has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Portsmouth Naval Shipyard is shown to be 5 percent minority and 7 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

On November 17, 1977, the National Park Service, U.S. Department of the Interior, entered the Portsmouth Naval Shipyard Historic District on the *National Register of Historic Places*. The district includes 54 acres of land and 59 buildings and structures. There are no known cultural resources in the area of the site where naval SNF would be stored.

Seavey Island is a rock knob, a prominent bedrock outcrop. The bedrock is a fine-grained, lime-silicate material consisting of chalky sandstone formed under heat and pressure, siltstone, and gray sandstone shale. There are no economic geologic resources at the site.

The shipyard is in Uniform Building Code Seismic Risk Zone 2A. Numerous small faults are found in rock units across the region, but only the Rye-Kittery contact is important enough to show on a geologic map.

The typical weather is caused by various incursions of cold, dry arctic air; warm land air from the Gulf States; and cool, damp air from the Atlantic Ocean. Dominance of these systems can change on a daily basis, creating highly variable weather conditions. Precipitation is evenly distributed over the year for an annual total of 108 centimeters (42.6 inches). Local fog is observed 15 percent of the time, and it is dense enough to restrict visibility to 2 kilometers (1.2 miles) or less about 35 percent of that time.

Winds average 3.9 meters per second (8.8 miles per hour), but speeds greater than 17.9 meters per second (40 miles per hour) can occur any time of year. Severe weather from tornadoes and hurricanes is rare.

The Code of Federal Regulations (40 CFR Part 81) states that the Air Quality Control Region for this site is in moderate nonattainment for ozone and is better than national standards for total suspended particulate matter and sulfur dioxide. The area has no specific classification for carbon monoxide and nitrogen dioxide. The nearest Class I Area to the site is the Presidential Range-Dry River Wilderness Area, which is approximately 120 kilometers (75 miles) from the shipyard.

The Piscataqua River, formed by the confluence of the Cocheco River and the Salmon Falls River, flows southeasterly for 21 kilometers (13 miles) until it enters the ocean at Portsmouth Harbor. The entire 21 kilometers (13 miles) of the river is tidal. The river is one of the fastest flowing tidal waterways of any commercial port in the northeastern United States. The Piscataqua River is designated as having acceptable water quality.

The limited amount of vegetation and the industrial nature of the shipyard limit the availability of suitable habitat for most terrestrial species. There is one small freshwater wetland located at the shipyard. No threatened or endangered species have been identified at the site.

Vehicles can reach the Kittery-Portsmouth area by means of Interstate 95 and U.S. Route 1. The shipyard is accessible by two federally owned bridges that cross to the residential streets of Kittery, Maine. Walker Avenue is the primary access route to Bridge 1, and Whipple Road provides direct access to Bridge 2.

There is daily freight rail service to the Shipyard by the Boston and Maine Railroad. The railroad connects Portsmouth with Manchester, New Hampshire; Portland, Maine; and Boston, Massachusetts.

Naval SNF has been removed from Navy nuclear ships at the shipyard and transported to the Idaho National Engineering Laboratory since 1959. There have been 43 shipments made, all by rail.

The annual airborne emissions from the site do not result in any measurable radiation exposure to the general public. Emissions of radionuclides from the site result in a calculated effective dose equivalent of less than 0.0001 rem (0.1 millirem) per year to any member of the general public.

In addition, normal activities associated with current naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site and independent U.S. Environmental Protection Agency monitoring of shipyard sites have shown that the operations at the site have had no adverse impacts on public health or safety. Additional discussion of these monitoring programs is found in Section 4.1.3 of Appendix D of Volume 1 of this EIS.

4.6.4 Pearl Harbor Naval Shipyard

The Pearl Harbor Naval Shipyard is located in the Southeast Loch of Pearl Harbor, Oahu, Hawaii (see Figure 4-10). The population of the island of Oahu was approximately 820,000 people in 1990.

The population within 80 kilometers (50 miles) of the Pearl Harbor Naval Shipyard has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Pearl Harbor Naval Shipyard is shown to be 68 percent minority and 7 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

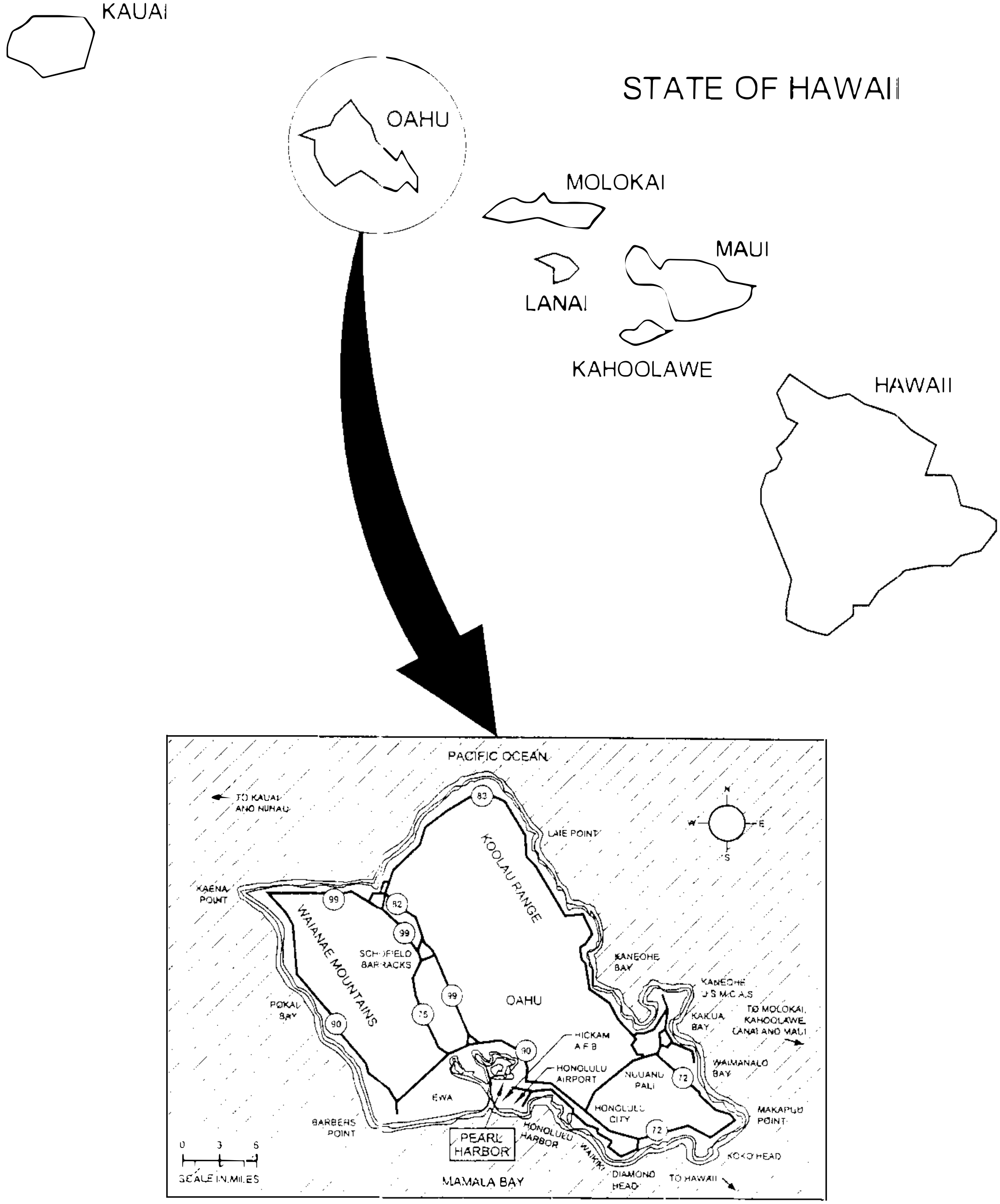


Figure 4-10. Pearl Harbor Naval Shipyard location and vicinity map.

The shipyard employs about 5,000 civilian employees, and, combined with other U.S. Department of Defense civilian employees, it accounts for 10,900 local jobs.

Pearl Harbor has been the site of several important historical events, and it is most noted for its role in the Pacific Theater Defense during World War II. Naval Base Pearl Harbor was designated as a National Historic Landmark in 1964; in 1974, it was listed on the *National Register of Historic Places*. There are no archaeological sites located within the boundary of the shipyard. There are no Native Hawaiian properties or ceremonial sites in the shipyard areas where naval SNF activities would be conducted.

Pearl Harbor estuary lies on the coastal sedimentary plain of southern Oahu. Streams, springs, and groundwater flow into the harbor. The estuary was formed by freshwater flows that have eroded the coastal plain and retarded coral growth. The west side of the harbor is primarily comprised of limestone reef material. The east side of the harbor is mainly compacted volcanic ash. Hard, dense volcanic rock forms the bulk of the rock material to the north. Much of the land area in Pearl Harbor is fill land created by dredge spoils. There are no geologic resources of economic value at the shipyard.

The Pearl Harbor Naval Shipyard is located in Uniform Building Code Seismic Risk Zone 1. Except for the island of Hawaii, the islands are not a highly seismic area. Even on Hawaii, most of the earthquakes originate from volcanic activity and do little or no damage, although a few have been quite severe. The Hawaiian Islands were formed by volcanic eruptions; however, the only active volcanic area is on the island of Hawaii. There are no volcanic hazards on the Island of Oahu.

Past tsunami inundation levels have been about 1 meter (3 feet) above mean sea level. Projected tsunami wave elevations for the 10-, 100-, and 500-year event are 0.2, 0.6, and 1.2 meters (0.8, 2.0, and 3.8 feet), respectively, for adjacent coastal areas. Maximum reasonably foreseeable typhoon storm water level rise would be approximately 4.3 meters (14.5 feet) above mean sea level.

The predominant winds are from the northeast, particularly from February to November. At certain times of the year, south to southwest winds and mild offshore breezes can be expected. Winds with speeds up to 22 meters per second (49 miles per hour) occasionally strike from the north or northeast, but they rarely reach gale velocities. Southerly winds are usually accompanied by wet tropical air and frequent heavy showers. Destructive hurricanes with high tidal surges have hit the Hawaiian Islands twice in the past 25 years (both times centered on Kauai), in 1982 and 1992.

The Code of Federal Regulations (40 CFR Part 81) states that the Air Quality Control Region for this site is better than national standards for total suspended particulate matter and sulfur dioxide. The area has no specific classification for ozone, carbon monoxide, and nitrogen dioxide. The nearest Class I Area is Haleakala National Park, on the Island of Maui, which is 188 kilometers (117 miles) from the shipyard.

Eight streams discharge into Pearl Harbor. Some flooding occurs along the major streams, but it is not a problem at the naval complex, affecting only a narrow strip along Aiea Stream. Naval Base Pearl Harbor receives most of its water from the Koolau Aquifer and a small portion from the Waianae Aquifer, which are located in south central Oahu.

No federally or state-listed threatened or endangered species or critical habitats are known to exist within the confines of the shipyard. Because the area has been greatly disturbed and native vegetation completely eliminated, there is little remaining terrestrial habitat of any consequence. Some migratory birds and indigenous waterfowl occasionally frequent the shoreline areas of the shipyard, but none are residents.

There are several wetland areas within the Pearl Harbor area, including the Pearl Harbor National Wildlife Refuge, which provides habitat for the endangered Hawaiian Coot and Hawaiian Stilt.

The traffic into and out of the base is a combination of commuting traffic, residential-related traffic, and service traffic. Kamehameha Highway is the primary access route to the base from the Ewa/Pearl City/central Oahu direction. Both Kamehameha Highway and Interstate Highway H-1 provide access to the Naval Base from Honolulu.

Naval SNF has been removed from Navy nuclear-powered ships and transported to the Expended Core Facility at the Idaho National Engineering Laboratory. Naval SNF shipments to the Idaho National Engineering Laboratory were initiated in 1962. Since then, 20 shipments have been made. The shipments were taken by ship to the Puget Sound Naval Shipyard, where the containers were then transported to the Idaho National Engineering Laboratory by rail.

The annual airborne emissions from the site do not result in any measurable radiation exposure to the general public. Emissions of radionuclides from the site result in a calculated effective dose equivalent of less than 0.0001 rem (0.1 millirem) per year to any member of the general public.

In addition, normal activities associated with current naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site and independent U.S. Environmental Protection Agency monitoring of shipyard sites have shown that the operations at the site have had no adverse impacts on public health or safety. Additional discussion of these monitoring programs is found in Section 4.1.1 of Appendix D of Volume 1 of this EIS.

4.6.5 Kesselring Site

The Kenneth A. Kesselring Site is located about 24 kilometers (15 miles) north of the City of Schenectady, New York, and 13 kilometers (8 miles) west of Saratoga Springs (see Figure 4-11). It contains three operating naval nuclear propulsion prototype plants and support facilities. The site also includes one prototype plant that is being permanently shut down and one prototype that has been permanently shut down. All operating facilities are located in a secure area near the center of the 1,578-hectare (3,900-acre) reservation.

In 1993, the site employed about 1,450 civilian workers. About 1.15 million people live within an 80-kilometer (50-mile radius) of the site according to the 1990 Census, but most of the land immediately adjacent to the site is either wooded or used for agriculture. The nearest cities include those previously mentioned and Gloversville, Amsterdam, and Albany.

The population within 80 kilometers (50 miles) of the Kesselring Site has been characterized for the purposes of identifying whether any disproportionately high and adverse impacts exist to minority and low-income communities. The population surrounding the Kesselring Site is shown to be 6 percent minority and 9 percent low-income, based on U.S. Bureau of Census information and the definitions and approach presented in Appendix L.

The Kesselring Site reservation was used primarily for agricultural purposes before Federal Government acquisition in 1948. There are no known archaeological, architectural, cultural, or Native American Indian sites in the secure area where SNF storage would take place.

The site lies on primarily unconsolidated material, primarily of glacial origin, that overlies bedrock. Where it exists, the overburden can be up to several hundred feet thick. The overburden consists of three basic kinds of depositional units: glacier debris, lake, and ice-contact/outwash deposits. Deposits from glaciers overlie much of the bedrock and form the elliptical hills throughout most of the reservation. The glacier deposits are a dense and poorly sorted mixture of clay, silt, sand, gravel, and boulders. Thinly stratified lake clay and silt deposits are mapped over the southeastern quadrant of the site. The ice-contact/outwash deposits mostly consist of stratified sands and gravels.

The general area of the site is in Uniform Building Code Seismic Risk Zone 2, with a moderate risk of damage caused by earthquakes. There is a Zone 1 (minor damage) area to the south and a Zone 3 (major damage) area to the north of the site. The maximum intensity earthquake within 161 kilometers (100 miles) of the site had a Modified Mercalli Intensity Scale value of VII. The most recent earthquake of that intensity occurred at Lake George, New York, on April 30, 1931. Because the site is located near the fault system that caused this quake, an earthquake of similar intensity could occur at the site. There are no volcanic hazards in the vicinity of the site.

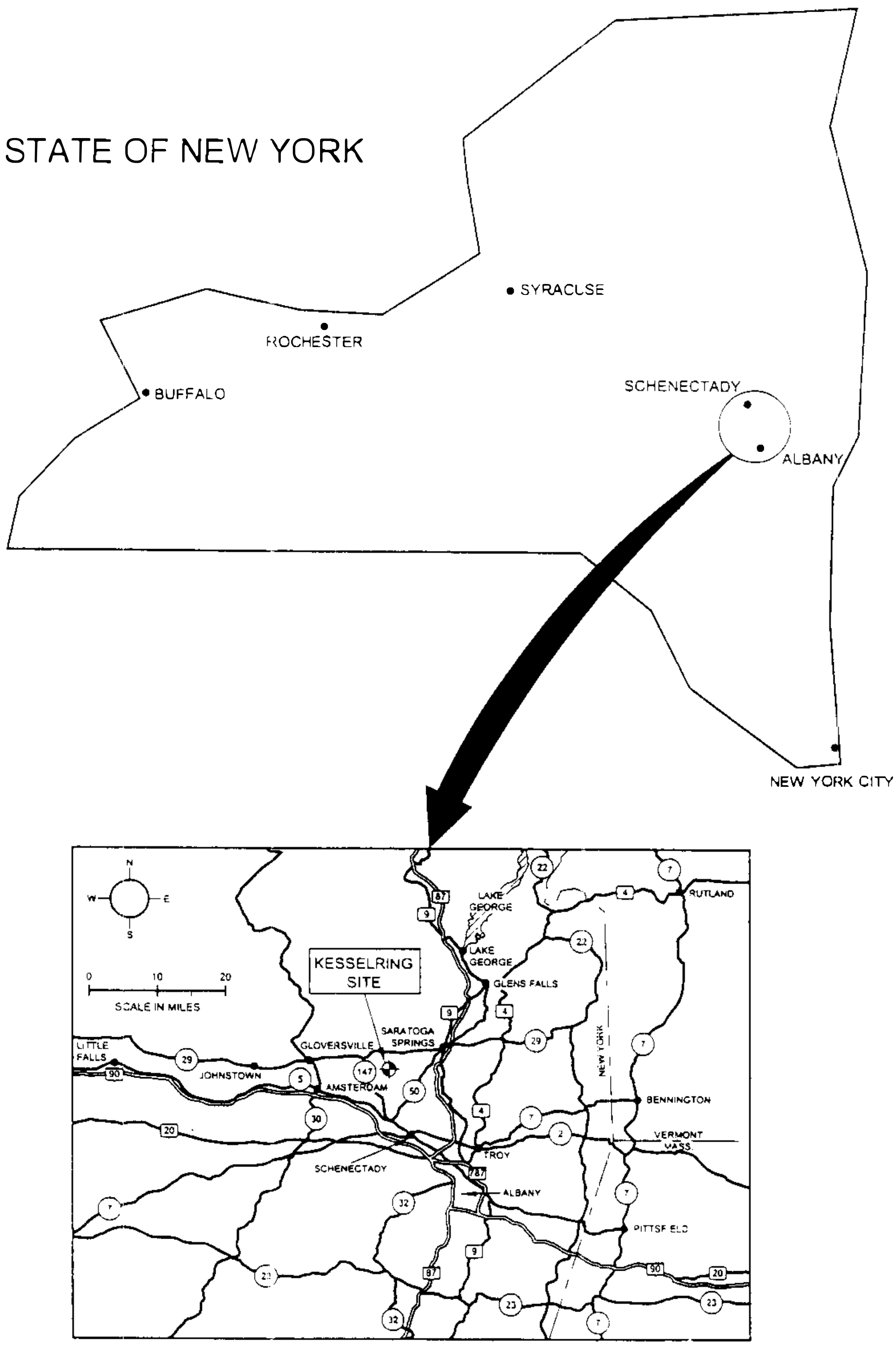


Figure 4-11. Kesselring Site location and vicinity map.

The general climate of the site is cold in winter and cool to warm in summer. Winds originate mostly from the west or northwest during the winter, but come from the south in the warmer months. Wind velocities are moderate and generally average less than 4.5 meters per second (10 miles per hour). Destructive winds [greater than 36 meters per second (80 miles per hour)] occur infrequently, and tornadoes are rare.

The Code of Federal Regulations (40 CFR Part 81) states that the Air Quality Control Region that includes this site is in marginal nonattainment for ozone and is better than national standards for total suspended particulate matter and sulfur dioxide. The area has no specific classification for carbon monoxide and nitrogen dioxide. The nearest Class I Area is at Lye Brook Wilderness, Suarderland, Vermont, which is 74 kilometers (46 miles) from the site.

The Kesselring Site is located in a predominately rural area. There are 13 wetlands on the Kesselring Site; current operations do not impact these wetlands. Federally or state-listed threatened and endangered species located in the Saratoga County area include the bald eagle, the karner blue butterfly, the peregrine falcon, and the red-shouldered hawk. There are, however, no records of any of these species on the site.

Only secondary roads follow the boundary of the site. They are used primarily by Kesselring Site employees and as delivery routes for small products and produce. State Route 29 runs 3 kilometers (2 miles) to the north, State Route 147 runs 6 kilometers (4 miles) to the west, and State Route 67 runs 6 kilometers (4 miles) to the south. State Route 50, 10 kilometers (6 miles) east, running from Saratoga Springs to Scotia, carries the only appreciable amount of truck and bus traffic. The majority of through traffic uses either Interstate 87 or parallel route U.S. Highway 9, 16 kilometers (10 miles) to the east.

Two lines of the Delaware and Hudson Railroad cross the region within 16 kilometers (10 miles) of the site. The main north-south line runs through Ballston Spa, just over 8 kilometers (5 miles) to the east, and a trunkline runs just over 8 kilometers (5 miles) to the northeast into the central Adirondack area.

SNF from the Kesselring Site has been sent to the Expended Core Facility at the Idaho National Engineering Laboratory since 1961. Shipping containers are transported by truck to a nearby commercial rail line where the containers were loaded onto rail cars. Since 1961, 20 shipments of naval SNF have been sent to the Expended Core Facility from the Kesselring Site.

The annual airborne emissions from the site do not result in measurable radiation exposure to the general public. Emissions of radionuclides from the site result in a calculated effective dose equivalent of less than 0.0001 rem (0.1 millirem) per year to any member of the general public.

In addition, normal activities associated with current naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site have shown that the operations at the site have had no adverse impacts on public health or safety.

4.7 Other Generator/Storage Locations

In addition to the five major sites, DOE is responsible for the management of SNF generated at several other DOE sites and other locations. These sites include DOE reactors at sites other than the Hanford Site, Idaho National Engineering Laboratory, the Savannah River Site, and the Oak Ridge Reservation; university and domestic research reactors; and three locations where specific types of commercial power reactor SNF for which DOE is responsible are stored. This section summarizes environmental characterization information for these sites that might be affected by programmatic decisions on SNF management. More detailed information characterizing the sites is presented in Appendix E, under separate cover.

The facilities and installations included in this category preclude the definition of their affected environments in a consistent and uniform manner without describing each site. The information available in existing facility documents varies widely depending on the nature of the installation and the requirements for describing the environment by the overseeing or regulatory agencies. For example, the environmental parameters required to be described by the U.S. Nuclear Regulatory Commission for licensing of small research reactors or material processing and storage facilities are fewer in number and less detailed than those required for larger reactor installations at DOE facilities. Thus, the ability to represent these environmental parameters in a consistent manner based on existing documentation is limited, and several parameters addressed for the major DOE sites are not discussed at all or are discussed only to a limited degree for many of these other generator/ storage locations. Because alternatives evaluated will not require alteration of these sites, the sites are not described in detail. See Appendix E, Chapter 4 for more information.

4.7.1 DOE Test and Experimental Reactors

In addition to facilities at the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, and Oak Ridge Reservation, experimental reactors are located at, and small quantities of SNF are in storage at, the following four DOE sites: Brookhaven National Laboratory, Los Alamos National Laboratory, Sandia National Laboratories, and Argonne National Laboratory-East.

4.7.1.1 Brookhaven National Laboratory. Brookhaven National Laboratory is located on a 2,131-hectare (5,265-acre) site on Long Island, New York, approximately 97 kilometers (60 miles) east of New York City, in a primarily suburban area. About 410,000 people reside in Brookhaven Township, which houses the Laboratory, and 8,000 people live within 0.8 kilometer (0.5 mile) of the Laboratory boundary.

In terms of meteorology, the laboratory can be characterized, like most Eastern Seaboard areas, as a well-ventilated site. The annual precipitation during 1991 was 45.3 inches (115 centimeters), which is about 3.1 inches (8.0 centimeters) below the 40-year annual precipitation average of 48.4 inches (123 centimeters).

Suffolk County, in which the site is located, is classified as being in nonattainment of the standards for the criteria pollutant ozone. The county is in attainment of standards for carbon monoxide, particulates, sulfur dioxide, nitrogen dioxide, and lead.

No active earthquake-producing taults are known in the Long Island area. The area lies in a Uniform Building Code Seismic Risk Zone 2A (moderate seismic hazard) area.

Groundwater flow under the Laboratory site is complex, moving in different directions in different sections of the site, but generally with a velocity estimated to range from 30 to 45 centimeters per day (12 to 18 inches per day), flowing either toward the Peconic River or in deeper layers recharging the Atlantic Ocean. The Nassau/Suffolk Aquifer System underlying the Brookhaven National Laboratory has been designated a sole source aquifer by the U.S. Environmental Protection Agency.

The releases of radioactive gaseous and liquid effluents from Brookhaven National Laboratory from 1988 to 1992 have resulted in calculated average doses to hypothetical maximally exposed individuals of 0.000113 and 0.000722 rem (0.113 and 0.722 millirem) per year, respectively.

4.7.1.2 Los Alamos National Laboratory. Los Alamos occupies an area of about 11,000 hectares (28,000 acres) located primarily in Los Alamos county in northern New Mexico, about 39 kilometers (24 miles) northwest of Santa Fe. The resident population of Los Alamos county in 1990 was 18,115; about 3,900 Los Alamos National Laboratory employees reside in the adjacent Rio Arriba and Santa Fe counties.

The climate at Los Alamos National Laboratory is characterized as semi-arid steppe, with an average annual rainfall of about 21 centimeters (8.1 inches). Severe weather affecting facility design or operation is extremely rare. Los Alamos National Laboratory is located in the New Mexico Intrastate Air Quality Control Region. Areas in Los Alamos National Laboratory and its surrounding counties are designated as in attainment with respect to the National Ambient Air Quality Standards.

The Los Alamos National Laboratory is located on the Pajarito Plateau, which is dissected by deep canyons separated by long narrow mesas. It lies within Seismic Zone 2B, and seismic hazards studies have identified three active faults in the area. Studies suggest seismic events with a magnitude of 6.5 to 7.8 have been produced in the last 500,000 years.

Surface water at Los Alamos consists of intermittent streams; several canyons receive treated industrial or sanitary effluents that rarely extend aboveground beyond Los Alamos National Laboratory boundaries. The depth to the main groundwater aquifer, which supplies nearly all water at Los Alamos National Laboratory, ranges from about 366 meters (1,200 feet) in the west to about 183 meters (600 feet) in the east part of the site, and groundwater discharges to springs along the Rio Grande.

The releases of radioactive effluents from Los Alamos National Laboratory over the period 1987 to 1991 have resulted in a calculated average dose to the hypothetical maximally exposed individual of about 0.004 rem (4 millirem) per year.

4.7.1.3 Sandia National Laboratories. The Sandia National Laboratories reactor and SNF operations are located on about 3,360 hectares (8,300 acres) of Kirtland Air Force Base allocated to DOE, approximately 10 kilometers (6.5 miles) southeast of downtown Albuquerque, New Mexico. The 1990 population of Albuquerque was about 385,000.

The climate at Sandia National Laboratories is characteristic of a semi-arid steppe, with an average annual rainfall of about 21 centimeters (8.1 inches). Severe weather affecting facility design or operation is extremely rare. The Sandia National Laboratories is within the Albuquerque-Mid Rio Grande New Mexico Intrastate Air Quality Control Region, portions of which are designated as nonattainment by the U.S. Environmental Protection Agency for Colorado.

The Sandia National Laboratories is located on the Albuquerque East Mesa in a Seismic Zone 2B, in a region of high seismic activity but of low magnitude and intensity. More than 1,100 earthquakes have occurred during the last 127 years, but only 3 have caused damage in Albuquerque.

The Rio Grande is the main surface drainage route for the area, with an average flow of about 28.5 cubic meters per second (37.3 cubic yards per second). No perennial streams flow through the Sandia National Laboratories area, and flooding is not a high probability at Kirtland Air Force Base. The groundwater is distinguished by a fault complex underlying the area; depths range from 15 to 30 meters (50 to 100 feet) on the east side of the complex and from 115 to 152 meters (380 to 500 feet) on the west side. Groundwater flow west of the complex is generally toward the north and northwest, and groundwater flow east of the fault complex is typically west toward the fault system.

4.7.1.4 Argonne National Laboratory-East. Argonne National Laboratory-East occupies about a 688-hectare (1,700-acre) site located in DuPage County, Illinois, within the Chicago metropolitan area. The site is surrounded by a 826-hectare (2,040-acre) green belt forest preserve operated by DuPage County. The 1990 population of the Chicago metropolitan area was about 6.6 million people.

The climate in the Argonne National Laboratory-East area is characterized as continental, with an average annual precipitation of 80 centimeters (31.5 inches). The area experiences about 40 thunderstorms annually, occasionally accompanied by hail, damaging winds, or tornadoes. The theoretical probability of a tornado strike at Argonne National Laboratory-East is about one every 1,200 years, although the site was struck by tornadoes in 1976 and 1978, with minor damage.

The Argonne National Laboratory-East site is located above about a 30-meter- (100-foot)-thick glacial till deposit on top of dolomite bedrock. The site is in Uniform Building Code Seismic Zone 1. Several areas of seismic activity are present at moderate distances from the site, but ground motions induced by these seismic sources are expected to be minimal at the site.

The Argonne National Laboratory-East site contains a number of small ponds and surface streams that enter the Des Plaines River about 2.0 kilometers (1.25 miles) southeast of the site center. Groundwater is extracted from two underlying aquifers. No aquifers in the region are considered sole-source aquifers by the U.S. Environmental Protection Agency.

4.7.2 Domestic Research and Test Reactors

Appendix E also identifies 55 non-DOE facilities representing domestic, licensed, small generators of SNF. They include training, research, and test reactors at universities, commercial establishments, and several Government installations. These facilities have been licensed by the U.S. Nuclear Regulatory Commission for reactor operation and the storage of the SNF they generate. Although they are not DOE facilities, past practices and long-term plans and agreements have always called for the SNF they generate to be transported to DOE facilities. In the past, this SNF was generally processed at the Savannah River Site, Hanford Site, or Idaho National Engineering Laboratory for recovery of the highly enriched uranium in their fuel. Under all but the No Action and Decentralization alternatives, these fuels would be transported to a DOE site for storage until ultimate disposition.

These 55 U.S. Nuclear Regulatory Commission licensed facilities, 40 of which are operated by universities, are located in 28 states. They are located in a wide variety of areas, ranging from rural locations to industrial research parks and urban university campuses, which does not permit a description of a typical affected environment for these facilities. Information on the environments of three of the larger of these U.S. Nuclear Regulatory Commission-licensed research reactors [the National Institute of Standards and Technology (former National Bureau of Standards), the Massachusetts Institute of Technology, and the University of Missouri reactors] is summarized in the following sections.

4.7.2.1 National Institute of Standards and Technology. The National Institute of Standards and Technology reactor is located on the Institute's 233-hectare (576-acre) campus in the city of Gaithersburg, Maryland, about 20 miles northwest of downtown Washington, D.C. The 1990 population of Gaithersburg, a Washington suburban area, was about 39,500. The nearest site boundary is about 0.40 kilometer (0.25 mile) southwest of the reactor.

The climate of the area is moderate, with infrequent occurrences of severe weather. Although a number of winter storms and hurricanes have affected the general area, the site is not subject to flooding, and the recurrence interval for a tornado at the site is about one in 2,000 years. Air quality is primarily determined by the presence of 12-lane Interstate Highway 270, used by commuters to and from the downtown Washington, D.C , area and suburban residential areas.

There are no known major faults in the site vicinity, although the site region is moderately seismic (Seismic Zone I). The maximum ground acceleration for the site area was estimated to be 0.07g.

There are no discharges from the National Institute of Standards and Technology reactor to surface streams or groundwater; liquid wastes are processed before discharge to the local sanitary sewer system and have averaged 2.7 curies of tritium and 1.9 millicuries of other beta-gamma emitters per year from 1988 to 1992. Over the same period, the site released airborne emissions containing an average of 710 curies of argon-41 and 353 curies of tritium per year, well below the license limits for the site. However, individual or collective doses are not reported, and because site meteorological data are not monitored, doses cannot be reliably estimated.

4.7.2.2 Massachusetts Institute of Technology. The Massachusetts Institute of Technology reactor, housed in a gas-tight building with 0.6-meter (2-feet) concrete shielding, is located on a 0.39-hectare (1-acre) site in a heavily industrialized section of Cambridge, Massachusetts, a few blocks from the main Massachusetts Institute of Technology campus and about 1.6 kilometer (1 mile) from Boston across the Charles River. The population of Cambridge was about 95,800 in 1990.

The meteorological conditions vary from highly stable with light winds to unstable atmospheric conditions with strong winds. Severe weather conditions are uncommon, and flooding of the area is not expected even under record rainfall conditions. Air quality is typical of an urban area.

The Cambridge area has been relatively free of earthquakes over the past 150 years, but it did experience an earthquake in 1755, which destroyed some buildings. The region is located in Seismic Zone 2, and the reactor is conservatively designed to withstand projected seismic activity.

There are no discharges from the Massachusetts Institute of Technology reactor to surface streams or groundwater; liquid wastes are processed before discharge to the local sanitary sewer system and have averaged 0.074 curies of tritium and 9.5 millicuries of other beta-gamma emitters per year from 1988 to 1992. Over the same period, the reactor released airborne effluents containing an annual average of 1,215 curies of argon-41, well below the license limits for the reactor.

However, individual or collective doses are not reported, and because site meteorological data are not monitored, doses cannot be reliably estimated, particularly given the highly urbanized vicinity.

4.7.2.3 University of Missouri. The Columbia Research Reactor is sited within a 34-hectare (85-acre) Research Park about 1.6 kilometers (1 mile) southwest of the main campus of the University of Missouri, located south of the main business district of Columbia, Missouri. The population of Columbia was about 69,000 in 1990. Agriculture is the predominant regional activity, although there are a number of small industrial activities in the area.

The climate of the region is continental, and high windspeeds are not uncommon; 150 kilometer per hour (94 mile per hour) winds have a recurrence interval of once in 100 years, but tornadoes are very uncommon. Air quality is representative of the nonurban midwest. Surface drainage from the site moves eventually to the Missouri River.

Columbia is located in the stable area of Missouri and, despite the proximity to the New Madrid area, the probability of seismic damage in the area is low as reflected by its location in Seismic Zone 1.

There are no discharges from the University of Missouri/Columbia Research Reactor to surface streams or groundwater; liquid waste is processed before discharge to the local sanitary sewer system and has averaged 0.21 curie of tritium and 25.6 millicuries of other beta-gamma emitters per year from 1988 to 1992. Over the same period, the reactor released airborne effluents containing an annual average of about 660 curies of argon-41 and about 7 curies of tritium, well below the license limits for the reactor. However, individual or collective doses are not reported, and because site meteorological data are not monitored, doses cannot be reliably estimated.

4.7.3 Spent Nuclear Fuel from Special Nuclear Power Plants

Three facilities house SNF from power reactors for which DOE has assumed responsibility. Unlike the facilities discussed previously, no additional SNF is either being generated at or being transported to these storage facilities. These facilities include the West Valley Demonstration Project, in West Valley, New York; the former Fort St. Vrain Nuclear Power Plant in Colorado; and the Babcock & Wilcox Research Center, Lynchburg, Virginia. Their environmental characterizations are summarized in the following sections and presented in more detail in Appendix E.

4.7.3.1 West Valley Demonstration Project. The West Valley Demonstration Project occupies an 88-hectare (220-acre) site formerly housing the first United States commercial nuclear fuel processing plant, within a larger 1,341-hectare (3,345-acre) site known as the Western New York Nuclear Service Center. The Center is located in Cattaraugus County, a rural area of western New York State, about 50 kilometers (31 miles) south of Buffalo, New York, and 40 kilometers (25 miles) east of Lake Erie.

A 60-meter (200-foot) onsite meteorological tower is operated by DOE at tbe West Valley Demonstration Project. A review of the West Valley Demonstration Project tower's 1992 data indicates that the prevailing wind was from tbe south-southeast with a mean wind speed of 2.4 meters per second (5.4 miles per hour). The precipitation for 1992 was 18 centimeters (7.1 inches) above the annual average of 104 centimeters (40.9 inches). The onsite 1992 wind data and National Weather Service wind data collected at the Buffalo airport did not compare well, thereby indicating that the Buffalo airport is not representative for predicting conditions at the West Valley Demonstration Project.

The West Valley Demonstration Project is located within the Cattaraugus Highlands, which is a transitional zone between the Appalachian Plateau Province and the Great Lakes Plain. No fold or fault of any consequence is recognized witbin the site. The Clarendon-Linden structure is the closest active "capable" earthquake- (fault-) producing feature known to exist in the region. It is approximately 37 kilometers (23 miles) from the site. The site has experienced a moderate amount of relatively minor seismic activity. During historical times, ground motion at the site probably has not exceeded a Modified Mercalli Intensity of IV or a horizontal acceleration of 0.05g. It is estimated that the maximum earthquake on the Clarendon-Linden structure would produce an earthquake of Modified Mercalli Intensity of VI or VII and a maximum horizontal acceleration of approximately 0.12g at the site.

The West Valley Demonstration Project is located in the Cattaraugus Creek drainage basin, which is part of tbe Great Lakes - St. Lawrence watershed. All surface drainage from the West Valley Demonstration Project is to Buttermilk Creek, which flows into Cattaraugus Creek and ultimately into Lake Erie. The uppermost water-bearing unit underlying the West Valley Demonstration Project is a hydrologically isolated part of tbe Cattaraugus Creek Aquifer System, which has been designated a sole source aquifer by tbe U.S. Environmental Protection Agency. This unit is included in tbe sole source designation due to its hydrologic similarity and proximity to the producing Cattaraugus Creek Aquifer.

4.7.3.2 Fort St. Vrain. The Fort St. Vrain site is located in Weld County in northeastern Colorado, approximately 5.6 kilometers (3.5 miles) northwest of the town of Platteville, 0.8 kilometer (0.5 mile) west of the Soutb Platte River, and 56 kilometers (35 miles) north of Denver. The Fort St. Vrain site consists of 1,132 hectares (2,798 acres). Based on the 1980 census, the population witbin an 8-kilometer (5-mile) radius of the site was estimated to be 3,148, with 1,662 residing in the town of Platteville (USBC 1982). Most of the land in the immediate area of the site is disturbed, agricultural land.

The general climate around the Fort St. Vrain site is generally mild. In this semi-arid region, the precipitation averages 25 to 38 centimeters (10 to 15 inches) a year, mostly from thunderstorms in late spring and summer. Northeastern Colorado has moderate thunderstorm activity. The region typically experiences 5 tornadoes per year per 25,900 square kilometers (10,000 square miles), with peak tornado activity occurring during the month of June. A study of tornadoes in the area concluded that 161-kilometer-per hour- (100-mile-per-hour) winds should constitute maximum wind forces to be expected at Fort St. Vrain.

The Fort St. Vrain site is located on the east flank of the Colorado Front Range, a complexly faulted anticlinal arch. Numerous faults and smaller folds are superimposed on the arch and are related to the uplift of the Front Range. The Fort St. Vrain site has not experienced any observed earthquake activity. A field examination of the area produced no evidence of recent movement along any of the known faults. The closest area of recent activity is about 40 kilometers (25 miles) south of the site. The site is located in Seismic Zone 1.

The nearest major surface water features to the Fort St. Vrain site are the South Platte River, about 0.8 kilometer (0.5 mile) east of the site, and the St. Vrain Creek, about 1.2 kilometer (0.75 mile) west of the site. Local surface water diversions from these rivers, which feed irrigation ditches to support agriculture, are somewhat closer, about 0.5 kilometer (0.33 mile) east and west of the site and about 0.64 kilometer (0.4 mile) to the north of the site, and an irrigation ditch is located 0.16 kilometer (0.1 mile) to the south of the site.

4.7.3.3 Babcock & Wilcox Research Center, Lynchburg. The Babcock & Wilcox Research Center occupies a 1.6-hectare (4-acre) fenced area within Babcock & Wilcox's 374-hectare (925-acre) Mount Athos site. The research center is in Campbell County, Virginia, near the James River, approximately 6.5 kilometers (4 miles) east of the city of Lynchburg. The research facility and the nearby city of Lynchburg are centrally located within the area of Amherst, Appomattox, Bedford, and Campbell Counties. The combined population of these counties is about 180,000.

The climate of the Lynchburg area is influenced by cold and dry polar continental air masses in the winter and warm and humid gulf maritime air masses in the summer. Rainfall amounts can be expected to reach 102.4 centimeters (40.3 inches) in any given year. Severe weather is limited to thunderstorms with a low probability of tornadoes. The mean number of thunderstorms occurring at Lynchburg is approximately 22 per year. The probability of a tornado actually striking the site is 3.0×10^{-4} per year, with a recurrence interval of 3,333 years.

The land at the Babcock & Wilcox Research Center is characterized by scattered hills of various dimensions lying eastward from the main chain of the Blue Ridge Mountains. The site is located in a western part of the central Virginia cluster region, which is classified as Seismic Zone 2. Approximately 121 earthquakes with epicenters in Virginia have occurred during the last 236 years. Two earthquakes have been recorded with intensities sufficient to cause some damage, but these were not in the area of the Center. Earthquakes are not expected to cause serious damage to the Lynchburg facilities nor result in release of hazardous materials.

The James River is formed about 154 kilometers (96 miles) upstream of the site by the confluence of the Jackson and Cowpasture Rivers. The James River flows generally south-southeast from the Valley and Ridge Province to the Atlantic Ocean through the Hampton Roads and Chesapeake Bay. The annual average flow rate of the James River at the plant is estimated to be about 110 cubic meters per second (3,900 cubic feet per second). The largest recent flood occurred in November 1985 and had a flood stage of 163 meters (534 feet) above mean sea level at Lynchburg. The groundwater elevation is between 134 and 140 meters (440 and 460 feet) above mean sea level, which is 3 meters (10 feet) below surface elevation at the annual average flow rate. Because of the relative impermeability of the silt and clay topsoils, neither the water in surface soils nor river flood water has a major effect on the groundwater supply or quality.

5. ENVIRONMENTAL CONSEQUENCES

This chapter presents the potential environmental consequences of implementing each of the alternatives described in Chapter 3. To focus on the most significant issues in the design of the SNF Program, this chapter summarizes and simplifies the more detailed site-specific analyses of environmental consequences presented under separate cover as self-contained appendices to Volume 1. The intent is to provide a collection of summary information across DOE sites, SNF interim storage alternatives, and issue areas without recounting the detail of the separate appendices.

The Centralization alternative generally produces the greatest impacts, with somewhat smaller impacts associated with the 1992/1993 Planning Basis and Regionalization alternatives. The No Action alternative may appear to have the least impact in some of the categories analyzed, such as transportation, but it also produces larger impacts in others, such as estimated radiation doses as the result of accidents. In addition, the increased exposure of workers to radiation and the increased risks of release of radioactive material to the environment with the continuing degradation of certain types of DOE SNF are potential impacts that cannot be completely analyzed.

This chapter is organized into eight sections. The disciplines (topical areas) studied that result in potential impacts, are of general public interest, or may help to discriminate among sites for alternatives are discussed in Section 5.1. In general, the consequences presented in Section 5.1 relate to socioeconomic impacts, electricity use, waste generation, and radiological and transportation impacts. The disciplines that were studied that showed small impacts or clearly did not discriminate among sites or alternatives are discussed in Section 5.2. Sections 5.3 through 5.8 address cumulative impacts, unavoidable adverse environmental effects, the relationship between short-term use and long-term productivity, irreversible and irretrievable commitments of resources, potential mitigation measures, and environmental justice, respectively.

The period covered in this EIS is the 40 years from 1995 to 2035. Detailed impact analyses are performed for the time period from 1995 to 2005. Normal operation impacts at the Idaho National Engineering Laboratory are then projected for the remaining 30 years covered by this EIS. The level of site-specific detail presented in Sections 5.1 and 5.2 is commensurate with the size of the SNF inventory and the number and types of sites where SNF would be stored. Therefore, the analyses of the major DOE and naval sites are more detailed than the analyses for the other generator/storage locations that would have limited inventories under the No Action and Decentralization alternatives. There are five major DOE sites that are or may be responsible for managing the great majority of SNF: Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site. The DOE did not consider the Nevada Test Site to be a preferred site for the management of SNF because of the State of Nevada's current role as the host site for the Yucca Mountain Site Characterization Project and the Nevada Test Site's lack of SNF management facilities and high-level waste infrastructure. Minor sites are the university and government reactor sites and the three facilities that store small quantities of SNF for which DOE has responsibility: West Valley Demonstration Project, Babcock & Wilcox Research Center, Lynchburg, and Fort St. Vrain.

For more detailed information on analyses of environmental impacts, and for a discussion of the analyses supporting the consequences reported here, refer to the appropriate site-specific appendix. These site-specific appendices, under separate cover, are organized as follows:

Appendix	Focus of Appendix
A	Hanford Site
B	Idaho National Engineering Laboratory
C	Savannah River Site
D	Naval Nuclear Propulsion Program
E	Other Generator/Storage Locations
F	Nevada Test Site and Oak Ridge Reservation

Appendix K presents site-specific data compiled from Appendices A through F that were used in developing the discussion of environmental consequences. The summary tables in Appendix K allow comparison of quantitative impacts (for example, increases or decreases in direct employment resulting from implementation of an alternative) among sites.

Appendix L presents an evaluation of environmental justice considerations at each of the alternative sites considered in this EIS. Environmental consideration and exposure pathways were evaluated within a 80-kilometer (50-mile) radius surrounding each of 10 potential sites of proposed activities. This 80-kilometer (50-mile) radius is in keeping with analysis conducted under the National Environmental Policy Act regarding proposed DOE activities to identify environmental impacts from proposed activities. This 80-kilometer (50-mile) radius represents the limit in which any impacts are considered to be of any potential significance. Minority and low-income communities surrounding each alternative site were identified through the use of a Geographical Information System, based on 1990 U.S. Census data. Demographic maps are provided for each site under consideration in Appendix L.

5.1 Environmental Consequences of Key Discriminator Disciplines

This section presents the environmental consequences of the alternatives, focusing on the key discriminator disciplines—those that may differentiate among sites, have the potential for a more significant impact, or are of general public interest. This section is organized in two parts: a background discussion providing perspective for each discipline and a presentation of consequences by alternative, discipline, and site.

5.1.1 Background

The following discussion provides background and perspective for the environmental consequences presented in Section 5.1.

5.1.1.1 Socioeconomics. Socioeconomic impacts are defined in terms of direct and secondary effects. Direct effects include changes in site employment and expenditures resulting from SNF-related construction and operation. Secondary effects include changes that result from regional purchases, nonpayroll expenditures, and payroll spending by site employees. For the major DOE sites, existing projections (regardless of SNF management decisions) indicate that jobs will be lost during the next few years for all sites. Potential SNF management impacts onsite and regional employment were considered in light of this trend.

For the sites considered, only minor increases in site employment over the declining job baseline would result from SNF management; therefore, secondary effects were considered as a lessening of the rate of job loss, without substantial impacts on associated regions. At the Idaho National Engineering Laboratory, the potential for appreciable job losses exists under certain alternatives. These reductions would contribute to an overall regional decline. The reductions are not anticipated to be significant, however, because they would occur over several years. For the naval sites, the number of staff required to manage SNF management facilities would be approximately less than 1 percent of site employment and less than 1/25 of 1 percent of regional employment, so secondary impacts were also considered small in this analysis. For other generator/storage locations, job creation was expected to be minimal even under the No Action alternative where long-term management of SNF would be required should operating reactors be required to shut down. The number of staff involved for long-term SNF management would be small in relation to existing staffing levels at these reactors.

With employment as an indicator, small changes in population are anticipated, creating minimal changes in demand on regional supporting infrastructures. The number of direct jobs that would be created under each alternative as a result of SNF management activities was estimated for each site. The employment graphs shown on Figures 5-1 through 5-9 (presented and discussed fully with the alternatives) represent the 10-year average of the incremental change in direct employment resulting from SNF management. Secondary effects, such as the need for additional housing and improved community services are discussed if an impact is indicated. Details on the socioeconomic impact analysis, as well as the baseline projections from which comparisons were made, are provided in Appendices A through F. Employment increases and decreases that are presented in the text are 10-year averages rather than the actual maximum increase or decrease in any single year as presented in Appendix A through F. Please see the specific site appendix for actual annual employment values.

5.1.1.2 Utilities (Electricity). New facilities (or the restarting of idle facilities) would result in increased demands on water, power, and sewage. Water and sewage requirements are considered minimal and are discussed in Section 5.2.9. However, power consumption under some of the alternatives would exceed existing capacity at certain sites and this is discussed in more detail in this section. Electricity requirements by site and by alternative vary significantly depending on whether a site is processing or storing SNF. For example, at the Hanford Site, the annual increase in power use from SNF management activities could vary from 0 megawatt-hours per year under the No Action alternative when storing only, to a maximum of about 130,000 megawatt-hours per year under the Centralization alternative when processing (Appendix K, Volume 1). In addition, the operation of an expended core facility consumes approximately 10,000 megawatt-hours per year of electricity. Therefore, the power requirements would be highest under alternatives where both processing and operating an expended core facility occur simultaneously. The graphs of electricity use in Figures 5-1 through 5-9 show the maximum and minimum incremental change in power consumption that would result from implementing the alternative. Current capacities and baseline usage of utilities and energy from which comparisons are made are discussed in Appendices A through F of Volume 1.

5.1.1.3 Materials and Waste Management. There are few impacts on materials and waste management activities except when SNF is processed. Stabilization of SNF, depending on the technology, may yield high-level, transuranic, low-level, mixed, and hazardous wastes. The wastes must usually be further treated to make them safe for transport, storage, or disposal. The capacity of sites for additional storing of high-level and transuranic wastes is generally limited. Low-level wastes are normally disposed of onsite at the major DOE facilities. Hazardous wastes are normally treated in some way and then disposed of in approved disposal facilities onsite or offsite. A few categories of mixed waste are being treated, but most are in storage awaiting development of treatment capabilities. The graphs of waste generation in Figures 5-1 through 5-9 illustrate the estimated annual average of low-level waste and high-level, transuranic, and mixed waste that each alternative would generate between 1995 and 2005. Site-specific details on materials and waste management and the current status of waste management activities at the sites are discussed in Appendices A through F.

5.1.1.4 Occupational and Public Health and Safety.

Radiation Effects—Radiation exposure and its consequences are topics of interest to the general public near nuclear facilities. Therefore, this EIS places more emphasis on the consequences of exposure to radiation than on other topics, even though the effects of radiation exposure under most of the circumstances evaluated in this EIS are small. This subsection explains basic concepts used in the evaluation of radiation effects to provide the background for later discussions of impacts.

The effects on people of radiation that is emitted during disintegration (decay) of a radioactive substance depends on the kind of radiation (alpha and beta particles, and gamma and x-rays) and the total amount of radiation energy absorbed by the body. The total energy absorbed per unit quantity of tissue is referred to as absorbed dose. The absorbed dose, when multiplied by certain quality factors and factors that take into account different sensitivities of various tissues, is referred to as effective dose equivalent, or where the context is clear, simply dose. The common unit of effective dose equivalent is the rem (1 rem equals 1,000 millirem).

An individual may be exposed to ionizing radiation externally, from a radioactive source outside the body, and/or internally, from ingesting or inhaling radioactive material. The external dose is different from the internal dose. An external dose is delivered only during the actual time of exposure to the external radiation source. An internal dose, however, continues to be delivered as long as the radioactive material remains in the body, although both radioactive decay and elimination of the radionuclide by ordinary metabolic processes decrease the dose rate with the passage of time. The dose from internal exposure is calculated over 50 years following the initial exposure.

The maximum annual allowable radiation dose to an individual of the public from DOE-operated nuclear facilities is 0.1 rem (100 millirem) per year (DOE Order 5400.5) (DOE 1993b). All DOE and naval facilities covered by this EIS operate well below this limit (see Chapter 4). It is estimated that the average individual in the United States receives a dose of about 0.3 rem (300 millirem) per year from natural sources of radiation. For perspective, a modern chest x-ray results in an approximate dose of 0.008 rem (8 millirem), while a diagnostic hip x-ray results in an approximate dose of 0.083 rem (83 millirem). A person must receive an acute (short-term) dose of approximately 600 rem (600,000 millirem) before there is a high probability of near-term death (NAS/NRC 1990).

Radiation can also cause a variety of ill-health effects in people. The most significant ill-health effect to depict the consequences of environmental and occupational radiation exposures is the induction of latent cancer fatalities. This effect is referred to as latent cancer fatalities because the cancer may take many years to develop and for death to occur.

The collective (or population) dose to an exposed population is calculated by summing the estimated doses received by each member of the exposed population. This total dose received by the exposed population is measured in person-rem. For example, if 1,000 people each received a dose of 0.001 rem (1 millirem), the collective dose is 1,000 persons × 0.001 rem (1 millirem) = 1 person-rem. Alternatively, the same collective dose (1 person-rem) results from 500 people each of whom received a dose of 0.002 rem (2 millirem) (500 persons × 0.002 rem = 1 person-rem).

The factor that this EIS uses to relate a dose to its effect is 0.0004 latent cancer fatalities per person-rem for workers and 0.0005 latent cancer fatalities per person-rem for individuals among the general population. The latter factor is slightly higher because of the presence of individuals in the general public that may be more sensitive to radiation than workers (for example, infants).

These concepts may be applied to estimate the effects of exposing a population to radiation. For example, in a population of 100,000 people exposed only to background radiation [0.3 rem (300 millirem) per year], 15 latent cancer fatalities per year would be inferred to be caused by the radiation [100,000 persons × 0.3 rem (300 millirem) per year × 0.0005 latent cancer fatalities per person-rem = 15 latent cancer fatalities per year].

Sometimes, calculations of the number of latent cancer fatalities associated with radiation exposure do not yield whole numbers, and, especially in environmental applications, may yield numbers less than 1.0. For example, if a population of 100,000 were exposed as above, but to a total dose per individual of only 0.001 rem (1 millirem), the collective dose would be 100 person-rem, and the corresponding estimated number of latent cancer fatalities would be 0.05 [100,000 persons × 0.001 rem (1 millirem) × 0.0005 latent cancer fatalities/person-rem = 0.05 latent fatal cancers].

How should one interpret a noninteger number of latent cancer fatalities, such as 0.05? The answer is to interpret the result as a statistical estimate. That is, 0.05 is the *average* number of deaths that would be expected if the same exposure situation were applied to many different groups of 100,000 people. In most groups, nobody (0 people) would incur a latent cancer fatality from the 0.001 rem (1 millirem) dose each member would have received. In a small fraction of the groups, 1 latent fatal cancer would result; in exceptionally few groups, 2 or more latent fatal cancers would occur. The *average* number of deaths over all the groups would be 0.05 latent fatal cancers (just as the average of 0, 0, 0, and 1 is ¼, or 0.25). The most likely outcome is 0 latent cancer fatalities.

These same concepts apply to estimating the effects of radiation exposure on a single individual. Consider the effects, for example, of exposure to background radiation over a lifetime. The "number of latent cancer fatalities" corresponding to a single individual's exposure over a (presumed) 72-year lifetime to 0.3 rem (300 millirem) per year is the following:

1 person × 0.3 rem (300 millirem)/year × 72 years × 0.0005 latent cancer fatalities/person-rem = 0.011 latent cancer fatalities.

Again, this should be interpreted in a statistical sense; that is, the estimated effect of background radiation exposure on the exposed individual would produce a 1.1-percent chance that the individual might incur a latent fatal cancer caused by the exposure. Said another way, about 1.1 percent of the population is estimated to die of cancers induced by the radiation background.

The dose-to-risk conversion factors presented above and used in this EIS to relate radiation exposures to latent cancer fatalities are based on the "1990 Recommendations of the International Commission on Radiation Protection" (ICRP 1991). These conversion factors are consistent with those used by the U.S. Nuclear Regulatory Commission in its rulemaking "Standards for Protection Against Radiation" (FR 1991). In developing these conversion factors, the International Commission on Radiological Protection reviewed many studies, including *Health Effects of Exposure to Low Levels of Ionizing Radiation (BEIR V)* and *Sources, Effects and Risks of Ionizing Radiation.* These conversion factors represent the best-available estimates for relating a dose to its effect; most other conversion factors fall within the range of uncertainty associated with the conversion factors that are discussed in NAS/NRC (1990). The conversion factors apply where the dose to an individual is less than 20 rem (20,000 millirem) and the dose rate is less than 10 rem (10,000 millirem) per hour. At doses greater than 20 rem (20,000 millirem), the conversion factors used to relate radiation doses to latent cancer fatalities are doubled. At much higher doses, prompt effects, rather than latent cancer fatalities, may be the primary concern. Unusual accident situations that may result in high radiation doses to individuals are considered special cases.

In addition to latent cancer fatalities, other health effects could result from environmental and occupational exposures to radiation. These effects include nonfatal cancers among the exposed population and genetic effects in subsequent generations. Table 5-1 shows the dose-to-effect factors for these potential effects, as well as for latent cancer fatalities. For clarity and to allow ready comparison with health impacts from other sources, such as those from chemical carcinogens, this EIS presents estimated effects of radiation only in terms of latent cancer fatalities. The nonfatal cancers and genetic effects are less probable consequences of radiation exposure. Estimates of the total detriment (fatal cancers, nonfatal cancers, and genetic effects) due to radiation exposure may be obtained from the estimates of latent cancer fatalities presented in this EIS by multiplying by 1.4 for workers and by 1.46 for the general public.

Table 5-1. Risk of latent cancer fatalities and other health effects from exposure to radiation.[a,b]

Population[c]	Latent cancer fatality	Nonfatal cancer	Genetic effects	Total detriment
Workers	0.0004	0.00008	0.00008	0.00056
General public	0.0005	0.0001	0.00013	0.00073

a. When applied to an individual, units are lifetime probability of latent cancer fatalities per rem (or 1,000 millirem) of radiation dose. When applied to a population of individuals, units are excess number of cancers per person-rem of radiation dose. Genetic effects as used here apply to populations, not individuals.

b. Source: ICRP (1991).

c. The difference between the worker risk and the general public risk is attributable to the fact that the general population includes more individuals in sensitive age groups (that is, less than 18 years of age and over 65 years of age).

During SNF handling and transportation, the principal radiation hazard is the direct radiation emitting from the SNF. In comparison, the hazard from release of radioactive fission products (gases and particulates) from within the solid SNF is small. Without adequate shielding, the radiation levels at the surface of the SNF are often high enough to induce a prompt fatality. Fortunately, this radiation is easily attenuated or stopped with the insertion of shielding materials such as lead, steel, or water between the SNF and the worker. Because radiation intensity decreases with distance, maintaining a distance of a few hundred meters also offers adequate protection from the radiation from unshielded SNF. For example, 10 CFR 71 requires sufficient shielding on shipping casks to reduce radiation levels at 2 meters (7 feet) from the cask to 0.01 rem (10 millirem) per hour or less. At 100 meters (328 feet), the distance effect would reduce this 0.01 rem (10 millirem) per hour by a factor of about 2,500, which would not be detectable.

During SNF interim storage, trace quantities of radioactive isotopes (principally gases and particulate fission products) may also be released to the environment from severely corroded SNF. These releases would result in small doses to the workers in the immediate vicinity of the SNF and, through atmospheric dispersion and groundwater pathways, would ultimately result in very small doses to members of the nearby general population.

Accidents involving SNF can also result in radiation releases and exposures. For most accidents, a very small fraction of the radioactive material within the SNF is released. This is because the SNF is in a solid form and the radioactive elements are intermingled within the solid SNF. Significant quantities of these radioactive elements can be released only when the accident generates enough energy to break up or cause particles of SNF to be released to the atmosphere. For most accidents, the energy is not high enough to cause much damage to the SNF and a small fraction of the radioactive material is released.

One type of accident, an accidental nuclear criticality (uncontrolled chain reaction), can release large quantities of direct radiation, as well as fission products and heat. Within a few tens of meters of the incidents, doses from direct radiation can be fatal. Further away, doses are principally from the released fission product gases and particulates. This type of accident is well understood and is easily prevented when handling solid materials such as SNF.

Risk—Another concept important to the presentation of results in this EIS is the concept of risk. Risk is most important when presenting accident analysis results. The chance that an accident might occur during the conduct of an operation is called the probability of occurrence. An event that is certain to occur has a probability of 1 (as in 100 percent certainty). The probability of occurrence of an accident is less than one because accidents, by definition, are not certain to occur. If an accident is expected to happen once every 5 years, the frequency (and probability) of occurrence is 0.2 per year (1 occurrence ÷ 5 years = 0.2 occurrences per year).

Once the frequency (occurrences per year) and the consequences (for radiation effects, measured in terms of the number of latent cancer fatalities caused by the radiation exposure) of an accident are known, the risk can be determined. The risk per year is the product of the annual frequency of occurrence times the number of latent cancer fatalities. This annual risk expresses the expected number of latent cancer fatalities per year, taking account of both the annual chance that an accident might occur and the estimated consequences if it does occur.

For example, if the frequency of an accident were 0.2 occurrences per year and the number of latent cancer fatalities resulting from the accident were 0.05, the risk would be 0.01 latent cancer fatalities per year (0.2 occurrences per year × 0.05 latent cancer fatalities per occurrence = 0.01 latent cancer fatalities per year). Another way to express this risk (0.01 latent cancer fatalities per year) is to note that if the operation subject to the accident continued for 100 years, one latent cancer fatality would be likely to occur because of accidents during that period. This is equivalent to 1 chance in 100 that a single latent cancer fatality would be caused by the accident source for each year of operation.

A frame of reference for the risks from accidents associated with SNF management alternatives can be developed in the same way. For an average resident in the vicinity of the Idaho National Engineering Laboratory, the risk of a latent cancer fatality caused by the water draining from the Expended Core Facility after a large earthquake would be approximately 1.7×10^{-7} per year (see Chapter 5 of Appendix D). This risk can be compared with the lifetime risks of death from other accidental causes to gain a perspective. For example, the risk of dying from a motor vehicle accident is about 1 in 80. Similarly, the risk of death for the average American from fires is approximately 1 in 500, and for death from accidental poisoning, the risk is about 1 in 1,000 (NNPP 1993). These comparisons are not meant to imply that risks of a latent cancer fatality caused by DOE operations are trivial, only to show how they compare with other, more common risks. Radiological risks to the general public from DOE operations are considered to be involuntary risks, as opposed to voluntary risks such as operating a motor vehicle.

Radiological Accidents—Activities associated with transporting, receiving, handling, processing, and storing SNF involve substantial quantities of radioactive materials and limited quantities of toxic chemicals. Either routine SNF operations or accidents involving either radioactive materials or toxic chemicals can result in exposure to workers or members of the public, or contamination of the surrounding environment.

A number of existing accident analyses were evaluated to find a small group with relatively severe consequences or risks. These accidents included events such as small fires; severe accidents that a facility is designed to withstand; and beyond-design-basis events, which a facility is not designed to withstand. These accidents included those initiated by internal events, such as operational errors; those initiated by natural external phenomena, such as floods, tornados, and earthquakes; and those initiated by human-influenced external events, such as aircraft crashes and nearby explosions or toxic material releases. The accidents evaluated included those with an estimated probability ranging from 1 chance in 1,000,000 to 1 chance in 10,000,000 per year.

Appendices A through F summarize the possible accidents involving SNF operations at each of the sites and evaluate the potential consequences of the accidents that present the highest risk, in terms of estimated frequency of occurrence multiplied by consequences, to the workers and the general public. As might be expected, the highest consequences, though frequently not the highest risk, were often found to be associated with the accidents with the lowest probabilities.

The accidents selected, the amount of radioactive and toxic materials released under the accident conditions, and the estimated probabilities were based on existing safety analyses for the SNF-related operations at each site, or for comparable operations at other sites. The accident evaluations also considered the 40 to 50 years of operational experience with SNF at the sites.

Accident consequences were analyzed utilizing radioactive and toxic material release estimates for each accident. The downwind concentrations of materials released in accidents were then calculated for a range of potential receptor locations and potential doses to individuals or people at those locations evaluated. Doses were evaluated for (a) an individual 100 meters (328 feet) downwind of the facility location where the release occurs, (b) a hypothetical resident at the site boundary nearest to the facility where the release occurs (called the maximally exposed offsite individual), and (c) the general population within 80 kilometers (50 miles) of the release location. The potential impacts to workers in the immediate vicinity of the accident were analyzed qualitatively.

Dispersion in air from the release site was estimated with both typical (50th percentile) and unlikely (95th percentile) meteorological conditions. The unlikely weather conditions represent those that would result in high air concentrations of the material released, elevating the exposure of affected individuals. Concentrations and human exposures are lower than these values 95 percent of the time. Dispersion was calculated using the GENII computer code (Napier et al. 1988) for all sites except Savannah River Site, for which the site-specific AXAIR89Q code was used (including 95 percent meteorologic conditions). Although the modeling for the Savannah River Site was performed using a different code, that code has been validated and shown to be consistent with the GENII code and conservative in its model results. The dispersion of nonradioactive materials was modeled using EPIcode (Homann 1988).

Nonradiological Accidents—Accidents with nonradiological effects include industrial hazards from construction and normal operation. Accidents that may affect occupational or public health were evaluated for each of the alternatives at each of the potentially affected sites and facility locations. The maximum reasonably foreseeable accidents include chemical spills, fires, and worker accidents. The accidents estimated to exceed the most widely accepted accident exposure (toxicological) guidelines, such as the Emergency Response Planning Guideline-3 and the Threshold

Limit Value of the American Conference of Governmental Industrial Hygienists, are summarized in Section 5.1, Volume 1. Exceeding these concentrations would result in an unacceptable likelihood that the worker or public would experience or develop life-threatening or very serious toxicological effects. The analysis methodologies and the accident descriptions are discussed in Appendices A through F.

Industrial accidents that do not involve the release of chemicals could occur at each of the existing or proposed storage and generation locations during the transition/construction phase at approximately current rates. Construction accidents would primarily occur during the construction period (estimated to be approximately 8 years under the Centralization alternative). Construction fatalities are estimated to be approximately one per year at the centralized site for the Centralization alternative only. After the SNF is transported to the centralized facility, normal operations would not be expected to be fatal accident-free, but fatal accident frequency is estimated to be less than one accident per year. The sites that are not selected for the centralized facilities would be expected to have less than one fatal accident per year throughout the SNF interim management period.

5.1.1.5 Transportation. In this EIS, one of the ways that may be used to discriminate between alternatives is through the transportation impacts associated with each alternative. Some alternatives, such as the No Action alternative, would involve limited transportation of SNF and have few transportation impacts; while other alternatives, such as the Centralization options, would involve extensive transportation of SNF and have greater transportation impacts.

SNF is transported in large, heavy containers called shipping casks. Shipping casks must meet stringent Federal standards and are designed and constructed to contain the radioactivity in SNF during severe transportation accidents. There are also standards that describe the routing requirements for SNF shipments. Because of the stringent standards for SNF shipping casks, the U.S. Nuclear Regulatory Commission has estimated that shipping casks will withstand 99.4 percent of truck and rail accidents without sustaining damage sufficient to breach the shipping cask. Only in the worst physically conceivable conditions, which are clearly of low probability, can the shipping cask be so damaged that there is a significant release of radioactivity to the environment.

Transportation impacts may be divided into two parts: (1) the impacts due to incident-free transportation and (2) the impacts due to transportation accidents. For incident-free transportation and transportation accidents, impacts may be further divided into two parts: (1) nonradiological impacts and (2) radiological impacts. The nonradiological impacts are composed of the vehicular impacts of transportation, such as vehicular emissions and traffic accidents, and are not related to the radioactivity present in the shipments.

In contrast to the nonradiological impacts, the radiological impacts are due to the radioactivity present in SNF shipments. In the case of incident-free transportation, the radiological impacts result from the radiation field that surrounds the SNF shipping cask. These impacts are estimated for workers and the general population along the transportation route. In the case of transportation accidents, the radiological impacts would result from the radioactivity released from the SNF shipping cask during an accident. These impacts are also estimated for the general population along the transportation route.

This EIS evaluated a full range of transportation accidents, up to and including accidents with very low probability, estimated to be on the order of one in 1 million years. In addition, the consequences of severe transportation accidents were evaluated. The probability of these severe accidents was estimated to be on the order of one in 10 million years.

For both incident-free transportation and transportation accidents, methodology developed by the U.S. Nuclear Regulatory Commission was used to estimate impacts. These impacts were quantified in terms of the estimated number of radiation-related cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions and traffic accidents associated with each alternative. Appendices A, B, C, D, F, and I contain more details on the methodology, data, and assumptions used to develop these estimates.

5.1.1.6 Uncertainties and Conservatism. The calculations in this EIS have generally been performed in such a way that the estimates of risk provided are unlikely to be exceeded during either normal operations or in the event of an accident. For routine operations, the results of monitoring actual operations provide realistic estimates of source terms, which when combined with conservative estimates of the effects of radiation, produce estimates of risk that are very unlikely to be exceeded. The effects for all alternatives have been calculated using the same source terms and other factors, so this EIS provides an appropriate means of comparing potential impacts on human health and the environment.

The analyses of hypothetical accidents are based on the calculations that in turn must be based on sequences of events and models of effects that have not occurred. The models have attempted to provide estimates of the probabilities, source terms, pathways for dispersion and exposure, and the effects on human health and the environment that are as realistic as possible. In many cases, the probability of the accidents postulated is very low and little experience is available; thus, the consequences are uncertain. This has required the use of models or values for input that produce estimates of consequences and risks that are higher than would actually occur because of the desire to provide results that will not be exceeded.

All the alternatives have been evaluated using the same methods and data, allowing a fair comparison of all the alternatives on the same basis. It should be observed that, even using these conservative analytical methods, the risks associated with implementing any of the alternatives are small.

5.1.2 No Action Alternative

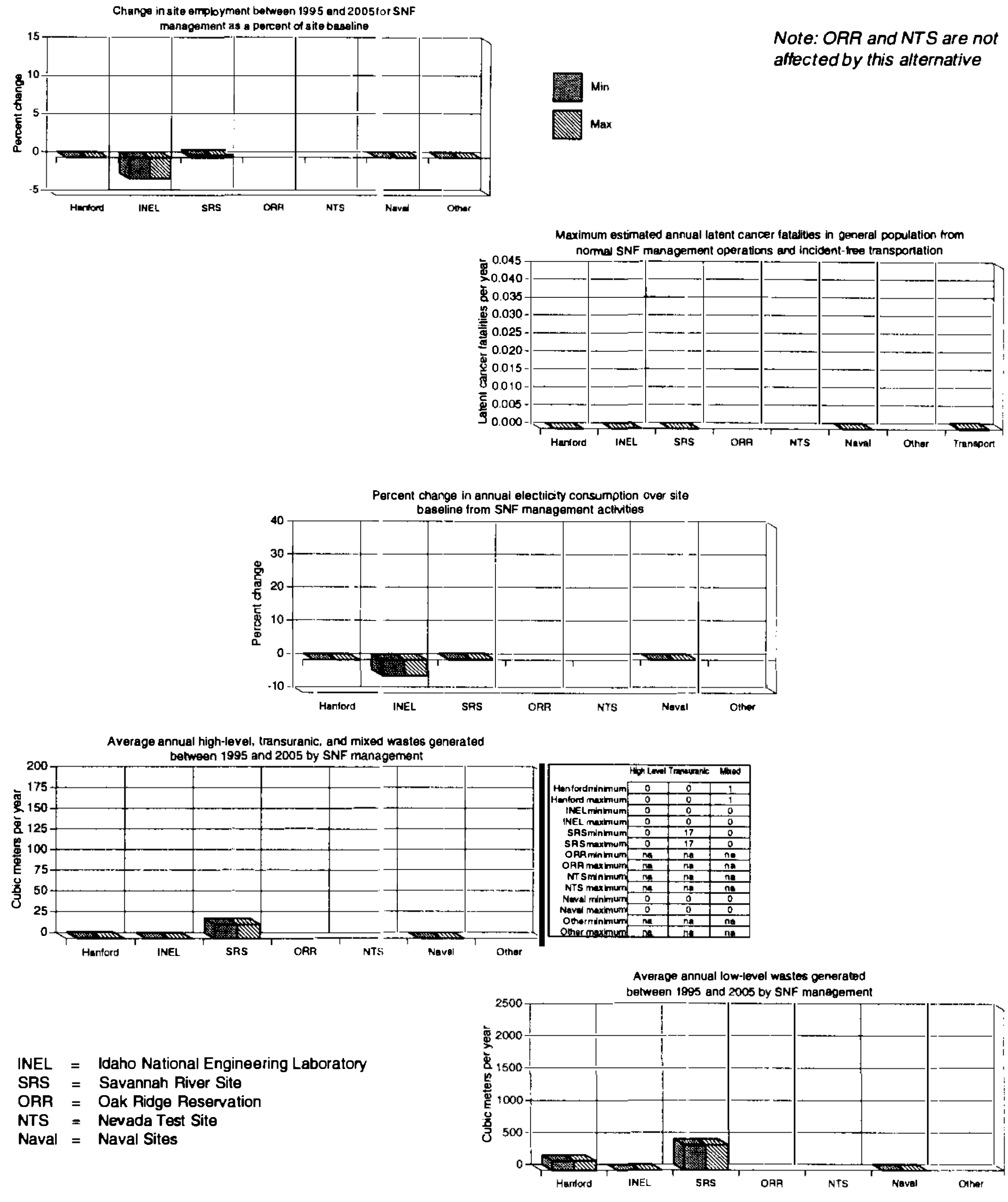
Under the No Action alternative, minimal actions would be taken for safe and secure management of SNF. SNF would not be transported to or from DOE facilities after a transition period, and facility upgrades or replacements and onsite fuel movements at DOE sites would be limited. Existing research and development activities at DOE sites would continue, but no new projects would be initiated. Naval SNF would be stored at naval sites at or near the point of refueling or defueling without examination at the Idaho National Engineering Laboratory. SNF from smaller DOE sites and university and other Government reactors would be stored at those reactors, and the special-case commercial fuels would remain at their current location. No foreign research reactor fuels would be accepted.

If this alternative were implemented, the Expended Core Facility at the Idaho National Engineering Laboratory would be shut down, the naval sites would store SNF in transport casks at naval sites, and the smaller DOE and university and other Government reactor sites would store the SNF they generate onsite. After a period of time, some smaller reactors would shut down to avoid the expense of building storage facilities, and the spent fuel would be stored in the reactor vessel.

In reviewing the impacts of the No Action alternative, it should be recognized that the consequences summarized in Figure 5-1 only approximately represent the consequences of this alternative. These consequences fall within four categories that may apply to one or more sites: increasing the potential for higher radiation exposures because of degrading fuels, increasing the potential for higher radiation exposures because of the location of SNF in or near major population centers, causing a potential loss of employment because research reactors would be shut down, and postponing the generation of wastes associated with research and converting SNF to a form acceptable for disposition. These issues are discussed in the following paragraphs.

Because there would be minimal actions taken to stabilize fuel under the No Action alternative, the frequency of an SNF-related radiation accident could increase as the stored fuels deteriorate with time. The lack of structural integrity of the fuel in some instances could result in an increase in handling-related accidents. In addition, releases from stored fuels could increase, increasing population doses, as the number of cladding failures increase. While the DOE is committed under the No Action alternative to ensure safe and secure management of SNF, future deterioration of fuels and facilities may increase accident risks over current risk estimates.

Under this alternative, DOE-managed SNF would be stored in over 50 locations around the country, many of which are in areas of relatively high population density. While the risk of exposure would be small for this alternative as with other alternatives, and the worst consequence accident is expected to be associated with one of the major DOE sites, the potential consequence of accidents could be greater because of the proximity of a larger population at many of the potential storage sites.



	High Level	Transuranic	Mixed
Hanford minimum	0	0	1
Hanford maximum	0	0	1
INEL minimum	0	0	0
INEL maximum	0	0	0
SRS minimum	0	17	0
SRS maximum	0	17	0
ORR minimum	na	na	na
ORR maximum	na	na	na
NTS minimum	na	na	na
NTS maximum	na	na	na
Naval minimum	0	0	0
Naval maximum	0	0	0
Other minimum	na	na	na
Other maximum	na	na	na

INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

Figure 5-1. Summary of impacts for the No Action alternative. (The maximum incremental change from baseline is illustrated in graphs. Input data are summarized in Appendix K.)

The employment associated with SNF management at other generator/storage locations would be higher under this alternative than others because economies of scale would not be achievable with storage facilities being distributed among more than 50 sites. At the same time, however, non-SNF-related employment would decrease because of SNF management-related concerns. Several hundred reactor operations and research jobs could be lost if research reactors were forced to close because of the inability to store SNF onsite. This job loss is not represented in the SNF management employment consequences presented in Section 5.1.2.1.

Under the No Action alternative, no new research would be initiated on appropriate technologies for converting fuels to an acceptable form for ultimate disposition and no new facilities would be built over the next 40 years for that purpose. Because this research was not initiated, potential adverse environmental impacts associated with research activities were not assessed under the No Action alternative. The lack of adverse environmental impacts makes the No Action alternative appear to be more environmentally acceptable than the other alternatives, when in fact the adverse impacts cannot be assessed until the research projects are planned.

The sites that would be affected by the No Action alternative are the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, naval sites, and other generator/storage locations. The environmental consequences at these sites are described below.

5.1.2.1 Socioeconomics. As shown in Figure 5-1, the graph of the maximum incremental change in employment from SNF management activities for the major DOE sites, except the Idaho National Engineering Laboratory, indicates there would be little socioeconomic impact associated with the No Action alternative between 1995 and 2005. Implementation of the No Action alternative would result in the shutdown of the Expended Core Facility at the Idaho National Engineering Laboratory, resulting in the loss of approximately 500 permanent jobs from a region with a relatively low population and few jobs. Closure of the Expended Core Facility would initially result in an increase in direct employment at the facility by 50 jobs over 3 years to handle the transport of containers, but then the 500-person work force would decrease to a caretaker work force of 10 (see Appendix D, Volume 1). This results in the loss of an average of approximately 240 jobs over the 10-year period or 3 percent of the Idaho National Engineering Laboratory's work force, as shown in Figure 5-1. At the Hanford and Savannah River Sites, there would either be no change or less than a 1 percent increase in direct employment, respectively, from implementing the No Action alternative. The peak employment would be 50 additional workers at the Savannah River Site, approximately 0.3 percent of the 1995 baseline.

Naval sites would require very few additional workers to secure the naval SNF in storage and monitor its condition. The incremental labor required for SNF management at the naval sites would be drawn from the existing work force and would be insignificant with respect to current employment levels at those sites. At the university and other Government reactors, there would be a need for security and maintenance personnel for reactors that would shut down. While this would not be an increase in employment at those sites because the staff required to run the reactors would no longer be required, it would be an increase in the staff that would be involved directly in SNF management. Across all sites, there would be a decrease in employment of less than 0.1 percent of the total workforce. Therefore, implementation of the No Action alternative would have no socioeconomic effect on a nationwide scale.

5.1.2.2 Utilities (Electricity). Figure 5-1 illustrates the maximum incremental power use with the No Action alternative in terms of percentage increase or decrease over baseline site use. For each of the sites, this change is very small and easily accommodated. Ongoing SNF operations are included in the baseline electric power usage, and the proposed actions under the No Action alternative are not power-intensive. At the Idaho National Engineering Laboratory, the shutdown of the Expended Core Facility would result in about a 5 percent reduction in electric power consumption below existing site usage. At naval and other generator/storage locations, there would be no discernable increase in power consumption over baseline use.

5.1.2.3 Materials and Waste Management. Figure 5-1 illustrates the annual average volume of high-level, transuranic, and mixed wastes and low-level waste that would be generated from SNF management over the next 10 years under the No Action alternative. Day-to-day SNF management and storage activities would annually generate approximately 20 cubic meters per year (26 cubic yards per year) of transuranic wastes and approximately 400 cubic meters per year (520 cubic yards per year) of low-level waste at the Savannah River Site. These volumes would be generated by activities required to safely store SNF, including the onsite consolidation of existing fuels and refurbishment of existing SNF storage pools. No high-level waste would be generated at any of the sites under the No Action alternative, and very small levels of all wastes would be generated by the Hanford Site and the Idaho National Engineering Laboratory.

At the naval sites, implementation of the No Action alternative would result in the production of limited amounts of solid municipal wastes and low-level radioactive waste. Wastes produced from the storage of naval SNF would be controlled and managed in accordance with existing site management programs. These small amounts of waste are shown as zero in Figure 5-1.

5.1.2.4 Radiological Impacts. For the No Action alternative, the radiological impacts from normal operations and accident risks are expected to be small at each of the major DOE and naval sites that handle and store SNF. Radiological impacts from normal operations and accidents are discussed by site below.

Radiological Impacts From Normal Operations—The airborne releases from the SNF interim storage pools at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site were estimated to result in low-level exposures to the population in the vicinity of the site with no additional latent cancers within that population expected. For naval sites, there would be no airborne releases; direct radiation is the only mechanism of exposure associated with the dry SNF interim storage technologies that would be used under this alternative. The estimated annual latent cancer fatalities for the general population are illustrated in Figure 5-1.

Radiological Impacts From Accidents—

Hanford Site. Under the No Action alternative, a wide range of accident scenarios was considered, including accidents initiated by operational events, external hazards such as aircraft crashes, and natural phenomena such as earthquakes. The highest risk SNF-related accidents identified in Section 5.15 of Appendix A are a liquid metal (sodium) fire in the Fast Flux Test Facility fuel storage area (highest to general population) and a spent fuel cask drop at the 105-K Basin (highest to workers). Major seismically induced accidents were also identified in buildings containing SNF (324 Building and 325 Building). Releases from these buildings were associated with materials other than SNF and therefore are not discussed here. Aircraft-crash initiated accidents were not considered to be reasonably foreseeable because of their very low frequency.

For both of the SNF-related accidents identified, the probabilities of occurrence are estimated to be less than one chance in 10,000 per year of operation. The estimated population doses, using very conservative meteorology and assuming no protective action, for the Fast Flux Test Facility sodium fire accident corresponds to an estimated 37 latent cancer fatalities in the general population within 80 kilometers (50 miles). The estimated risk per year, taking into account the probability of occurrence of this accident, is less than 3.7×10^{-3} potential latent cancer fatalities in the general population.

The potential dose to the maximally exposed offsite individual corresponds to an estimated probability of a latent cancer fatality of 2.5×10^{-4} for the Fast Flux Test Facility sodium fire. Emergency actions would likely reduce the actual exposures to any offsite individuals.

An onsite worker at the maximum exposure location downwind of the spent fuel cask drop is estimated to receive doses that correspond to an estimated probability of a latent cancer fatality of 1.4×10^{-3}. The estimated risk for a worker is 1.4×10^{-7} latent cancer fatalities per year.

Workers (up to 12) in the immediate vicinity of the cask drop accident could receive doses on the order of 70 to 140 rem (70,000 to 140,000 millirem). Acute doses of this magnitude are in the lower end of the range of doses that might produce symptoms of acute radiation syndrome in humans. For that accident, workers could be near the cask when it drops and receive direct radiation and inhale airborne fission products.

Potential secondary impacts identified for the Fast Flux Test Facility liquid metal fire (Table 5.15-2 of Appendix A) include temporary closure of the Hanford Reach of the Columbia River to boat traffic, temporary restriction of water use locally, possible loss of crops, environmental contamination in the vicinity of the facility and near offsite environs, potential restriction on land use for agriculture, temporary restriction on fishing access, and cleanup costs. The secondary impacts associated with the K Basin cask drop would be somewhat lower but similar in nature.

Idaho National Engineering Laboratory. Under the No Action alternative, a wide range of accident scenarios were also considered, including accidents initiated by operational events, external hazards such as aircraft crashes, and natural phenomena such as earthquakes. A number of SNF-related accidents are identified in Section 5.15 of Appendix B.

The highest risk to the general population is associated with the melting of a small number of assemblies as a result of a major earthquake and hot cell breach at the Hot Fuel Examination Facility. The estimated probability of this accident is about 1 chance in 100,000 per year of operation. General population consequences are estimated to be approximately 7 latent cancer fatalities, with an estimated risk of a latent cancer fatality of 7.0×10^{-5} latent cancer fatalities per year.

The highest risk to workers is an inadvertent nuclear criticality in the Idaho Chemical Processing Plant CPP-603 Underwater Fuel Storage Facility, which has an estimated probability of 1 chance in 1,000 per year of operation. The estimated probability of a latent cancer fatality in a worker approximately 100 meters (about 330 feet) downwind of the accident would be 3.9×10^{-5}. The estimated risk for a worker is 4.0×10^{-8} latent cancer fatalities per year.

If workers were in the immediate vicinity, doses under some circumstances could be very high but are not likely to be fatal immediately. In the criticality accident, the criticality would occur under approximately 6.1 meters (20 feet) of water. Shielding by the water would be sufficient to prevent exposure of nearby workers. Expulsion of a cone of water above the criticality might lead to significant exposure to any workers who were directly above the location of the criticality.

Fuel-handling accidents have the highest estimated frequency of occurrence at 1.0×10^{-2} per year, but because of their lower consequences, fuel-handling accidents do not represent the highest risk accidents under the No Action alternative. The frequency of fuel-handling accidents is directly related to the amount of fuel handled and the annual number of SNF shipments projected under the alternative.

Potential secondary impacts identified (Table 5.15-8 of Appendix B) for the criticality accident at the Idaho Chemical Processing Plant are limited adverse effects to vegetation or wildlife and local contamination requiring cleanup around the accident site. More extensive contamination and impacts are expected should a cell breach occur at the Hot Fuels Examination Facility. Additional secondary impacts identified include the potential for a 1-year restriction in agricultural use of up to 10,000 acres on and off the Idaho National Engineering Laboratory site, the potential interdiction of affected agricultural products on nearby lands, and the potential for temporary restricted access to affected public land (less than 10,000 acres).

The Expended Core Facility at the Idaho National Engineering Laboratory would be shut down after a transition period of approximately 3 years. Potential accidents during this period are presented in Attachment F of Appendix D under the subheading of the Decentralization alternative.

Savannah River Site. Under the No Action alternative, a wide range of accident types and accident initiators were considered for the existing SNF wet storage activities, including accidents initiated by operational events, external hazards such as aircraft crashes, and natural phenomena such as earthquakes. Five types of SNF-related accidents are identified in Section 5.15 and Attachment A of Appendix C. These include (a) a fuel assembly breach because of dropping, objects falling onto the assembly, or accidental cutting into the fuel part of an assembly, (b) an inadvertent nuclear criticality in an SNF interim storage pool, (c) a fire and explosion in an adjacent facility, and (d) spills of contaminated storage pool water either within the storage facility or to the ground outside of the facility. The initiators for these accidents include both operational events and natural phenomena such as earthquakes. Aircraft-crash-initiated accidents were not considered to be reasonably foreseeable because of their very low frequency.

The highest risk accident, both to the general population and workers, was identified as the fuel assembly breach accident with an estimated frequency of 0.16 per year. The estimated population dose for this accident corresponds to 8.5×10^{-3} latent cancer fatalities in the general population within 80 kilometers (50 miles). The estimated risk, taking into account the probability of occurrence of this accident, is 1.4×10^{-3} latent cancer fatalities per year. The estimated dose to the maximally exposed offsite individual corresponds to an estimated probahility of a latent cancer fatality of 1.6×10^{-7} per year.

A co-located worker downwind of the accident is estimated to receive a dose that corresponds to an estimated probability of 4.8×10^{-6} latent cancer fatalities. The estimated risk for a worker is 7.7×10^{-7} latent cancer fatalities per year.

Based on past experience at the Savannah River Site (two fuel cutting/breach accidents have occurred in the Receiving Basin for Offsite Fuels), no fatalities nor high exposures to facility workers are expected for this type of accident. This type of accident would likely occur with the assembly under 0.3 to 6 meters (1 to 20 feet) of water and result in small amounts of fuel and fission products being released to the pool water. The shielding effects of the pool water would attenuate most of the radiation released, but the noble gases released would rise to the surface of the water and enter the room atmosphere, causing a direct radiation exposure to workers in the area. Upon releases into the room's atmosphere, radiation alarms would sound requiring evacuation of nearby workers. Timely evacuation would likely prevent substantial radiation exposure.

Potential secondary impacts identified for the SNF-related accidents (Table 5-25 of Appendix C) are land contamination around the site of the accident, with minor contamination outside of the immediate facility area. This would not likely require cleanup of more than 4 hectares (10 acres).

Naval Facilities. Under the No Action alternative, newly generated SNF would be stored at naval sites, which differs from the historical practice of SNF management at the Idaho National Engineering Laboratory. The naval sites are generally located in densely populated areas. As a result, the consequences of an accident involving naval SNF at a naval site would be higher than the same accident at the Idaho National Engineering Laboratory.

After a limited transition period, naval SNF would be stored dry in shipping containers at Puget Sound, Pearl Harbor, Norfolk, and Portsmouth Naval Shipyards and the Kesselring Site. A review of a wide range of potential accidents (see Attachment F of Appendix D) indicated the limiting hypothetical accident scenario with the potential to release radioactive material from the storage containers was an airplane crash into the dry storage area. This accident is the highest risk accident for the general population and workers among all of the sites.

The highest risk to the general population occurs at Pearl Harbor. The probability of an aircraft crash at the Pearl Harbor facility is estimated to be 1 chance in 100,000 per year of operation. The estimated population consequences, using very conservative meteorology, is estimated to be 26 latent cancer fatalities in the general population within 80 kilometers (50 miles) of the site. The estimated risk to the general population, taking into account the probability of occurrence of this accident, is 2.6×10^{-4} latent cancer fatalities per year. The probability of a latent cancer fatality in the maximally exposed offsite individual is estimated to be 9.5×10^{-3}.

The highest risk to workers occurs at Norfolk. The probability of an airplane crash at Norfolk is estimated to be 1 chance in 1,000,000 per year of operation. An onsite worker approximately 100 meters (about 330 feet) downwind of the accident is estimated to receive a dose that corresponds to a probability of a latent cancer fatality of 7.4×10^{-2}. The estimated risk for a worker is 7.4×10^{-8} latent cancer fatalities per year.

It is not likely that any fatalities would occur in workers in the vicinity because workers are normally near the containers for only brief periods when a container is being placed in the dry storage array. At most, two or three nearby workers might receive significant radiation exposure from inhalation of airborne radioactivity if the container seal were breached. The low probability of the airplane crash itself, coupled with the probability that workers would be close enough to be affected, coupled with the probability that the wind would be blowing in the direction of the workers, makes it very unlikely that any worker would receive substantial radiation exposure.

Secondary impacts are principally land contamination around the site of the accident and temporary contamination of naval vessels at the shipyard. A total of approximately 43 hectares (106 acres) might require cleanup. The contamination could extend about 0.6 kilometers (0.4 miles) beyond the closest site boundary.

Other Generator/Storage Locations. Accident analyses were evaluated for these facilities. These accidents included (a) handling accidents that resulted in fuel drops with potential for fuel cladding breaches that could release portions of the more volatile fission products, such as noble gases and iodine, (b) accidental nuclear criticalities, (c) building collapse due to natural phenomena or external events such as major earthquakes or aircraft crashes, and (d) release of contaminated storage pool water. The analysis of these accidents indicated that they were similar in kind and consequence to those described for the major DOE sites and, therefore, these problems are not presented for each of the 57 other generator/storage locations. For the No Action alternative, no accidents related to SNF management were identified for the Nevada Test Site because no SNF is currently managed at the site. Two accidents were evaluated for the No Action alternative at the Oak Ridge Reservation. The first involved a dropped dam during refueling at the High Flux Isotope Reactor fuel pool. This accident resulted in an estimated 9.2×10^{-6} latent cancer fatalities to the worker and 1.7 latent cancer fatalities to the general population with a risk to the worker of 9.2×10^{-10} and to the general population of 1.7×10^{-4}. A beyond design basis accident at the High Flux Isotope Reactor could result from a roof collapse triggered by a tornado. This accident could result in an estimated 2.0×10^{-2} latent cancer fatalities to the worker and 2.3 latent cancer fatalities to the general population with a risk to the worker of 3.8×10^{-9} and to the general population of $4.4 \times 10\text{-}6$.

5.1.2.5 Nonradiological Impacts. A series of the maximum reasonably foreseeable accidents was evaluated at each of the SNF management sites that would potentially release hazardous or toxic chemicals to the workplace or the environment. The specific accident was defined and effects were estimated based on the characteristics of the specific facility, potentially affected public adjacent to the facility, and local residents (at the site boundary).

The maximum reasonably foreseeable chemical accident at SNF management facilities at the Hanford Site could result in the release of polychlorinated biphenyls and sulfuric acid at the 105-KE and 105-KW Basins. Should these releases occur, workers and the general public travelling adjacent to the accident could be subjected to chemical concentrations that might cause fatalities or serious health effects. The general public at the reservation boundary would be subjected to approximately 20 percent or less of the guideline value.

A maximum reasonably foreseeable chemical accident at the Idaho Chemical Processing Plant would be expected to release chlorine and nitric acid. Should such an event occur, workers would be subjected to chemical concentrations that might cause fatalities or serious health effects. The general public at the site boundary would be subjected to approximately 7 percent or less of the guideline value (Emergency Response Planning Guideline-3). The expected concentration on public access adjacent to the spill would be approximately 30 percent of the guideline value. Because these accidents would occur in each of the alternatives evaluated and do not discriminate among alternatives, they are not discussed further.

The release of nitrogen dioxide vapor from the interaction of target cleaning solution and sodium nitrite at the Receiving Basin for Offsite Fuel is the maximum reasonably foreseeable chemical accident at the Savannah River Site. Should this accident occur, the estimated concentration would be approximately 1 percent of the concentration that would be expected to cause fatalities or serious health effects for the worker and 0.1 percent for the maximally impacted offsite individual.

A diesel spill and fire was identified as the maximum reasonably foreseeable accident at each of the naval sites. Such an accident would be expected to produce toxic gas concentrations. Such an incident, should it occur, would be expected to cause fatalities or serious health effects from three chemicals (sulfur dioxide, oxides of nitrogen, and nitric acid) that are produced during the fire. Workers and the public on the nearest public access point at each of the five naval sites would be affected. The releases might also be expected to adversely affect the public immediately outside the facility boundary at the Norfolk Naval Shipyard site.

5.1.2.6 Transportation.

Shipments—Under the No Action alternative, the only offsite transportation of SNF involves shipments of naval SNF from the Newport News Shipyard to the Norfolk Naval Shipyard and shipments of irradiated test specimens from the Expended Core Facility at the Idaho National Engineering Laboratory to offsite locations. Onsite transportation of SNF would occur at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site.

Incident-Free Transportation—For the No Action alternative, the incident-free transportation of SNF was estimated to result in a total of 0.0089 fatalities over the 40-year period 1995 through 2035. These fatalities were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions. The estimated number of radiation-related latent cancer fatalities for transportation workers was 0.0026, the estimated number of radiation-related cancer fatalities for the general population was 0.00032, and the estimated number of nonradiological fatalities from vehicular emissions was 0.0059.

Onsite shipments of SNF were estimated to result in 0.0022 fatalities. Offsite shipments of SNF were estimated to result in 0.0067 fatalities. These fatalities represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents—The cumulative transportation accident risks over the 40-year operational period were estimated to be 4.1×10^{-6} latent cancer fatalities and 0.047 traffic fatalities. If an accident occurred, it would be unlikely to result in the release of any radioactivity. The maximum reasonably foreseeable accident has a chance of occurrence between 1×10^{-6} and 1×10^{-7} per year. If it occurred in an urban or suburban population zone, the likelihood of a single latent cancer fatality within the exposed population was estimated to be about 1 in 100. In a rural population zone, the likelihood of a single latent cancer fatality was estimated to be about 1 in 500.

Onsite transportation of SNF would occur under the No Action alternative at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The maximum reasonably foreseeable accident for this alternative would occur at the Idaho National Engineering Laboratory, with a latent cancer fatality risk of about 7.5×10^{-7} for a rural population zone and about 1.1×10^{-5} for a suburban population zone. In the extremely unlikely event that this accident occurred under stable (worst-case) weather conditions, it could result in 6 latent cancer fatalities in a rural population, such as around the Idaho National Engineering Laboratory, within 80 kilometers (50 miles) of the accident, or 85 latent cancer fatalities in a suburban population zone. For comparison, the rural population zone would be expected to experience 350 cancer fatalities and the suburban population zone would experience 42,000 cancer fatalities from other causes.

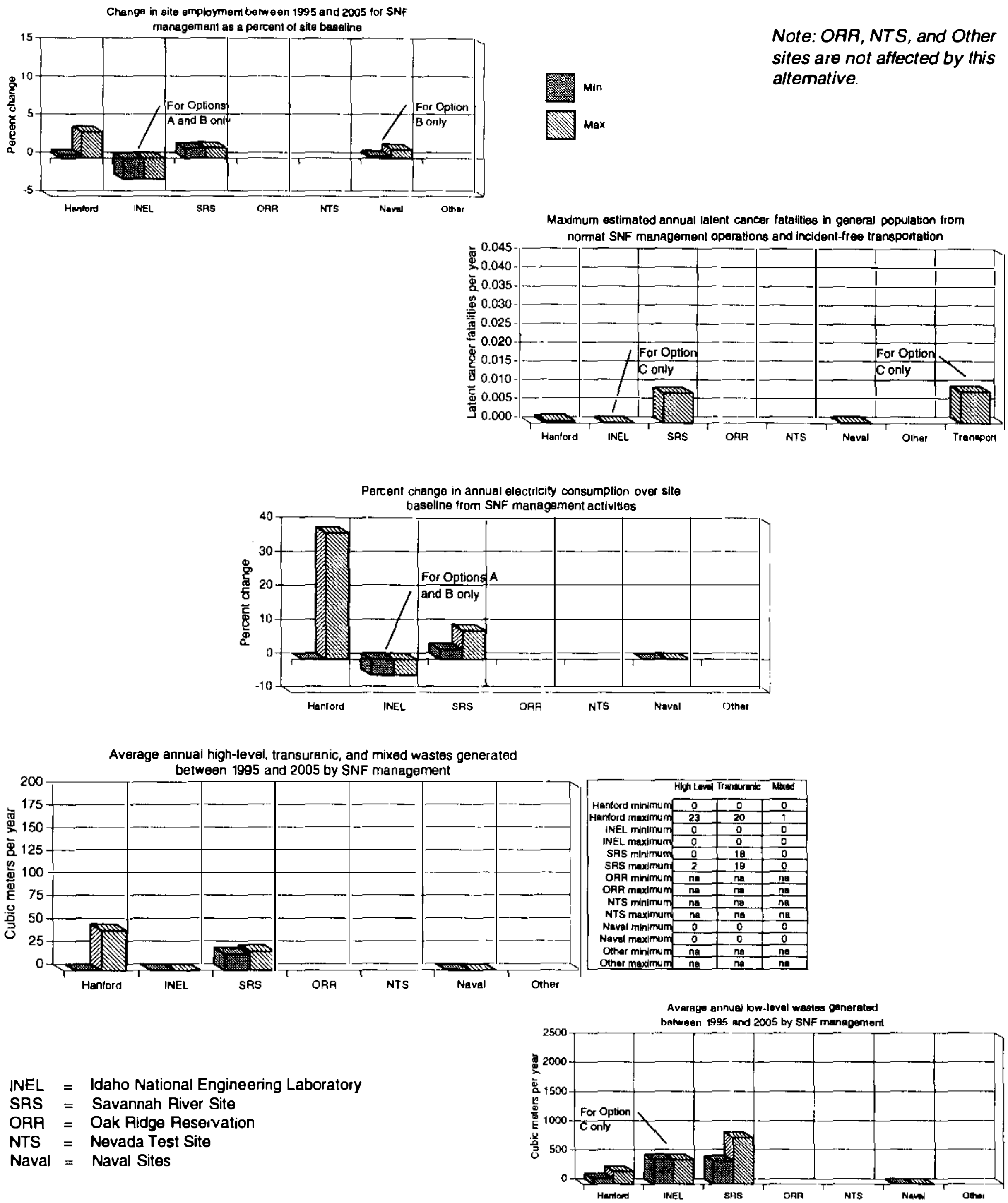
5.1.3 Decentralization Alternative

Under the Decentralization alternative, SNF currently stored or generated at DOE sites would remain at those sites, and SNF generated by university, other Government reactors, and foreign research reactors would be transported to either the Idaho National Engineering Laboratory or the Savannah River Site. Special-case commercial SNF would be transported to the Idaho National Engineering Laboratory. Storage facilities would be upgraded or replaced at DOE sites to improve the safe and secure storage of SNF. Existing research and development of technologies improving the safe and secure storage of SNF at DOE sites would continue, and new projects would commence. The Navy would store SNF at or near the point of refueling or defueling (Option A), transport about 10 percent of its SNF to the Puget Sound Naval Shipyard for limited examinations and storage with the remainder stored at or near the point of fueling or defueling (Option B), or transport all naval SNF to the Expended Core Facility at the Idaho National Engineering Laboratory for examination and then transport it back to naval sites for storage (Option C).

The implications of this alternative would be the closure of the Expended Core Facility at the Idaho National Engineering Laboratory under Options A and B and the modification of an existing facility at Puget Sound Naval Shipyard to provide limited examination under Option B. Major DOE sites might build new storage facilities to replace existing facilities or to accept newly generated SNF from other sites. Degraded fuels at the major DOE sites might be stabilized to improve safe storage.

The sites affected by the Decentralization alternative include the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, and naval sites. The environmental consequences at these sites are described below.

5.1.3.1 Socioeconomics. For the Decentralization A and B options, one socioeconomic consequence would be similar to that described for the No Action alternative—closing the Expended Core Facility would result in the loss of an average of approximately 240 direct jobs over 10 years at the Idaho National Engineering Laboratory (Figure 5-2), with an ultimate loss of about 500 jobs. This represents a decrease in employment at the Idaho National Engineering Laboratory of approximately 6 percent. Under the Decentralization C option, the Expended Core Facility would continue to operate at the Idaho National Engineering Laboratory with no socioeconomic consequences. At the Hanford and Savannah River Sites, this alternative would result in significant new construction, employing an additional 80 to 640 workers at the Hanford Site and 200 to 220 workers at the Savannah River Site over a 10-year period depending on the options chosen for SNF management at those sites. The higher value reflects an increase above baseline site employment of approximately 3 percent at the Hanford Site and approximately 1 percent at the Savannah River Site. The peak in employment would be an additional 1,100 workers at the Hanford Site, approximately 6 percent of the 1995 baseline.



	High Level	Transuranic	Mixed
Hanford minimum	0	0	0
Hanford maximum	23	20	1
INEL minimum	0	0	0
INEL maximum	0	0	0
SRS minimum	0	18	0
SRS maximum	2	19	0
ORR minimum	na	na	na
ORR maximum	na	na	na
NTS minimum	na	na	na
NTS maximum	na	na	na
Naval minimum	0	0	0
Naval maximum	0	0	0
Other minimum	na	na	na
Other maximum	na	na	na

INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

Figure 5-2. Summary of impacts for the Decentralization alternative. (The maximum incremental change from baseline is illustrated in all graphs. Input data summarized in Appendix K).

Increases in construction activity over the short-term at the Hanford Site could strain the housing market and put additional demands on school capacity. Operations after the construction period would have very small consequences through the overall project timeframe. No secondary effects on the local community are expected at the Savannah River Site.

At the naval sites, the Decentralization alternative would require construction workers and laborers to construct fuel storage areas and to staff these areas, but it is expected that these workers would come from the sites or the local area, and there would not be a significant socioeconomic impact on the surrounding communities. Nevertheless, staff required would be approximately 1 percent increase over existing naval site staffing.

5.1.3.2 Utilities (Electricity). Figure 5-2 illustrates the minimum and maximum incremental change in power use with respect to existing site usage from implementing the Decentralization alternative. As previously discussed in Section 5.1.1.2, the variation in power use by site shown on this graph reflects whether processing occurs or not. As an example, if the Hanford Site were to choose a storage option over a processing option, the power required for the storage option would be less than 1 percent of the overall site use; however, if a processing option were selected, then power use could increase to 37 percent above existing site use (see Appendix K). At each of the sites, the increase in electricity consumption could be accommodated with the existing site electric power infrastructure. At Hanford, if a processing option were selected, an extension of existing utilities in the 200 Area to the project area would be necessary. The maximum potential electricity usage shown at the Savannah River Site would be associated with the processing option that requires the operation of the F- and H-Canyons. These have operated for many years, and onsite and offsite utilities are adequate for their operation. At the Idaho National Engineering Laboratory, the principal differences among options are due to the operation or shutdown of the Expended Core Facility as was discussed in Section 5.1.2.2.

5.1.3.3 Materials and Waste Management. The minimum and maximum volumes of high-level, transuranic, mixed, and low-level wastes that would be generated by SNF management activities over the next 10 years relative to the baseline are shown in Figure 5-2. The combined volume of high-level, transuranic, and mixed waste generated annually, if processing options were implemented, is estimated to average from approximately 18 to 44 cubic meters per year at the Savannah River Site and Hanford Site, respectively. In contrast, if wet storage options for N-Reactor fuel were selected at the Hanford Site then no high-level, transuranic, or mixed waste would be expected to be generated. Figure 5-2 also illustrates the volume of low-level waste that would be generated from implementation of the Decentralization options. It should be noted that the volume of low-level waste would increase if a processing option were selected at either the Hanford Site or the Savannah River Site. Additional volumes of low-level waste would be generated at the Savannah River Site from the limited receipt of SNF shipments from offsite and by the addition of a new canning facility. Low-level waste would only be generated at the Idaho National Engineering Laboratory under the Decentralization alternative, where the Expended Core Facility would continue to operate. Operation of an Expended Core Facility could result in the annual production of approximately 430 cubic meters (526 cubic yards) of low-level waste (Appendix D).

At the naval sites, the implementation of the Decentralization alternative would have the same impact as that described in Section 5.1.2.3 for the No Action alternative because interim storage would be at the naval sites under both alternatives.

5.1.3.4 Radiological Impacts. Radiological exposures to both workers and the public from normal operations for the Decentralization alternative were estimated to be small, similar to the No Action alternative, with the principal differences associated with possible implementation of the processing options at the Hanford and Savannah River Sites because of higher radionuclide releases to the atmosphere. This increases the offsite population doses and potential for latent cancer fatalities. Figure 5-2 illustrates the estimated latent cancer fatalities associated with SNF operations at the major sites. The estimated latent cancer fatalities from 40 years of SNF operation would be less than one for each site.

Hanford Site—The Decentralization alternative considers several options for construction of new facilities at the Hanford Site, including a new wet storage facility for N-Reactor SNF and a new dry storage facility for fuels currently stored at other onsite locations. A second option for implementation of the Decentralization alternative at the Hanford Site is processing of the N-Reactor SNF followed by dry storage.

Under this alternative, one of the highest risk SNF-related accidents identified for the No Action alternative remains—the spent fuel cask drop at a wet storage facility. Because of the locations of the new storage facility, the offsite consequences and risks associated with this accident could be reduced to 25 percent of those described under the No Action alternative. The other highest risk accident, the sodium fire in the Fast Flux Test Facility fuel storage area, is no longer applicable because the Fast Flux Test Facility SNF would be moved to a new dry storage facility.

Potential accidents at the proposed new facilities include a severe cask impact followed by a fire at a new dry storage facility and a uranium metal fire at a new facility for processing N-Reactor SNF. Appendix A indicates that the cask impact and fire accident scenario presents the highest estimated risk to both the onsite workers and the general public of the accident scenarios identified for this alternative at Hanford.

For the severe cask impact accident, the estimated probability is 6 in 1,000,000 per year of operation. The estimated population dose, using very conservative meteorology, corresponds to 81 latent cancer fatalities in the general population within 80 kilometers (50 miles). The estimated risk per year, taking into account the chance of occurrence of this accident, would be 4.9×10^{-4} latent cancer fatalities per year in the general population. The potential dose to the maximally exposed offsite individual, assuming no protective action, corresponds to an estimated probability of a latent cancer fatality of 2.5×10^{-4}.

An onsite individual approximately 100 meters (about 330 feet) downwind of the accident who remains within the plume while the fire burns could receive a dose of 120 rem (120,000 millirem). Acute doses of this magnitude are in the lower end of the range of doses that might produce symptoms of acute radiation syndrome in humans. Because a fire is also involved, the close-in dose is highly dependent on the meteorological conditions at the time, the amount of plume rise that is generated by the heat from the fire, the exact location of the accident relative to buildings, etc. An individual 100 meters (about 330 feet) downwind is estimated to receive a dose that is sufficient to cause immediate health impacts, but probably would not be lethal. This dose corresponds to an estimated worker probability of a latent cancer fatality of 9.4×10^{-2}. The estimated risk for a worker is 5.6×10^{-7} latent cancer fatalities per year.

Workers in the immediate vicinity of this accident could receive very high doses that could be lethal unless they immediately evacuated the area of the accident. There are likely to be two time scales for releases associated with this accident: immediately following the accident and while the fire burns. Nearby workers may not be able to avoid the immediate radiological impacts but could likely evacuate the area and avoid most of the fire-related radiological releases unless incapacitated by the accident.

Potential secondary impacts identified for the severe cask impact with fire accident (Table 5.15-2 of Appendix A) include possible restriction of use of the Hanford Reach of the Columbia River for recreation, potential loss of crops, moderate environmental contamination in the vicinity of the facility and near offsite environs, temporary restriction on land use for agriculture, possible short-term restriction on fishing access, and cleanup costs.

Idaho National Engineering Laboratory—Under the Decentralization alternative at the Idaho National Engineering Laboratory the highest consequence and highest risk SNF-related accidents are associated with SNF storage and are the same as described under the No Action alternative. Under the Decentralization alternative, there are more SNF shipments, and consequently more handling of SNF compared to the No Action alternative. As a result, the potential frequency of fuel-handling accidents could be about 20 percent higher than under the No Action alternative, but because of lower consequences, fuel-handling accidents would not represent the highest risk accidents under the Decentralization alternative (see DOE-ID 1994).

Savannah River Site—The Decentralization alternative considers several options for SNF management at the Savannah River Site, including wet storage (Option 2b), new facilities for dry storage (Option 2a), and processing the SNF followed by dry storage (Option 2c), which were not considered under the No Action alternative.

The highest risk accident for both the general population and workers, however, would be the fuel assembly breach accident that was discussed under the No Action alternative.

The accident frequency is expected to be about 0.35 fuel assembly breaches per year of operation with implementation of this alternative. The risks to the general public, the maximally exposed offsite individual, and co-located workers were estimated to be 3×10^{-3}, 3.5×10^{-7}, and 1.7×10^{-6} latent cancer fatalities per year of operation, respectively.

Naval Facilities—The accident risks for the three subalternatives were evaluated for the naval facilities under the Decentralization alternative: (a) decentralization with SNF retained at the shipyards and the Kesselring Site without examination of the SNF, (b) decentralization with limited examination at Puget Sound Naval Shipyard, and (c) decentralization with performance assessment examination at the Expended Core Facility at the Idaho National Engineering Laboratory followed by storage at naval sites. Attachment F of Appendix D presents a full discussion of the accident risks at each of the naval sites.

The accident risks associated with this alternative would be the same as with the No Action alternative, with the highest risk accident being an aircraft crash into a dry storage container. The consequences and risks of this maximum risk accident would be the same as those described under the No Action alternative.

Other Generator/Storage Locations—For the Decentralization alternatives, the accident risks at the Oak Ridge Reservation and other SNF interim storage sites that do not transport their SNF elsewhere would be expected to be similar to and bounded by the accident risks under the No Action alternative.

5.1.3.5 Nonradiological Accidents. The maximum reasonably foreseeable chemical accident at the Idaho National Engineering Laboratory, Savannah River Site, naval sites, and other generator/storage locations would be similar to those described under the No Action alternative. An accident at the wet storage facility on the Hanford Site could release sulfuric acid vapor and subject workers to up to 130 percent of the chemical concentrations that are associated with fatalities or serious health effects.

5.1.3.6 Transportation.

Shipments—Under the Decentralization alternative, university, foreign, and non-DOE research reactors would transport SNF to the Idaho National Engineering Laboratory and the Savannah River Site. In addition, naval SNF shipments would be equal to or greater than those under the No Action alternative, depending on the choice of subalternative with respect to fuel

Incident-Free Transportation—For the Decentralization alternative, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.12 to 0.38 over the 40-year period 1995 through 2035. These fatalities represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was because of three factors: (a) different examination options for naval SNF (see Appendix D), (b) the option of using truck or rail transport for DOE SNF (see Appendix I), and (c) different SNF management options at the Savannah River Site (see Appendix C). Navy shipments would be made using a combination of truck and rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.026 to 0.090, the estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.041 to 0.24, and the estimated number of nonradiological fatalities from vehicular emissions ranged from 0.047 to 0.050 for this alternative.

Onsite shipments of SNF were estimated to result in 0.0025 to 0.0036 fatalities. Offsite shipments of SNF were estimated to result in 0.12 to 0.37 fatalities. These fatalities also represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents—The cumulative transportation accident risks over the 40-year operational period were estimated to be in the range of 0.00085 to 0.0009 latent cancer fatalities, and 0.20 to 1.01 traffic fatalities, if all SNF were transported by truck. If all SNF were transported by rail, the corresponding risks were estimated to be in the range of 0.00029 to 0.00034 latent cancer fatalities, and 0.26 to 1.07 traffic fatalities. The range of fatality estimates reflects the different fuel examination options for naval SNF (see Appendix D).

The maximum reasonably foreseeable offsite transportation accident under the Decentralization alternative involves transport of naval SNF by rail in a suburban area. The consequences of such an accident were estimated to be 1.7 latent cancer fatalities. The probability of occurrence of such an accident would be slightly greater than 1.0×10^{-7} per year. This probability accounts for the accident rate per mile traveled, the number of miles traveled, the percentage of the total distance that occurs in a suburban area, the meteorological conditions, and the severity of the accident. Based on DOE guidance (DOE 1993b), accidents with a probability of occurrence less than 1.0×10^{-7} per year are not reasonably foreseeable and are not evaluated in this EIS. Consistent with this guidance, an accident of similar severity to that above for the suburban area, but occurring in an urban area, would not be reasonably foreseeable. This is because the total miles traveled in an urban area would be only a few percent of the total transportation route, resulting in a probability of occurrence of less than 1.0×10^{-7} per year. Thus, the maximum reasonably foreseeable offsite transportation accident in an urban area would be less severe than postulated to occur in a suburban area and is estimated to result in 0.065 latent cancer fatalities. (A more complete discussion of this apparent anomaly is presented in Section A.5.2 of Volume I, Appendix D, Part B, Attachment A.)

Onsite transportation of SNF would occur under the Decentralization alternative at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The maximum reasonably foreseeable accident for this alternative occurs at the Idaho National Engineering Laboratory, and the potential impacts would be the same as those described under the No Action alternative.

5.1.4 1992/1993 Planning Basis Alternative

Under the 1992/1993 Planning Basis alternative, SNF currently stored at major DOE sites would remain at those sites, and newly generated SNF from DOE, university, and other Government reactors would be transported to the Idaho National Engineering Laboratory or the Savannah River Site for storage. Special-case commercial SNF and naval SNF would be transported to the Idaho National Engineering Laboratory for storage. Existing research and development of technologies improving the safe and secure storage of SNF at DOE sites would continue, and new projects would commence. Examination of naval fuels would be conducted at the Expended Core Facility at the Idaho National Engineering Laboratory.

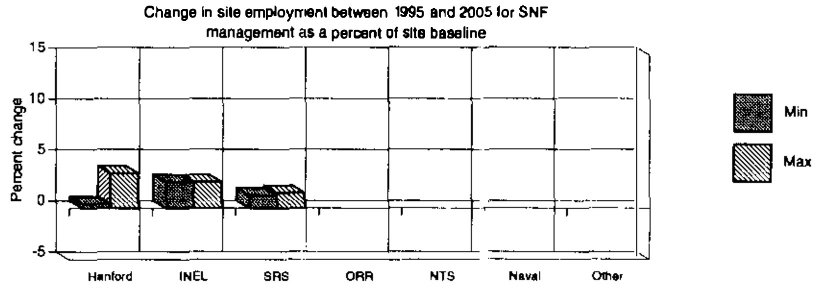
The implications of this alternative for major DOE sites would be similar to those described for the Decentralization alternative. New storage facilities would be built at the major DOE sites to replace existing facilities or to accept newly generated SNF from other sites. Degraded fuels at the Savannah River Site and the Hanford Site might be stabilized to improve safe storage.

The sites that would be affected by the 1992/1993 Planning Basis alternative are the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The environmental consequences at these sites are described below.

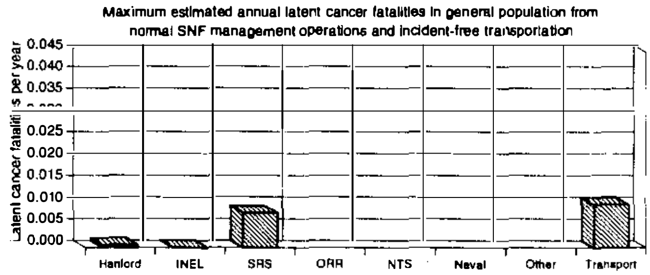
5.1.4.1 Socioeconomics. Implementation of the 1992/1993 Planning Basis alternative would not have a significant socioeconomic impact at any of the major DOE or naval sites (Figure 5-3). The impacts at the Hanford and Savannah River Sites would be similar to those described for the Decentralization alternative in Section 5.1.3.1 and shown on Figure 5-2. Proposed new construction and maintenance activities at the Idaho National Engineering Laboratory would result in the addition of approximately 130 workers over 10 years, less than a 2 percent increase above baseline site employment. The peak employment at Hanford would be the same as that described for the Decentralization alternative, a maximum of about 1,100 additional workers at the Hanford Site, an increase of approximately 6 percent above the 1995 baseline. Secondary socioeconomic impacts at the Hanford Site would be similar to those described under the Decentralization alternative.

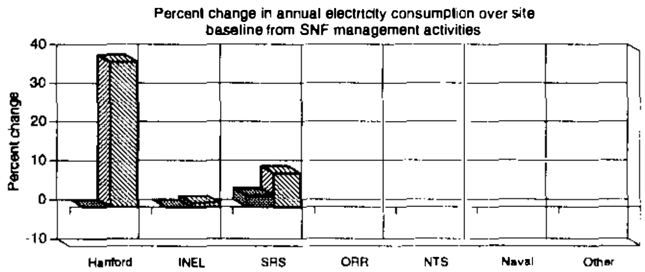
There would be no socioeconomic impact at the naval sites because current practices would not be altered. Storage facilities would not need to be constructed at the individual naval sites, and no employment would be generated at naval sites.

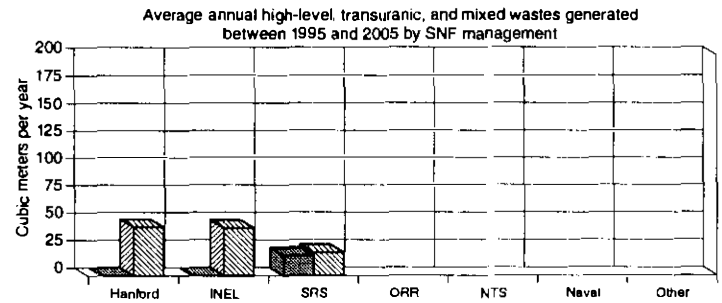
5.1.4.2 Utilities (Electricity). The minimum and maximum change in power use from implementing the 1992/1993 Planning Basis alternative with respect to the site baseline is shown in Figure 5-3. The impact on power consumption at the sites would be the same as that described for the Decentralization alternative in Section 5.1.3.2 (compare with Figure 5-2) except at the Idaho



Note: ORR, NTS, Naval, and Other sites are not affected by this alternative.







	High Level	Transuranic	Mixed
Hanford minimum	0	0	0
Hanfordmaximum	23	20	1
INEL minimum	0	0	0
INEL maximum	6	36	1
SRSminimum	0	16	0
SRSmaximum	2	19	0
ORR minimum	na	na	na
ORRmaximum	na	na	na
NTS minimum	na	na	na
NTSmaximum	na	na	na
Naval minimum	na	na	na
Naval maximum	na	na	na
Other minimum	na	na	na
Other maximum	na	na	na

INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

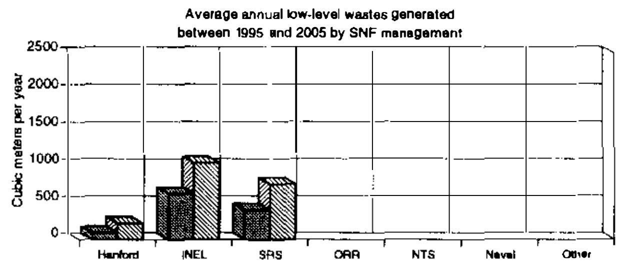


Figure 5-3. Summary of impacts for the 1992/1993 Planning Basis alternative. (The maximum incremental change from baseline is illustrated in all graphs. Input data are summarized in Appendix K).

National Engineering Laboratory. The variation in power use over site baseline use at the Savannah River and Hanford Sites reflects whether a storage or processing option is selected for SNF management. The increase in power use at the Idaho National Engineering Laboratory would be because of the Electrometallurgical Process Demonstration Project. If processing options were implemented at the Hanford Site, an extension of existing utilities to the project area would be necessary.

5.1.4.3 Materials and Waste Management. Figure 5-3 illustrates the combined average annual volumes of high-level, transuranic, and mixed wastes and of low-level wastes that would be generated over the next 10 years as a result of SNF management activities with the implementation of the 1992/1993 Planning Basis alternative. The volume of low-level waste and the combined volume of high-level, transuranic, and mixed waste would be similar to the volumes generated under the Decentralization alternative for the Hanford and Savannah River Sites (see Figures 5-2 and 5-3). The minimum and maximum values shown for these sites reflect whether a storage option or a processing option would be implemented, respectively.

At the Idaho National Engineering Laboratory, implementation of the 1992/1993 Planning Basis alternative would result in the generation of high-level, transuranic, and mixed wastes. These wastes would be generated by the Electrometallurgical Process Demonstration Project. The volume of low-level waste generated at the Idaho National Engineering Laboratory would be from the construction and operation of new storage and characterization facilities at the site. Adequate storage capacity exists at the site for these wastes until 2005, when additional capacity would be expected to be required for managing low-level waste (Appendix B).

5.1.4.4 Radiological Impacts. Radiological exposures to both workers and the public from normal SNF management operations and onsite accidents for the 1992/1993 Planning Basis alternative would be essentially the same as estimated for the Decentralization option. Figure 5-3 illustrates the estimated latent cancer fatalities associated with SNF operations at the major sites.

SNF Facility Accidents—

Hanford Site. The implementation of the 1992/1993 Planning Basis alternative at the Hanford Site would not result in accident risks significantly different from those identified for the Decentralization alternative (Section 5.15 of Appendix A).

Idaho National Engineering Laboratory. Under the 1992/1993 Planning Basis alternative at the Idaho National Engineering Laboratory, the consequences and risks of accidents associated with SNF storage would be the same as described under the No Action alternative (Section 5.15 of Appendix B). The consequences of fuel-handling accidents would be the same as described under the No Action alternative, but increased SNF shipments, and consequently more handling of SNF, could result in a frequency of fuel-handling accidents about three times higher than for the No Action alternative (Slaughterbeck et al. 1995). Because of the increased frequency of fuel-handling accidents, risk to the public from fuel-handling accidents may exceed the risk from SNF storage accidents.

Savannah River Site. The implementation of the 1992/1993 Planning Basis alternative at the Savannah River Site would not result in accident consequence estimates that differ from those identified under the Decentralization alternative (Section 5.15 and Attachment A of Appendix C). Because of increases in amount of SNF handled, the accident frequencies would be expected to increase.

The accident frequency for the highest risk accident, the fuel assembly breach, would be expected to be about 0.40 fuel assembly breaches per year of operation with implementation of this alternative. This results in estimated risk to the general public, maximally exposed offsite individual, and co-located worker of 3.4×10^{-3}, 4.0×10^{-7}, and 1.9×10^{-6} latent cancer fatalities per year of operation, respectively.

Naval Facilities. With implementation of the 1992/1993 Planning Basis alternative for naval facilities, all storage and examination activities occur at the Idaho National Engineering Laboratory. The maximum risk accident at this facility was not the maximum risk accident at the Idaho National Engineering Laboratory, so it is not discussed further in this volume. See Attachment F of Appendix D for details.

Other Generator/Storage Locations. For the 1992/1993 Planning Basis alternative, the accident risks at the Oak Ridge Reservation and other SNF interim storage sites that do not transport their SNF elsewhere would be similar to the accident risks under the No Action alternative.

5.1.4.5 Nonradiological Accidents. The maximum reasonably foreseeable chemical accident at the Idaho National Engineering Laboratory, Savannah River Site, and other generator/storage locations would be similar to those described under the No Action alternative. The Hanford Site accidents would be similar to those in the Decentralization alternative.

Two independent accidents were evaluated to describe the maximum reasonably foreseeable chemical hazards during the operation of the Expended Core Facility at the Idaho National Engineering Laboratory. Such a release could subject workers to chemical concentrations that could cause fatalities or serious health effects but would not subject the public to such concentrations.

5.1.4.6 Transportation.

Shipments—Under the 1992/1993 Planning Basis alternative, university, foreign, and non-DOE research reactors would transport SNF to the Idaho National Engineering Laboratory and the Savannah River Site. Commercial SNF stored at the West Valley Demonstration Project and graphite SNF stored at the Fort St. Vrain site would be transported to the Idaho National Engineering

Laboratory. DOE research reactor SNF stored at various DOE sites would be transported to the Idaho National Engineering Laboratory and the Savannah River Site. Naval SNF would be transported from naval shipyards to the Expended Core Facility and irradiated test specimens would be transported between the Expended Core Facility and offsite locations. Onsite transportation would relocate SNF from one facility to another for stabilization or storage.

Incident-Free Transportation—For the 1992/1993 Planning Basis alternative, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.14 to 0.45 over the 40-year period 1995 through 2035. These fatalities were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was due to two factors: (a) the option of using truck or rail transport for DOE SNF (see Appendix I) and (b) different SNF management options at the Savannah River Site (see Appendix C). Navy shipments would be made using a combination of truck or rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.029 to 0.11, the estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.044 to 0.30, and the estimated number of nonradiological fatalities from vehicular emissions ranged from 0.045 to 0.071.

Onsite shipments of SNF were estimated to result in 0.0028 to 0.0036 fatality. Offsite shipments of SNF were estimated to result in 0.14 to 0.45 fatality. These fatalities were also the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents—The cumulative transportation accident risks over the 40-year operational period were estimated to be 0.0010 latent cancer fatality and 0.70 traffic fatality if all SNF were transported by truck. If all SNF were transported by rail, the corresponding risks were estimated to be 0.00035 latent cancer fatality and 0.73 traffic fatality.

The maximum reasonably foreseeable offsite transportation accident involves a rail shipment of special-case commercial SNF in a suburban population zone under neutral (average) weather conditions. The accident has a probability of occurrence of about 2.0×10^{-7} per year and would result in an estimated 7 latent cancer fatalities in the exposed population. For comparison, the same population would be expected to experience about 100,000 cancer fatalities from other causes. The probability of this accident occurring in an urban population zone would be less than 1×10^{-7} per year. In a rural population zone, the accident consequences would be estimated to be about 0.2 latent cancer fatalities.

Onsite transportation of SNF would occur under the 1992/1993 Planning Basis alternative at the Hanford Site, the Idaho National Engineering Laboratory, and the Savannah River Site. The maximum reasonably foreseeable accident for this alternative occurs at the Idaho National Engineering Laboratory, and the potential impacts would be the same as those described under the No Action alternative.

5.1.5 Regionalization Alternative

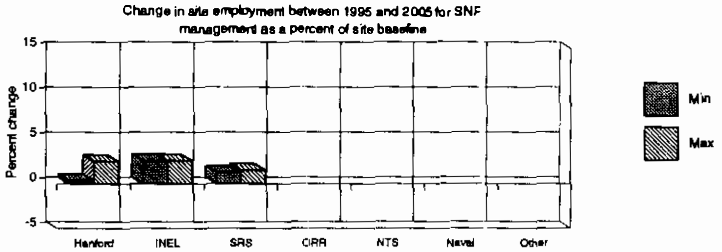
There are two alternatives under Regionalization: Regionalization 4A would relocate SNF according to fuel type; Regionalization 4B would relocate SNF according to location.

Under Regionalization 4A, certain types of SNF from other DOE sites, and SNF from university and other Government reactors, special-case commercial SNF, and foreign research reactor SNF would be transported to either the Idaho National Engineering Laboratory or Savannah River Site for storage. Existing research and development of technologies improving the safe and secure storage of SNF at DOE sites would continue, and new projects would commence. Naval SNF would be examined at the Expended Core Facility at the Idaho National Engineering Laboratory, then stored at the Idaho Chemical Processing Plant.

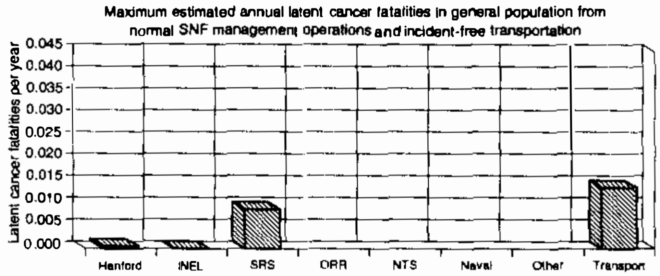
The implications of Regionalization 4A are essentially the same as those of the 1992/1993 Planning Basis alternative because there would be minor differences in the amounts of fuel transported to each destination under these alternatives (see Figure 5-4).

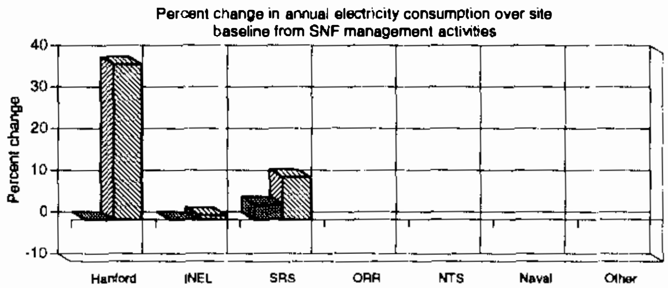
Under Regionalization 4B, however, two regional sites would be selected, and SNF would be moved to one site or the other. In the west, either the Hanford Site, Idaho National Engineering Laboratory, or Nevada Test Site would be the regional site; in the east, either the Savannah River Site or Oak Ridge Reservation would be designated. SNF stored or generated west of the Mississippi River would be transported to the Western Regional Site, and SNF stored or generated east of the Mississippi River would be transported to the Eastern Regional Site. An expended core facility would be built at either the Eastern or Western Regional Site (unless the Western Regional Site were the Idaho National Engineering Laboratory, in which case no new facility would be required). Research and development would be conducted at the regional sites.

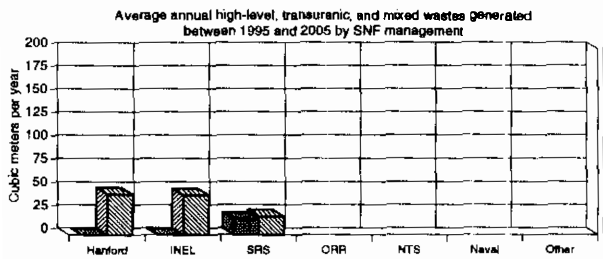
Regionalization 4B affects more sites than Regionalization 4A. Only one site would have SNF management responsibility in the east and in the west; thus, SNF management activities would be phased out at those sites not selected as regional sites. If the Idaho National Engineering Laboratory were not selected as the Western Regional Site, the Expended Core Facility in Idaho would be closed, and a new facility would be built at either the Eastern or Western Regional Site. If the Oak Ridge Reservation were chosen as the Eastern Regional Site, SNF now at Savannah River would be transported to the Oak Ridge Reservation. This would require the development of new storage facilities at the Reservation. Some fuels might need to be stabilized before transport. If the Savannah River Site were selected as the Eastern Regional Site, there would be few differences between Regionalization 4B and Regionalization 4A except that an expended core facility might be built at the site. In the west, transport of Hanford SNF to another site would require stabilization of the N-Reactor fuels, the great majority of the SNF now stored there. Some Idaho National Engineering Laboratory fuels would also require stabilization if they were transported to another site. New SNF management facilities would be required at any Western Regional Site selected because of the large volumes of SNF that would be received.



Note: ORR, NTS, Naval, and Other sites are not affected by this subalternative.







	High Level	Transuranic	Mixed
Hanford minimum	0	0	0
Hanford maximum	23	20	1
INEL minimum	0	0	0
INEL maximum	8	36	1
SRS minimum	0	17	0
SRS maximum	2	18	0
ORR minimum	na	na	na
ORR maximum	na	na	na
NTS minimum	na	na	na
NTS maximum	na	na	na
Naval minimum	na	na	na
Naval maximum	na	na	na
Other minimum	na	na	na
Other maximum	na	na	na

INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

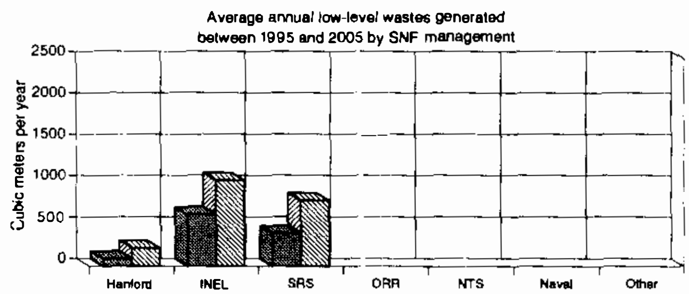


Figure 5-4. Summary of impacts for Regionalization 4A (by fuel type). (The maximum incremental change from baseline is illustrated in all graphs. Input data are summarized in Appendix K.)

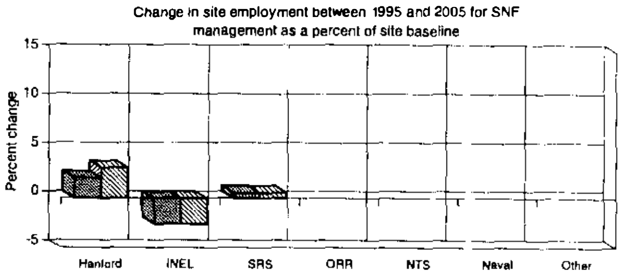
This alternative would affect only the five major DOE sites. The environmental consequences at these sites are described below.

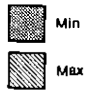
5.1.5.1 Socioeconomics. Under Regionalization 4A, the socioeconomic impacts at the Idaho National Engineering Laboratory would be the same as those described for the 1992/1993 Planning Basis alternative described in Section 5.1.4.1. The peak employment under Regionalization 4A would be an additional 470 workers at the Hanford Site, approximately 3 percent above the 1995 baseline. Implementation of Regionalization 4A would have no socioeconomic consequences at either the Oak Ridge Reservation or the Nevada Test Site because this would result in no changes to existing operations at either site.

Impacts of Regionalization 4A on the naval sites would be the same as that described for the 1992/1993 Planning Basis alternative because naval SNF would be transported to the Expended Core Facility in Idaho for examination and storage at the Idaho National Engineering Laboratory.

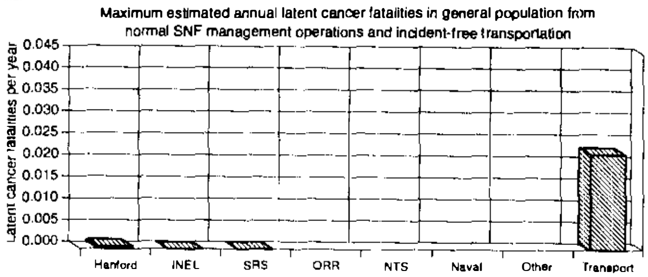
If either the Hanford Site, Idaho National Engineering Laboratory, or Savannah River Site were not selected as a regional site under Regionalization 4B, there would be an eventual reduction in employment equal to existing employment for SNF management at these sites. This would add to the currently predicted loss of jobs at each of these sites. In the short term, additional jobs would be required to prepare SNF for transport offsite (see Figure 5-5). The closure of the Expended Core Facility at the Idaho National Engineering Laboratory, however, would lead to a short-term loss of jobs as well, increasing the rate of job loss at that site.

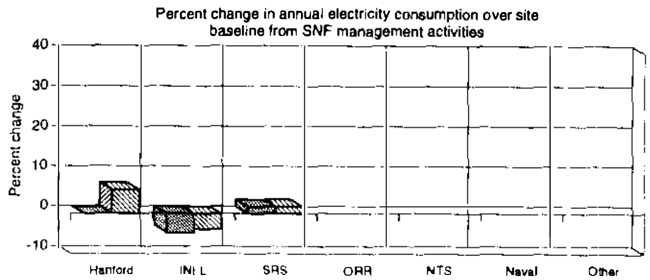
Sites that were selected as regional sites would have generally increased employment over baseline levels (see Figure 5-6). Site employment levels would also increase at whatever site an expended core facility were constructed (Figure 5-7). Employment at the Oak Ridge Reservation and Nevada Test Site would increase if these sites were chosen as the Eastern and Western Regional Sites. Operation of storage facilities at both the Oak Ridge Reservation and Nevada Test Site could ultimately result in the creation of approximately 500 jobs per year at both sites, a 3-percent increase above current site employment at Oak Ridge Reservation and a 6-percent increase above current site employment at the Nevada Test Site without the expended core facility or a 7- and 13-percent increase with an expended core facility, respectively (Figure 5-6). The peak annual employment from implementation of Regionalization 4B would be an additional 1,100 workers at the Nevada Test Site. The secondary impacts of increased employment at either the Oak Ridge Reservation or the Nevada Test Site could result in an increased housing demand. At the Nevada Test Site, overall socioeconomic impacts could be absorbed within the projected expansion of the local economy, infrastructure, public service, and real estate development. At the Oak Ridge Reservation, increased employment could result in increases in capital expenditures to meet the increased demand of housing, transportation, and educational facilities.

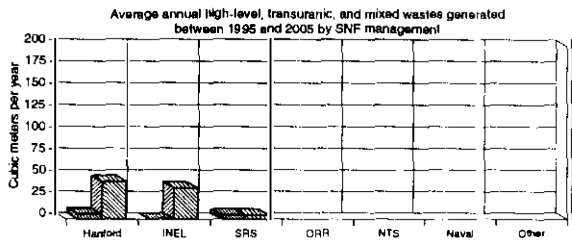




Note: Naval and Other sites are not affected by this alternative.







	High Level	Transuranic	Mixed
Hanford minimum	6	0	0
Hanford maximum	23	20	1
INEL minimum	0	0	0
INEL maximum	3	32	1
SRS minimum	0	6	0
SRS maximum	0	5	0
ORR minimum	na	na	na
ORR maximum	na	na	na
NTS minimum	na	na	na
NTS maximum	na	na	na
Naval minimum	na	na	na
Naval maximum	na	na	na
Other minimum	na	na	na
Other maximum	na	na	na

INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

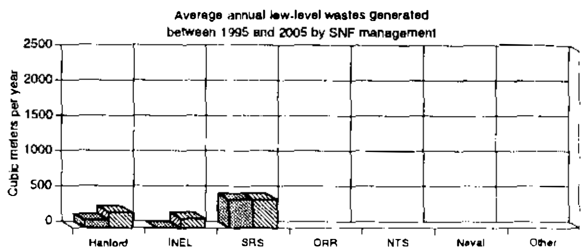
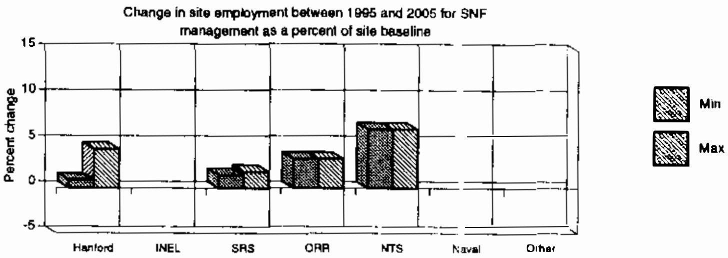
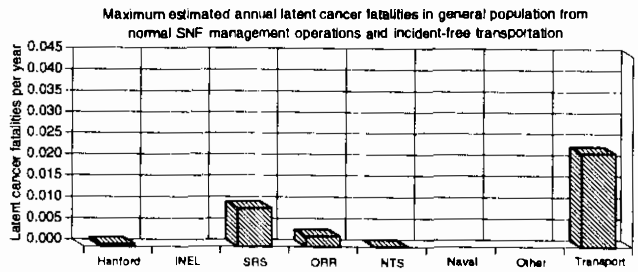


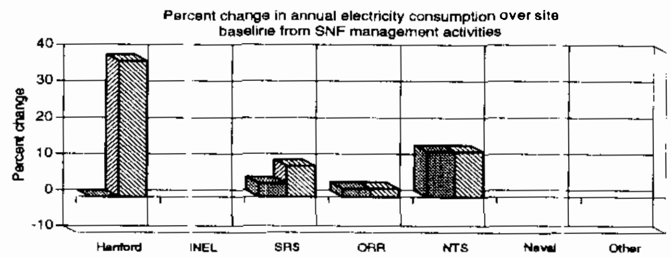
Figure 5-5. **Summary of impacts for Regionalization 4B (by geography) if the site is not selected as the regional site. (The maximum incremental change from baseline is illustrated in all graphs. Input data summarized in Appendix K.)**

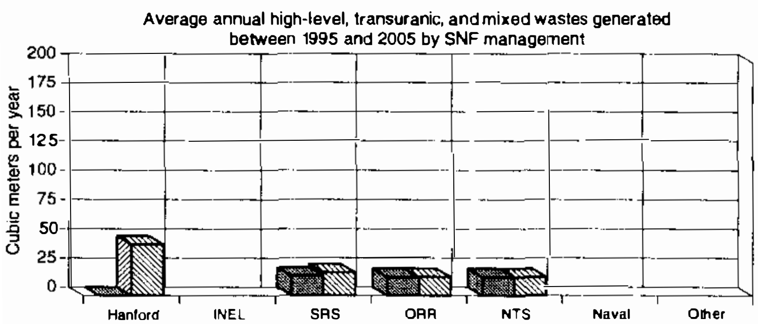


Note: Naval and Other sites are not affected by this alternative.

There are no cases where the INEL would be selected and not have the Expended Core Facility







	HighLevel	Transuranic	Mixed
Hanford minimum	0	0	0
Hanford maximum	23	20	1
INEL minimum	na	na	na
INEL maximum	na	na	na
SRS minimum	0	17	0
SRS maximum	2	16	0
ORR minimum	0	16	0
ORR maximum	0	16	0
NTS minimum	0	16	0
NTS maximum	0	16	0
Naval minimum	na	na	na
Naval maximum	na	na	na
Other minimum	na	na	na
Other maximum	na	na	na

INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

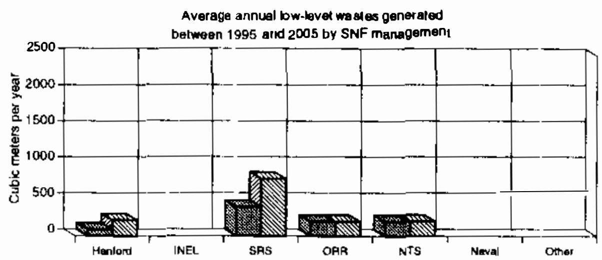
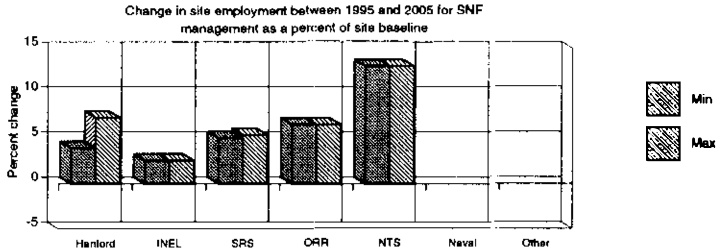
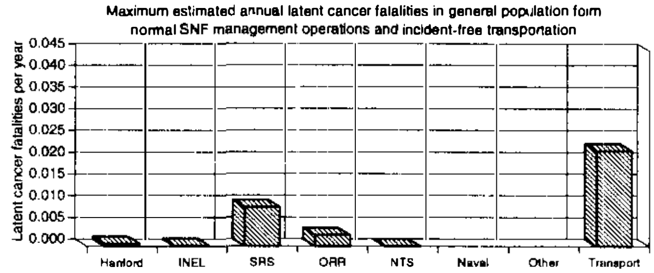
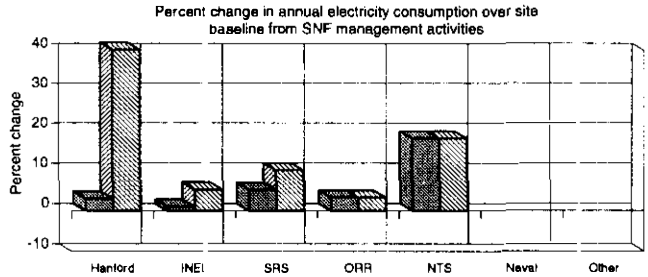


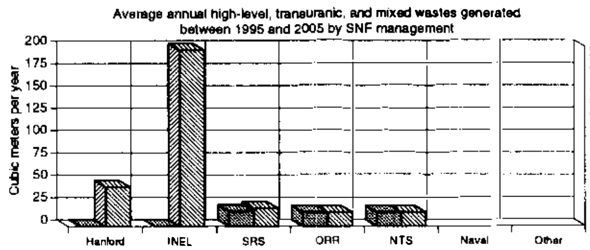
Figure 5-6. Summary of impacts for Regionalization 4B (by geography) if sites were selected as a regional site and do not have the expended core facility. (The maximum incremental change from baseline is illustrated in all graphs. Input data are summarized in Appendix K.)



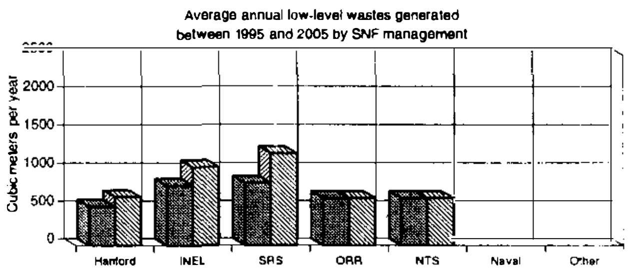
Note: Naval and Other sites are not affected by this alternative.







	High Level	Transuranic	Mixed
Hanford minimum	0	0	0
Hanford maximum	23	20	1
INEL minimum	0	0	0
INEL maximum	160	35	1
SRS minimum	0	17	0
SRS maximum	2	18	0
ORR minimum	0	16	0
ORR maximum	0	16	0
NTS minimum	0	16	0
NTS maximum	0	16	0
Naval minimum	na	na	na
Naval maximum	na	na	na
Other minimum	na	na	na
Other maximum	na	na	na



INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

Figure 5-7. Summary of impacts for Regionalization 4B (by geography) if sites were selected as a regional site and have the expended core facility. (The maximum incremental change from baseline is illustrated in graphs. Input data are summarized in Appendix K.)

For the naval sites, implementing Regionalization 4B would have no socioeconomic consequences.

5.1.5.2 Utilities (Electricity). As shown in Figure 5-4, implementing Regionalization 4A would have a similar impact on power consumption as the 1992/1993 Planning Basis alternative (compare Figures 5-3 and 5-4). There would be no effect on power consumption at the Oak Ridge Reservation, Nevada Test Site, or naval sites from the implementation of Regionalization 4A.

Figures 5-5, 5-6, and 5-7 illustrate the minimum and maximum change from baseline site power use from implementing Regionalization 4B with and without an expended core facility and if the site were not selected as the regional site. Regionalization at the Hanford Site or the Nevada Test Site could produce an impact on power consumption at these sites.

Figure 5-5 illustrates the impact on power consumption if a site were not selected as a regional site. The increase in electricity consumption at the Hanford Site and the Savannah River Site reflects the power required to prepare or process the SNF for transport as required. The decrease in power consumption at the Idaho National Engineering Laboratory would be from shutdown of the Expended Core Facility.

Figure 5-6 shows the minimum and maximum percent change, without an expended core facility, over baseline site power consumption if a site were selected as a regional center. At the Hanford Site and Savannah River Site, the power consumption increases slightly with the transport of naval fuel to the site. Regionalization at the Oak Ridge Reservation would result in a small (less than 3 percent) increase in electric power demand. The site electricity supply at each of these sites would be more than adequate. However, regionalization at the Nevada Test Site would increase power consumption about 13 percent above existing site usage and may require additional transmission lines or another substation at the site (see Appendices F and K).

Regionalization 4B with an expended core facility onsite is illustrated in Figure 5-7. The electricity requirements at each of the major DOE sites would increase with the addition of an expended core facility for examination of naval SNF. Power consumption at the Nevada Test Site would increase approximately 18 percent above baseline and about 40 percent at Hanford if the processing (figure maximum) option were selected. The storage only options (figure minimum) at the Hanford site would result in only a 3-percent increase in electricity consumption. The Nevada Test Site would require additional transmission lines or another substation to handle additional loads. The increased load could be handled at the Savannah River Site, and relatively minor increases could occur at the Idaho National Engineering Laboratory.

5.1.5.3 Materials and Waste Management. Figures 5-4 through 5-7 illustrate the effects of implementing the different Regionalization alternatives: Regionalization 4A, Regionalization 4B with SNF transported offsite, Regionalization 4B without an expended core facility located at the selected site, and Regionalization 4B with an expended core facility located at the selected site. The annual average waste volumes generated from SNF management activities at a nonselected site would decrease over the next 10 years, but at the selected sites the annual generation rate of waste from SNF management activities would increase with implementation of the Regionalization alternative. The construction of an expended core facility at any site would also increase the annual volume of low-level waste generated.

The annual waste volumes generated from SNF management activities associated with Regionalization 4A are illustrated in Figure 5-4. The effects of Regionalization 4A would be similar to those described for the 1992/1993 Planning Basis alternative in Section 5.1.4.3 (see Figures 5-3 and 5-4).

Figure 5-5 illustrates the effect of not being selected as a regional center. In comparison to the Decentralization and 1992/1993 Planning Basis alternatives, the annual generation rate of high-level, transuranic, mixed, and low-level wastes would ultimately decrease at the affected site because the SNF inventory would be transported offsite. However, characterization and stabilization activities prior to transport would generate transient increases in waste volumes.

The effect of being selected as a regional center without a replacement expended core facility is illustrated in Figure 5-6. Implementation of this Regionalization 4B alternative would have similar effects at the Hanford Site and Savannah River Site as the 1992/1993 Planning Basis alternative. The Oak Ridge Reservation and Nevada Test Site would generate waste from SNF management activities under the alternative. Regionalization at either of these two sites would be expected to generate approximately 16 cubic meters (21 cubic yards) of transuranic waste and approximately 200 cubic meters (260 cubic yards) of low-level waste annually from operating an SNF management complex.

Figure 5-7 illustrates the effect on annual waste volume generation of being selected as a regional center with the addition of an expended core facility to examine naval SNF. The addition of the expended core facility would have no effect on the annual volume of high-level, transuranic, or mixed waste generated, but would increase the volume of low-level waste that would have to be managed at any site.

The effects from implementing either of the Regionalization alternatives at the naval sites would be the same as that described for the 1992/1993 Planning Basis alternatives in Section 5.1.4.3.

5.1.5.4 Radiological Impacts. Radiological exposures to both workers and the public for Regionalization 4A would to be similar to the 1992/1993 Planning Basis alternative. These are not discussed further in this section. Figure 5-4 illustrates the potential latent cancer fatalities to the population within 80 kilometers (50 miles) from SNF operations at the major sites for Regionalization 4A.

Radiological exposures to both workers and the public for Regionalization 4B would to be similar to the 1992/1993 Planning Basis alternative if the Savannah River Site, Idaho National Engineering Laboratory, or Hanford Site were selected as regional sites. Figures 5-5, 5-6, and 5-7 illustrate the potential latent cancer fatalities to the population within 80 kilometers (50 miles) from SNF operations for Regionalization 4B if SNF is transported offsite, or if the site is selected as the regional site without and with the expended core facility, respectively.

For any of the Regionalization alternatives, the maximum estimated latent cancer fatalities in the general population from normal operations are estimated to be 7.6×10^{-3} per year.

SNF Facility Accidents—

Hanford Site. Accident risks under Regionalization 4A are the same as those for the Decentralization alternative. The selection of the Hanford Site as the regional site would not result in accident risks significantly different from those identified for the Decentralization alternative (Section 5.15 of Appendix A), although higher activity under this alternative would increase the annual frequency of accidents. The probability of the cask impact and fire accident scenario was estimated to be 7 in 1,000,000 if the Hanford Site were selected as a regional site.

Selecting a different site as the regional site would reduce the estimated accident risks from those identified for the Decentralization alternative because the existing wet storage facilities would be shut down and the amount of SNF handled at the dry storage facility would change slightly. The accident probability for the dry storage cask impact and fire was estimated to be 5 in 1,000,000 such that the estimated risk from this, the highest risk accident, would be 4.1×10^{-4} latent cancer fatalities in the general population per year of operation.

Idaho National Engineering Laboratory. While the consequences of potential SNF storage and handling accidents would be similar for all alternatives, the estimated frequency of handling accidents depends on the amount of SNF handled under the alternatives. For alternatives where all stored SNF is transported to another site, SNF storage and handling risks would be reduced to those associated with SNF generated at the Idaho National Engineering Laboratory research reactors. Under Regionalization 4A, the consequences and risks of accidents associated with SNF storage would be the same as described under the No Action alternative (Section 5.15, Appendix B). The consequences of fuel-handling accidents would be the same as described under the No Action alternative, but increased transporting and handling of SNF would result in a frequency of fuel-handling accidents about five times higher than for the No Action alternative (Slaughterbeck et al. 1995). Because of the increased frequency of fuel-handling accidents, risk to the public from fuel-handling accidents may exceed the risk from SNF storage accidents.

If the Idaho National Engineering Laboratory were selected as a regional site under Regionalization 4B, the highest consequences to the offsite population result from accidents involving stored SNF and would be the same as described under the No Action alternative (Section 5.15 of

Appendix B). With the resumption of processing at the Idaho Chemical Processing Plant, the postulated accident with the highest consequence and risk to workers would be an inadvertent nuclear criticality during processing that has an estimated probability of 1 chance in 1,000 per year of operation. The estimated probability of a latent cancer fatality in a worker approximately 100 meters (330 feet) downwind of the accident would be 3.6×10^{-3}, corresponding to an estimated risk to a worker of 3.6×10^{-6} latent cancer fatalities per year of operation. The consequences of fuel-handling accidents would be the same as described under the No Action alternative, but increased transporting and handling of SNF results in a frequency of fuel-handling accidents about 20 times higher than for the No Action alternative (Slaughterbeck et al. 1995). Because of the increased frequency of fuel-handling accidents, risk to the public from fuel-handling accidents may exceed the risk from SNF storage and processing accidents.

If the Idaho National Engineering Laboratory were not selected as a regional site under Regionalization 4B, the consequences and risks of accidents associated with SNF storage would be the same as described under the No Action alternative (Section 5.15 of Appendix B). The consequences of fuel-handling accidents would be the same as described under the No Action alternative, but increased transporting and handling of SNF would result in a frequency of fuel-handling accidents about nine times higher than for the No Action alternative (Slaughterbeck et al. 1995). Because of the increased frequency of fuel-handling accidents, risk to the public from fuel-handling accidents may exceed the risk from SNF storage accidents.

Savannah River Site. Accident risks under Regionalization 4A would be essentially the same as those for the 1992/1993 Planning Basis alternative. The accident frequency for the highest risk accident, a fuel assembly breach, would be expected to be about 0.44 fuel assembly breaches per year of operation with implementation of this alternative. The estimated risk of latent cancer fatalities to the general public, maximally exposed offsite individual, and co-located worker would be 3.7×10^{-3}, 4.4×10^{-7}, and 2.1×10^{-6} per year of operation, respectively.

The implementation of Regionalization 4B at the Savannah River Site, including the three options of dry storage, wet storage, and processing followed by dry storage, would not result in accidents significantly different from those identified for the same options under the Decentralization alternative (Section 5.15 and Attachment A of Appendix C). Because of an increase in the amount of SNF handled, however, the accident frequency for some accidents would increase.

Under Regionalization 4B, the accident frequency for the highest risk accident, a fuel assembly breach, would be expected to be about 0.41 fuel assembly breaches per year of operation with implementation of this alternative. This results in a proportional increase in risk to the general public and the workers. The estimated risk of latent cancer fatalities to the general public, maximally exposed offsite individual, and co-located worker would be 3.5×10^{-3}, 4.1×10^{-7}, and 2.0×10^{-6} per year of operation, respectively. With regionalization elsewhere, the highest risk accident would still be the fuel assembly breach with an estimated risk approximately the same as with the No Action alternative.

Naval Facilities. The accident risks associated with the implementation of the Regionalization alternative at sites other than the Idaho National Engineering Laboratory are presented in detail in Attachment F of Appendix D. That evaluation considered the accidents associated with operation of an expended core facility and wet and dry storage facilities at the Hanford Site, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site. Accidents evaluated were the same set of accidents identified for the Decentralization alternative. The maximum risk accidents, for either the general population and workers at sites where an expended core facility might be located if they are associated with an expended core facility, are discussed under the affected sites.

Oak Ridge Reservation. The Oak Ridge Reservation would not be affected by Regionalization 4A. The implementation of Regionalization 4B at the Oak Ridge Reservation would be expected to be similar to implementation of the Centralization alternative, except that less storage requirements would be needed. Section 5.15 (Part 3) of Appendix F indicates that the accident consequences would be similar for both alternatives and that it is reasonable to assume that the accident consequences and risks described for the Centralization alternative would envelop the Regionalization alternative.

A wide range of accident scenarios were considered, including accidents initiated by operational events, external hazards such as aircraft crashes, and natural phenomena such as earthquakes. The highest risk SNF-related accidents identified were (a) a fuel assembly breach as a result of dropping the assembly, objects falling on the assembly, or cutting into the fuel portion of the assembly, (b) a dropped fuel cask, (c) a severe impact that results in breach of a transport cask and fire, (d) an aircraft crash into the SNF dry storage facility, (e) an aircraft crash into the SNF dry cell facility, (f) a wind-driven missile impact into storage casks, and (g) and aircraft crash into a water storage pool.

The highest risk to the general population would be a fuel assembly breach, with an estimated frequency of 0.16 per year. General population consequences were estimated to be approximately 2.1×10^{-2} latent cancer fatalities per year. The estimated risk to the general population, taking into account the probability of occurrence of this accident, would be 3.4×10^{-3} latent cancer fatalities per year. The estimated probability of maximum latent cancer fatalities to the maximally exposed individual would be 6.0×10^{-6}.

The dropped fuel cask accident has the maximum risk to workers with an estimated frequency of less than 1 in 10,000 per year. A worker downwind of the accident was estimated to receive a dose that corresponds to an estimated probability of 1.9×10^{-3} latent cancer fatalities. The estimated risk for a worker would be 1.9×10^{-7} latent cancer fatalities per year.

Workers in the immediate vicinity of the cask drop accident could receive very high doses; however, the doses would not result in a fatality. For that accident, workers could be expected to be very near the cask when it drops and receive both direct radiation as well as inhale airborne fission products. Workers would be expected to quickly evacuate the area and thus reduce their potential radiation exposure.

Nevada Test Site. The implementation of Regionalization 4B at the Nevada Test Site would also be expected to be similar to implementation of the Centralization alternative, except that storage requirements would be less. Section 5.15 (Part 2) of Appendix F indicates that the accident consequences would be similar for both alternatives and that it is reasonable to assume that the accident consequences and risks described for the Centralization alternative would envelop the Regionalization alternative.

A wide range of accident scenarios were considered for the Centralization alternative, which also apply to Regionalization 4B, including accidents initiated by operational events, external hazards such as aircraft crashes, and natural phenomena such as earthquakes. The highest risk SNF-related accidents identified for the Nevada Test Site were a fuel assembly breach (highest risk to the general public) and a dropped fuel cask (highest risk to workers).

The fuel assembly breach is the highest risk to the general population with an estimated frequency of 0.16 per year and an estimated offsite population dose corresponding to 6.6×10^{-4} latent cancer fatalities. The estimated risk to the general population, taking into account the probability of occurrence of this accident, would be 1.1×10^{-4} latent cancer fatalities per year. The potential dose to the maximally exposed offsite individual would correspond to a probability of a latent cancer fatality of 1.6×10^{-7}.

The dropped fuel cask accident was the highest risk accident to workers with an estimated frequency of less than 1 in 10,000 per year. A worker approximately 100 meters (330 feet) downwind of the accident would have a probability of a latent cancer fatality of 1.9×10^{-3}. The estimated risk to a worker would be 1.9×10^{-7} latent cancer fatalities per year of operation.

Workers in the immediate vicinity of the cask drop accident could receive very high doses; however, the doses would not result in a fatality. For that accident, workers could be expected to be very near the cask when it drops and receive both direct neutron and gamma radiation as well as inhale airborne fission products. Workers would be expected to quickly evacuate the area and thus reduce their potential radiation exposure.

Other Generator/Storage Locations. For Regionalization 4A and 4B, the accident risks would be expected to be similar to the accident risks under the No Action alternative.

5.1.5.5 Nonradiological Accidents. The maximum reasonably foreseeable chemical accident at the Idaho Engineering National Laboratory, Savannah River Site, and other generator/storage locations would be similar to those described under the No Action alternative. An accident during the operation of a wet storage facility at the Hanford Site could release sulfuric acid and subject workers to fatalities or serious health effects.

Two independent accidents have been evaluated to describe the maximum reasonably foreseeable chemical accident during the operation of the expended core facility at each of its potential locations. Such a release could subject workers to chemical concentrations that could cause fatalities or serious health effects but would not subject the public to such concentrations except at potential locations on the Oak Ridge Reservation and adjacent to the Savannah River Site.

5.1.5.6 Transportation.

Regionalization 4A (by fuel type)—

Shipments. Under Regionalization 4A, the same SNF types would be transported as under the 1992/1993 Planning Basis alternative with differences occurring in the destinations of some SNF based on fuel type. Onsite shipments would relocate SNF for continued safe storage or stabilization.

Incident-Free Transportation. For Regionalization 4A, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.17 to 0.61 over the 40-year period 1995 through 2035. These fatalities represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was due to two factors: (a) the option of using truck or rail transport for DOE SNF (see Appendix I), and (b) different SNF management options at the Savannah River Site (see Appendix C). Navy shipments would be made using a combination of truck and rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.031 to 0.15, the estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.054 to 0.41, and the estimated number of nonradiological fatalities from vehicular emissions ranged from 0.052 to 0.084.

Onsite shipments of SNF were estimated to result in 0.0025 to 0.0034 fatalities. Offsite shipments of SNF were estimated to result in 0.17 to 0.61 fatalities. These fatalities also represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents. The cumulative transportation accident risks over the 40-year operational period were estimated to be 0.0011 latent cancer fatality and 0.77 traffic fatality if all SNF were transported by truck. If all SNF were transported by rail, the corresponding risks were estimated to be 0.00037 latent cancer fatality and 0.76 traffic fatality.

As in the 1992/1993 Planning Basis alternative, the maximum reasonably foreseeable offsite transportation accident involves a rail shipment of special-case commercial SNF in a suburban population zone under neutral (average) weather conditions. The accident has a probability of occurrence of about 2.8×10^{-7} per year, and the consequences are the same as those described under the 1992/1993 Planning Basis alternative.

Onsite transportation of SNF would occur under Regionalization 4A at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The maximum reasonably foreseeable accident for this alternative would occur at the Idaho National Engineering Laboratory, and the potential impacts would be the same as those described under the No Action alternative.

Regionalization 4B (by geography)—

Shipments. Under Regionalization 4B, the same SNF types would be transported as under the 1992/1993 Planning Basis alternative with differences occurring in the destinations of the SNF based on geographical considerations. Non-naval SNF originating from western United States locations or points of entry would be transported to the Idaho National Engineering Laboratory, Hanford Site, or Nevada Test Site. Non-naval SNF originating from eastern United States locations or points of entry would be transported to the Savannah River Site or Oak Ridge Reservation. Naval SNF would not be split on an east-west basis because the Navy would operate a facility for examining naval SNF at one of the DOE sites. Onsite shipments at major DOE sites may relocate SNF from one facility or another for continued safe storage or stabilization, if applicable.

Incident-Free Transportation. For the six Regionalization 4B alternatives, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.14 (Idaho National Engineering Laboratory and Oak Ridge Reservation alternative) to 0.90 (Nevada Test Site and Oak Ridge Reservation alternative). The other four alternatives would result in fatalities between these two alternatives. These fatalities were over the 40-year period 1995 through 2035 and represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was due to two factors: (1) the option of using truck or rail transport for DOE SNF (see Appendix I), and (2) the six regionalization alternatives. Navy shipments would be made using a combination of truck or rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

For regionalization at the Idaho National Engineering Laboratory and Oak Ridge Reservation, the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.033, the estimated number of radiation-related latent cancer fatalities for the general population was 0.043, and the estimated number of nonradiological fatalities from vehicular emissions was 0.059.

For regionalization at the Nevada Test Site and Oak Ridge Reservation, the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.21, the estimated number of radiation-related latent cancer fatalities for the general population was 0.60, and the estimated number of nonradiological fatalities from vehicular emissions was 0.091.

For regionalization at the Idaho National Engineering Laboratory and Oak Ridge Reservation, onsite shipments of SNF were estimated to result in 0.0025 fatalities. Offsite shipments of SNF were estimated to result in 0.13 fatalities. These fatalities also represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

For regionalization at the Nevada Test Site and Oak Ridge Reservation, onsite SNF shipments were estimated to result in 0.0023 fatalities. Offsite shipments of SNF were estimated to result in 0.90 fatalities. These fatalities also represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents. Cumulative accident risks for transportation by truck would range from 0.00090 latent cancer fatalities and 0.72 traffic fatalities for regionalization at the Idaho National Engineering Laboratory and Savannah River Site, to 0.0012 latent cancer fatalities and 1.0 traffic fatalities for regionalization at the Nevada Test Site and Oak Ridge Reservation. Cumulative accident risks for transportation by rail would range from 0.00024 latent cancer fatalities and 0.72 traffic fatalities for regionalization at the Idaho National Engineering Laboratory and Oak Ridge Reservation, to 0.00035 latent cancer fatalities and 0.91 traffic fatalities for regionalization at the Nevada Test Site and Oak Ridge Reservation.

As in the 1992/1993 Planning Basis alternative, the maximum reasonably foreseeable offsite transportation accident would involve a rail shipment of special-case commercial SNF in a suburban population zone under neutral (average) weather conditions. The accident has a probability of occurrence that ranges from about 2.7×10^{-7} per year for regionalization at the Hanford Site and Savannah River Site, to about 3.7×10^{-7} per year for regionalization at the Nevada Test Site and Savannah River Site. Accident consequences would be the same for each alternative and would be the same as those described under the 1992/1993 Planning Basis alternative.

Onsite transportation of SNF would occur under Regionalization 4B at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The maximum reasonably foreseeable accident for tbis alternative would occur at tbe Idaho National Engineering Laboratory, and tbe potential impacts would be tbe same as tbose described under the No Action alternative.

5.1.6 Centralization Alternative

Under this alternative, all stored and newly generated SNF would be transported to and stored at one of five sites: the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, or Nevada Test Site. SNF management activities at unselected sites would cease. All SNF-related research and development activities would be conducted at the selected site, and the expended core facility would also be located there.

The implications of this alternative would be similar to those of Regionalization 4B alternative for western sites, but if an eastern site were selected, considerably greater volumes of SNF would be stored there than under any other alternative because the site would receive fuels from the Hanford Site and the Idaho National Engineering Laboratory. Therefore, substantially larger storage facilities would be needed under this alternative than under any other. New facilities with the largest capacity for SNF would be built at the Oak Ridge Reservation and Nevada Test Site because they do not now have the capacity to accept additional fuels and do not currently store significant volumes of SNF. The potential environmental consequences at these sites are described below.

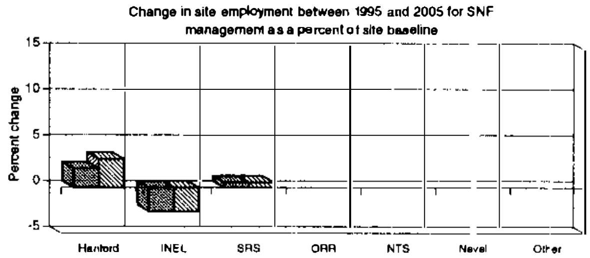
5.1.6.1 Socioeconomics. The Centralization alternative would result in the largest socioeconomic impact in terms of the number of direct jobs created (or lost) on a local basis by SNF management activities (see Figure 5-7). The change in site employment would range from a decrease of less than 3 percent of total site employment at the Idaho National Engineering Laboratory to a maximum increase of about 13 percent above existing site employment at the Nevada Test Site when an expended core facility were constructed at the site. The intensity of this impact at the major DOE sites would depend on (a) whether the SNF management programs used existing personnel or required workers to move into the region, and (b) future actions at each site competing for the available labor pool. Under Centralization if the site were selected, the peak in employment would occur at the Savannah River Site where an additional 1,700 workers would be required for the proposed SNF management activities, an increase of approximately 11 percent above the projected 1995 baseline. If the site were not selected, the peak in employment would be an additional 580 workers at the Hanford Site or approximately 3 percent above the projected 1995 baseline. If either the Hanford Site, Idaho National Engineering Laboratory, or Savannah River Site were not selected as a central site under the Centralization alternative, there would ultimately be a reduction in employment equal to existing employment for SNF management at these sites. This would add to the forecast loss of jobs at each of these sites. In the short term, additional jobs would be required to prepare SNF for transport offsite (see Figure 5-5). The closure of the Expended Core Facility at the Idaho National Engineering Laboratory, however, would lead to a long-term loss of jobs as well, increasing the rate of job loss at that site.

Sites selected as central sites would generally have increased employment over baseline levels (see Figure 5-6). This increased direct employment would also result in an indirect increase in employment in the surrounding communities. At the Oak Ridge Reservation, the associated population growth could result in increases in capital expenditures to meet the increased demand of housing, utilities, including electricity generation, wastewater treatment, and water, transportation, and education facilities. At the Hanford Site, centralization activities could strain the housing market and add to school-capacity concerns. For centralization at the Savannah River Site or the Idaho National Engineering Laboratory, DOE expects that potential impacts on the demand for community resources and services would be minimal. For centralization at the Nevada Test Site, there is a potential increase in housing demand. Overall socioeconomic impacts for centralization at the Nevada Test Site could be absorbed within the projected expansion of the local economy, infrastructure, public service, and real estate development.

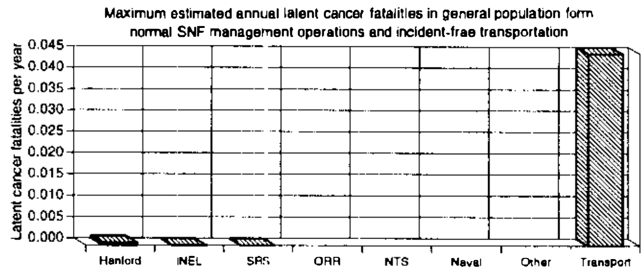
5.1.6.2 Utilities (Electricity). The effect on power consumption from implementing the Centralization alternative would be generally similar to that described for Regionalization 4B where the SNF is transported offsite or where the SNF is transported to the regional site except at the Savannah River Site. Power consumption minimum increase would be about 8 percent over the site baseline usage at the Savannah River Site from the construction and operation of additional wet storage facilities under the Centralization alternative. Figures 5-8 and 5-9 illustrate the Centralization impacts for the two cases: if a site were selected or not selected as the central site (compare with Figures 5-5 and 5-7). The impacts would be the same as those described in Section 5.1. Thus, for example, electric power requirements with centralization at the Nevada Test Site would be similar to Regionalization 4B at the Nevada Test Site with a replacement expended core facility also located at that site (Figure 5-6).

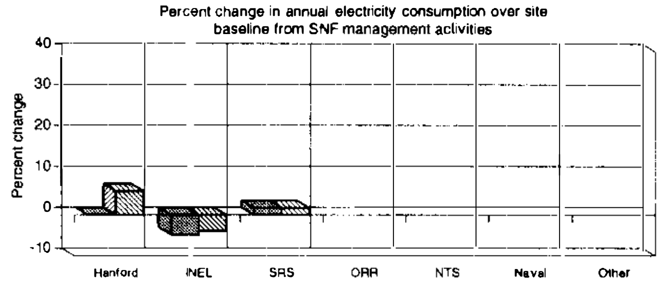
Under the Centralization alternative at Hanford, the power consumption would rise by approximately 3 percent if SNF were only stored and could rise as much as 40 percent if processing were required. While the increase in power required for processing appears large (as a percent of baseline) when compared to the Savannah River Site, much of the difference would be the result of a higher Savannah River Site baseline with power consumption.

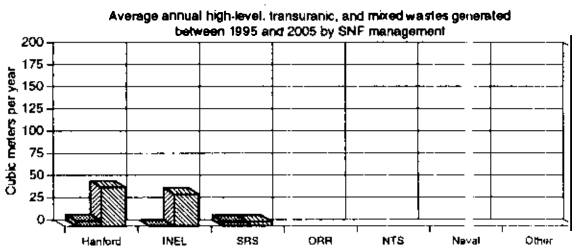
5.1.6.3 Materials and Waste Management. The Centralization alternative would have similar effects at the major DOE sites to those described in Section 5.1.5.3 for the Regionalization alternative (see Figures 5-5 and 5-7). If a site were not selected as the central site, the annual volume of waste generated from SNF management activities would ultimately decrease; however, transient activities to stabilize and package the fuel could be substantial. The site selected as the central site would increase the annual volume of wastes generated from SNF management activities. The increase in waste would not necessarily be proportional to the larger amount of SNF being managed onsite because the originating sites would characterize and can their fuel before transport so it could be placed directly into storage at the receiving site. The waste volumes would be generated from transferring fuel from water pools at some sites, characterizing and canning small amounts of new fuel, and operating the expended core facility. Figures 5-8 and 5-9 show the effects of not being selected as well as being selected as the central site for SNF management activities.



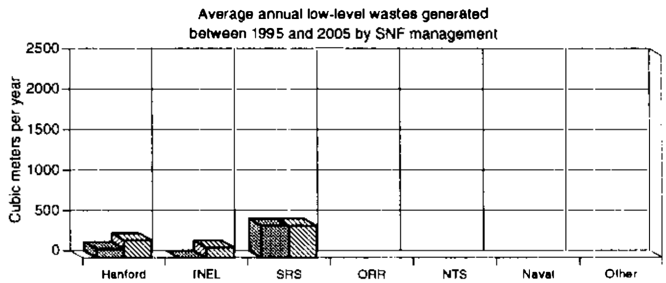
Note: Naval and Other sites are not affected by this alternative.





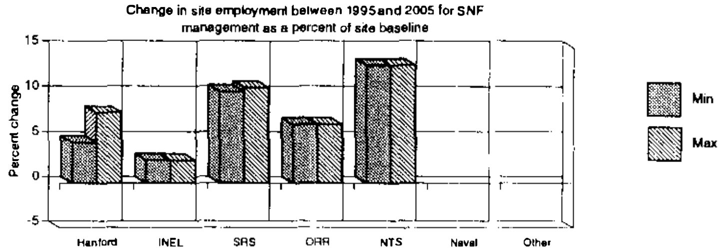


	High Level	Transuranic	Mixed
Hanford minimum	6	0	0
Hanford maximum	23	20	1
INEL minimum	0	0	0
INEL maximum	3	32	1
SRS minimum	0	5	0
SRS maximum	0	5	0
ORR minimum	na	na	na
ORR maximum	na	na	na
NTS minimum	na	na	na
NTS maximum	na	na	na
Naval minimum	na	na	na
Naval maximum	na	na	na
Other minimum	na	na	na
Other maximum	na	na	na

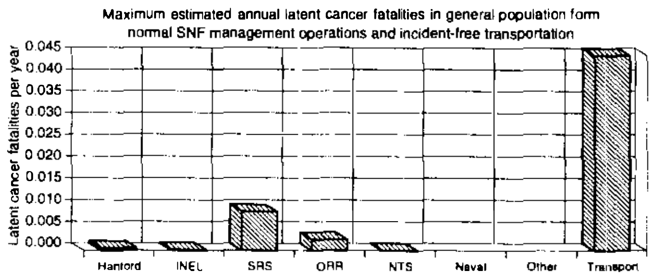


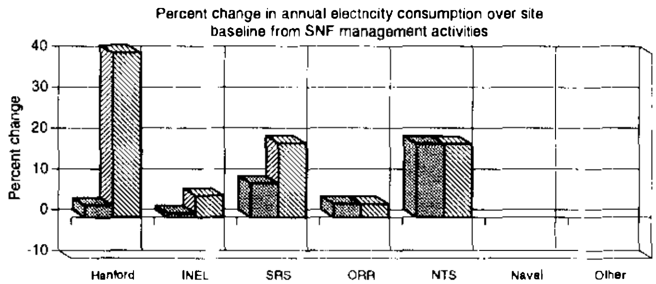
INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

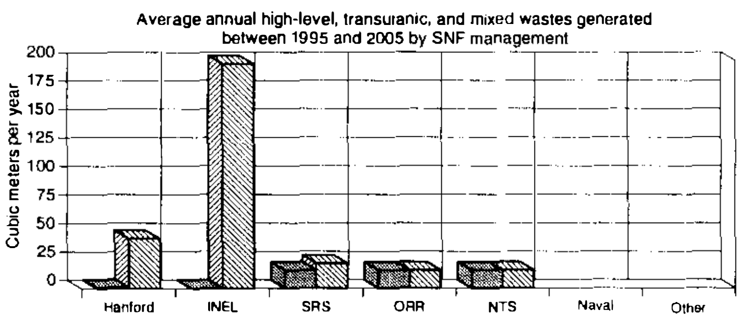
Figure 5-8. Summary of impacts for the Centralization option if sites were not selected as a central site. (The maximum incremental change from baseline is illustrated in graphs. Input data are summarized in Appendix K.)



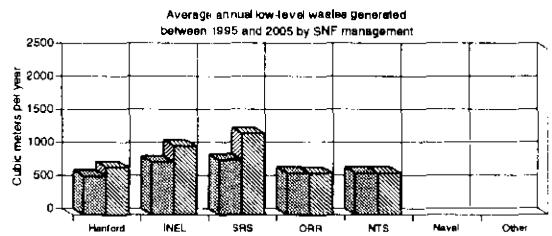
Note: Naval and Other sites are not affected by this alternative.







	High Level	Transuranic	Mixed
Hanford minimum	0	0	1
Hanford maximum	23	20	1
INEL minimum	0	0	0
INEL maximum	160	36	1
SRS minimum	0	16	0
SRSmaximum	2	20	0
ORRminimum	0	16	0
ORRmaximum	0	16	0
NTS minimum	0	16	0
NTS maximum	0	16	0
Naval minimum	na	na	na
Naval maximum	na	na	na
Other minimum	na	na	na
Other maximum	na	na	na



INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

Figure 5-9. Summary of impacts for the Centralization option if sites were selected as a central site and have an expended core facility. (The maximum incremental change from baseline is illustrated in graphs. Input data are summarized in Appendix K.)

5.1.6.4 Radiological Impacts. For the Centralization alternative, the radiological impacts from both normal operations and accidents at both the originating site and the central storage site would be expected to be low and similar in magnitude. Accident analysis for both existing and proposed SNF interim storage facilities indicates that the probabilities of accidents with the potential for significant impacts would be extremely low.

Figure 5-7 illustrates the estimated latent cancer fatalities among the population within 80 kilometers (50 miles) from SNF operations at each of the major sites. For each major site, this figure includes the potential impacts associated with site SNF operations with centralization at another site, as well as with centralization at that site.

Accident risks from SNF activities would be principally because of handling and storage activities and, therefore, would be expected to be similar for each of the centralization sites. The principal differences would be due to activities at the existing SNF sites necessary to prepare the SNF for transport to the central site.

SNF Facility Accidents—

Hanford Site. The implementation of the Centralization alternative at the Hanford site would be expected to result in accident risks for some accidents slightly different from those identified for the Decentralization alternative (Section 5.15 of Appendix A). The amount of SNF handled at the dry storage facility would be greater, resulting in an increase in the accident probability for the dry storage cask impact and fire to approximately 8 in 1,000,000. The estimate of risk from this, the highest risk accident to the general population, would be 6.5×10^{-4} latent cancer fatalities in the general population per year of operation. The corresponding risk to an individual worker would be 7.5×10^{-7} potential latent cancer fatalities per year of operation.

Implementation of the Centralization alternative (or Regionalization 4B) elsewhere reduces the estimates of accident risks from those identified for the Decentralization alternative because the existing storage facilities would be shut down and the amount of SNF handled at the site decreases slightly. The accident probability for the dry storage cask impact and fire would be expected to decrease slightly, to approximately 5 in 1,000,000. This yields an estimated accident risk to the general population of 4.1×10^{-4} latent cancer fatalities per year of operation. The corresponding highest risk accident to a worker would be 4.75×10^{-7} potential latent cancer fatalities per year of operation.

Idaho National Engineering Laboratory. The implementation of the Centralization alternative at the Idaho National Engineering Laboratory is estimated in Section 5.15 of Appendix B to result in additional accident scenarios and accident risks from those identified for the No Action alternative due to the assumed resumption of chemical processing of SNF at the Idaho Chemical

Processing Plant. The consequences and risks from SNF-related accidents would be the same as Regionalization 4B if the Idaho National Engineering Laboratory is selected as a regional site.

The implementation of the Centralization alternative at a site other than the Idaho National Engineering Laboratory would result in potential accident consequences and risks the same as the Regionalization 4B when the Idaho National Engineering Laboratory is not selected as a regional site.

Savannah River Site. The implementation of the Centralization alternative at the Savannah River Site, including the three options of dry storage, wet storage, and processing followed by dry storage, is assessed in Section 5.15 and Attachment A of Appendix C to result in accidents not significantly different from those identified for the same options under the Decentralization alternative. Because of an increase in the amount of SNF handled, however, the accident frequency for some accidents would increase.

The accident frequency for the highest risk accident, a fuel assembly breach, would be expected to be about 0.84 fuel assembly breaches per year of operation with implementation of this alternative. The estimated risk of latent cancer fatalities to the general public, maximally exposed offsite individual, and co-located worker would be 7.2×10^{-3}, 8.4×10^{-7}, and 4×10^{-6} per year of operation, respectively. With centralization elsewhere, the highest risk accident would still be the fuel assembly breach with an estimated risk approximately the same as with the No Action alternative.

Oak Ridge Reservation. The accident risks associated with implementation of the Centralization alternative at the Oak Ridge Reservation are presented in detail in Section 5.15 (Part 3) of Appendix F. These accident risks are summarized under Regionalization 4B.

Nevada Test Site. The accident risks associated with implementation of the Centralization alternative at the Nevada Test Site are presented in detail in Section 5.15 (Part 2) of Appendix F. These accident risks are summarized under Regionalization 4B.

Other Generator/Storage Locations. The accident risks under the Centralization alternative would be expected to be the same as the accident risks under the No Action alternative.

5.1.6.5 Nonradiological Accidents. Abnormal operational events could result in the release of toxic or hazardous substances from the centralized facility or from SNF management facilities at the other storage/generator sites prior to the shipment of SNF to the central site. The events that would be expected to exceed exposure guidelines would be similar to those described under the 1992/1993 Planning Basis alternative.

Two independent accidents have been evaluated to describe the maximum reasonably foreseeable chemical hazard during the operation of the expended core facility at each of its potential locations. Such a release could subject workers to chemical concentrations that would exceed the Emergency Response Planning Guideline value but would not subject the public to such concentrations except at potential locations on the Oak Ridge Reservation and adjacent to the Savannah River Site.

5.1.6.6 Transportation.

Shipments—Under the Centralization alternative, all stored and newly generated SNF would be transported to one of five sites: the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, or Nevada Test Site.

Incident-Free Transportation—For the five Centralization alternative sites, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.21 (centralization at the Oak Ridge Reservation) to 1.7 (centralization at the Savannah River Site). These fatalities were over the 40-year period 1995 through 2035 and represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The range of fatalities was due to two factors: (a) the option of using truck or rail transport for DOE SNF (see Appendix I) and (b) the five centralization options. Navy shipments would be made using a combination of truck and rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

For centralization at the Oak Ridge Reservation, the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.050, the estimated number of radiation-related latent cancer fatalities for the general population was 0.073, and the estimated number of nonradiological cancer fatalities from vehicular emissions was 0.083.

For centralization at the Savannah River Site the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.43, the estimated number of radiation-related latent cancer fatalities for the general population was 1.2, and the estimated number of nonradiological fatalities from vehicular emissions was 0.11.

For centralization at the Oak Ridge Reservation, onsite shipments of SNF were estimated to result in 0.0023 fatalities. Offsite shipments of SNF were estimated to result in 0.20 fatalities. These fatalities were also the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

For centralization at the Savannah River Site, onsite shipments of SNF were estimated to result in 0.0035 fatalities. Offsite shipments of SNF were estimated to result in 1.7 fatalities. These fatalities were also the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents—Cumulative accident risks for transportation by truck would range from 0.0048 latent cancer fatalities and 1.0 traffic fatalities for centralization at the Idaho National Engineering Laboratory, to 0.0020 latent cancer fatalities and 1.44 traffic fatalities for centralization at the Savannah River Site. Cumulative accident risks for transportation by rail would range from 0.0013 latent cancer fatalities and 0.95 traffic fatalities for centralization at the Idaho National Engineering Laboratory, to 0.0014 latent cancer fatalities and 1.19 traffic fatalities for centralization at the Nevada Test Site.

For centralization at either the Hanford Site or Idaho National Engineering Laboratory, the maximum reasonably foreseeable offsite transportation accident would involve a rail shipment of special-case commercial SNF in a suburban population zone under neutral (average) weather conditions. The accident has a probability of occurrence of about 5×10^{-7} per year and the consequences would be the same as those described under the 1992/1993 Planning Basis alternative.

For centralization at the Oak Ridge Reservation or the Nevada Test Site, the maximum reasonably foreseeable offsite transportation accident involves a rail shipment of special case commercial SNF in an urban population zone under neutral (average) weather conditions. The accident has a probability of occurrence of about 1×10^{-7} per year and could result in an estimated 36 latent cancer fatalities in the exposed population for Oak Ridge Reservation; for the Nevada Test Site, the accident would result in approximately 36 latent cancer fatalities. For comparison, the same population would be expected to experience about 540,000 cancer fatalities from other causes. The probability of this accident occurring under stable (worst-case) weather conditions is less than 1×10^{-7} per year for urban and suburban zones; the probability of occurrence is 5.7×10^{-7} per year if the accident occurred in a rural population zone and could result in an estimated 2 latent cancer fatalities.

For centralization at the Savannah River Site, the bounding offsite transportation accident would involve a rail shipment of commercial SNF in a suburban population zone under stable (worst-case) weather conditions. The accident has a probability of occurrence of about 1.2×10^{-7} per year and could result in an estimated 55 latent cancer fatalities in the exposed population. For comparison, the same population would be expected to experience about 42,000 cancer fatalities from other causes. The probability of this accident occurring in an urban population zone is less than 1×10^{-7} per year. In a rural population zone, the accident consequences would be approximately 3 percent of the suburban zone consequences.

Onsite transportation of SNF would occur under the Centralization alternative at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The bounding accident among the three sites occurs at the Idaho National Engineering Laboratory, and the potential impacts would be the same as those described under the No Action alternative.

Table 5-2 summarizes the comparison of incident-free transportation fatalities for each of the SNF management alternatives. Table 5-3 provides the comparison of transportation accident risks for each of the SNF management alternatives.

Table 5-2. Comparison of incident-free transportation total fatalities for alternatives over the 40-year period.

	Minimum[a,b] total fatalities	Maximum[b,c] total fatalities
No Action	0.0089	0.0089
Decentralization	0.12 to 0.15	0.35 to 0.38
1992/1993 Planning Basis	0.14	0.45
Regionalization 4A (fuel type)	0.17	0.61
Regionalization 4B (geography)		
Idaho National Engineering Laboratory and Savannah River Site	0.15 to 0.17	0.51 to 0.53
Idaho National Laboratory and Oak Ridge Reservation	0.14 to 0.15	0.53 to 0.54
Hanford Site and Savannah River Site	0.17	0.55 to 0.56
Hanford Site and Oak Ridge Reservation	0.15	0.57
Nevada Test Site and Savannah River Site	0.19	0.88
Nevada Test Site and Oak Ridge Reservation	0.17	0.90
Centralization		
Hanford Site	0.23	1.3
Idaho National Engineering Laboratory	0.21	1.1
Savannah River Site	0.26	1.7
Oak Ridge Reservation	0.21	1.6
Nevada Test Site	0.26	1.6

a. The minimum total fatalities would be associated with transport of DOE fuel by rail; naval SNF shipments would be by both truck (onsite) and rail (offsite).

b. Total fatalities were calculated for the 40-year period 1995 through 2035 and were the sum of the estimated number of radiation-related latent cancer fatalities for workers and the general population and the estimated number of nonradiological fatalities from vehicle emissions.

c. The maximum total fatalities would be associated with transport of DOE fuel by truck, naval SNF shipments would be by both truck (onsite) and rail (offsite).

Table 5-3. Comparison of estimated transportation accident risks for alternatives over the 40-year period.

Alternative	Truck Accident Risks[a]		Rail Accident Risks[a]	
	Latent cancer fatalities	Traffic fatalities	Latent cancer fatalities	Traffic fatalities
No Action	4.1×10^{-6}	0.047	4.1×10^{-6}	0.047
Decentralization[b]	0.00085 to 0.00090	0.20 to 1.01	0.00029 to 0.00034	0.26 to 1.07
1992/1993 Planning Basis	0.0010	0.70	0.00035	0.73
Regionalization 4A (fuel type)	0.0011	0.77	0.00037	0.76
Regionalization 4B (geography)				
Idaho National Engineering Laboratory and Savannah River Site	0.00090	0.72	0.00034	0.73
Idaho National Engineering Laboratory and Oak Ridge Reservation	0.00095	0.73	0.00024	0.72
Hanford Site and Savannah River Site	0.0013	0.84	0.00075	0.82
Hanford Site and Oak Ridge Reservation	0.0013	0.81	0.00050	0.78
Nevada Test Site and Savannah River Site	0.0012	0.99	0.00045	0.91
Nevada Test Site and Oak Ridge Reservation	0.0012	1.00	0.00035	0.91
Centralization				
Hanford Site	0.0050	1.10	0.0013	1.05
Idaho National Engineering Laboratory	0.0048	1.00	0.0013	0.95
Savannah River Site	0.0020	1.44	0.00080	1.09
Oak Ridge Reservation	0.0017	1.35	0.00055	1.00
Nevada Test Site	0.0050	1.33	0.0014	1.19

a. Assumes SNF shipments would be 100 percent by truck or 100 percent by rail, except for naval SNF shipments that would be by both truck (onsite) and rail (offsite).

b. Range of values in each column for the Decentralization alternative reflects the different fuel examination options for naval SNF.

5.2 Issues Not Discussed in Detail

This section discusses potential impacts for issues that are not discussed in detail because they are small and do not distinguish among alternatives, but about which the public may have general interest. The discussion for each discipline generally concentrates on sites and alternatives that have the largest expected impacts, demonstrating that the environmental consequences for that discipline are not of sufficient importance to be given strong consideration in the programmatic decisionmaking process.

5.2.1 Land Use

The proposed alternatives would not result in major impacts on land use at either the DOE or the naval sites. The largest amount of land that would be disturbed at any of the DOE sites would be 53 hectares (130 acres) at the Hanford Site. This would occur under the Centralization alternative and would take less than 0.5 percent of the land at that site. Less than 6.5 hectares (16 acres) of land would be required at the naval sites for the No Action alternative for the storage of SNF on railcars, and no additional land outside of the existing sites would be required. At all SNF sites, new facilities would be located near existing facilities or new facilities would be built on previously disturbed or industrialized land. Additional land might be required for infrastructure and buffer zones if a new SNF management facility is required. Because less than 0.5 percent of the land at any of the DOE sites would be needed and the current land use at the naval sites would not change, land use was determined not to be a discriminating factor (discriminator) among sites or alternatives and is not considered further in this volume. Detail on land use impacts is presented in Appendices A through F. The EIS does not explicitly consider land that is currently used for SNF operations or land that might or might not be made available for other uses under some alternatives.

5.2.2 Cultural Resources

Cultural, archaeological, historic, and architectural resources are defined as prehistoric and historic sites, districts, structures, and evidence of human use that are considered important to a culture, subculture, or a community for scientific, traditional, religious, or other reasons.

Most of the major DOE sites and some of the naval sites contain areas of archaeological, cultural, or historical interest. Direct impacts to archaeological resources would be associated with ground disturbance activities. Indirect impacts would result from improved visitor access, changes in land status, or other actions that would limit future scientific investigation. Although the major DOE sites have not been surveyed completely, the locations for the construction of proposed new facilities have generally been evaluated for their cultural importance. No known cultural resources would be affected by construction under any of the proposed alternatives. Specific surveys would be conducted before beginning any construction to determine the impacts to cultural resources. As described in Section 5.7.3, if cultural resources (for example, prehistoric or historic artifacts) were encountered during construction, earth-moving activities would stop and the State Historic Preservation Officer would be contacted immediately. If Native American or Native Hawaiian resources were to be involved, their leaders would also be contacted. Impacts to cultural resources were determined not to be an important discriminator among sites and alternatives; therefore, they are not considered further in this chapter. Details on cultural impacts are given in Appendices A through F.

5.2.3 Aesthetic and Scenic Resources

At all DOE sites, any proposed new SNF management facilities would be located far from areas with public access. Where new facilities would be visible to the public, similar facilities are already visible. At naval sites, SNF storage locations would be located at existing industrial facilities. Aesthetic and scenic resources would not be significantly affected by SNF management activities and are not considered further in this chapter. Discussion of impacts on aesthetic and scenic resources are contained in Appendices A through F.

5.2.4 Geologic Resources

None of the sites has known significant geologic resources that would be affected by the alternatives. Except for the potential existence of gold, tungsten, and molybdenum at the Nevada Test Site, geologic resources at the candidate sites consist of surficial sand, gravel, or clay deposits that have low economic value. The alternatives that involve constructing new facilities would result in disturbing or extracting surface deposits to construct the facilities. New construction would increase the use of surface deposits (that is, sand and gravel deposits), but because of the large volume of these materials on the sites, the impact is expected to be small.

All the major DOE sites have experienced earthquakes; however, they are located in areas with low to moderate seismic potential with respect to more seismically active areas in the United States (Algermissen et al. 1982, 1990). Because any new facility would be constructed to meet current seismic design criteria for a given area, seismic concerns are not a discriminating factor among sites. Details on site geology are provided in Appendices A through F.

5.2.5 Air Quality

SNF management activities under some alternatives would result in slightly increased releases of pollutants to the atmosphere. At the major DOE sites, the projected emissions from SNF management activities would not contribute to nonattainment of state or Federal standards. There would be no impact on nonradiological ambient air quality at the naval sites (Appendix D). Construction activities at several different sites are expected to cause short-term, minor increases in fugitive dust emissions, but the use of standard dust suppression techniques would be expected to minimize this problem. These particulate emissions could temporarily affect visibility in localized areas but would not cause nonattainment of state or Federal standards. Because SNF management activities would not be expected to cause either radiological or nonradiological air quality impacts to exceed state or Federal standards at any site for any alternative considered, or to significantly affect air quality in any other respect, air quality impacts are not discussed further in this chapter. The potential radiological impacts on health are discussed in Section 5.1. The computer models used for evaluating air quality impacts, and detailed results are discussed in Appendices A through F.

5.2.6 Water Resources

The proposed alternatives would have small impacts on water resources at each of the candidate sites. Compared with existing activities at all proposed SNF sites, additional water consumption would be minor and would relate primarily to the increased demand of a larger work force because SNF water pools use recycled water. The maximum increase of water usage over baseline at any candidate site would be approximately 5 percent. There would be net increases in employment at the Oak Ridge Reservation, and the Nevada Test Site; however, water resources would not be expected to be appreciably affected under any alternative. Nevertheless, at the Nevada Test Site, where available water is limited, a cumulative water supply impact is possible. The effects of groundwater withdrawal from the Frenchman Flat hydrographic area at the Nevada Test Site to support a proposed SNF facility on groundwater yields are unknown and require additional study. The Frenchman Flat hydrographic area is part of the Ash Meadows sub-basin whose perennial yield has greatly exceeded its annual water withdrawals. Some potential also exists for minor, short-term impacts of sedimentation during construction at the Oak Ridge Reservation and the Savannah River Site.

Storing SNF in water pools creates a potential for radiological groundwater contamination through undetected leaks or accidents that breach containment systems. Releases to groundwater caused by accidental minor breaches of leak containment systems are very small compared with accidental minor releases, which are presented in Appendices A through F under Occupational and Public Health and Safety. Water resources are discussed in detail in Appendices A through F.

5.2.7 Ecological Resources

The major DOE sites under consideration are located on large reservations that are predominantly "natural." The naval sites, on the other hand, are generally much smaller with significant industrial infrastructure. Similarly, the majority of the other generator and storage sites are in urban or suburban settings, where natural flora and fauna are limited to species that have developed a tolerance to human activities. Therefore, the largest impacts to ecological resources are expected to occur at the five major DOE sites where undisturbed or semi-disturbed natural areas could be converted to industrial activity. Under any of the alternatives involving the construction of new facilities at DOE sites, individuals or small populations of some wildlife species may be disturbed, displaced, or destroyed.

The development of new DOE facilities would affect some natural habitats. The size of the areas affected would be small in relation to the size of the sites and the size of remaining natural habitats. The type of habitats affected would vary but would be typical of the regional area in which the sites are located. The habitat losses would probably not affect any threatened or endangered species or critical habitats with the possible exception of the proposed facilities at the Nevada Test Site and the Hanford Site. At the Nevada Test Site, the proposed SNF facilities could be constructed within the range of the desert tortoise, a federally listed threatened species. At the Hanford Site, construction related to SNF management could result in a habitat loss up to 28 hectares (70 acres) for Federal and state-listed candidate species (for example, loggerhead shrike, sage sparrows, burrowing owls, pygmy rabbits). As described in Section 5.7.7, mitigation plans would be developed in consultation with the appropriate agencies if any threatened or endangered species were identified on the project site. Habitat fragmentation is not expected because new facilities would be constructed adjacent to existing facilities. Because minor impacts to ecological resources would occur at all sites for all alternatives involving construction, ecology was not considered a significant discriminator among sites and, therefore, is not discussed further in this chapter. Appendices A through F present a detailed discussion of ecological impacts.

5.2.8 Noise

The construction of SNF management facilities at any of the sites would generate noise levels consistent with light industrial activity. However, at the major DOE sites, noise generated onsite does not propagate offsite at levels that would affect the general population. Noise at the naval sites is primarily from truck and car traffic, shiploading, and diesel-powered equipment. Noise impact analyses at the naval sites indicate that noise from construction or operation of facilities would not cause the ambient noise levels to exceed U.S. Environmental Protection Agency or state guidelines. Construction would occur at the naval sites under the No Action and Decentralization alternatives. Noise impacts would be expected to be comparable at the major DOE sites for all alternatives except for the No Action alternative, which does not involve construction of new facilities. Because these new facilities would be located in industrialized areas, however, no impacts are expected. Because noise impacts would be minor and do not differentiate among the sites or the alternatives, they are not considered further in this chapter. Details on the noise impact analyses are provided in Appendices A through F.

5.2.9 Utilities and Energy

New facilities (or the restarting of idle facilities) would result in increased demands on water, power, and sewage. The greatest resource requirements would result from the implementation of the Centralization alternative. Based on available data, the increased water usage would range from less than 1 percent at the Idaho National Engineering Laboratory to a maximum of less than 5 percent above existing site usage at the Savannah River Site. Electricity requirements are discussed in Section 5.1. The increase in sewage generation resulting from implementation of the alternatives would range from less than 1 percent at the Idaho National Engineering Laboratory to a maximum of 9 percent at the Savannah River Site. A central sewage treatment system would have to be constructed for the SNF facilities at the Nevada Test Site under the Regionalization and Centralization alternatives if the Nevada Test Site were selected as a regional or central site. The existing system capacities at all sites could manage the estimated changes in utility usage rates for water. Appendices A through F provide details on utilities and energy consumption.

5.3 Cumulative Impacts

A cumulative impact on the environment results from the incremental impact of the action when added to other past, present, and reasonably foreseeable actions. "Other" actions include DOE projects at the potentially affected sites not related to SNF management, as well as projects proposed by other Government agencies, private businesses, or individuals. This type of an assessment is important because significant cumulative impacts can result from several smaller actions that by themselves do not have significant impacts. The programmatic cumulative impacts from the implementation of the DOE SNF Management Program are discussed in Section 5.3.1. The site-specific cumulative impacts are described in Section 5.3.2.

5.3.1 Programmatic Cumulative Impacts

On a nationwide basis, the implementation of any of the SNF Management Program alternatives would not be expected to significantly contribute to cumulative impacts. There would be a small change in regional employment, little use of nonrenewable resources, low radiological emissions, and a low rate of radioactive waste generation. Under most alternatives, subalternatives, and options, the activities required for SNF management would be very small in comparison to other non-SNF-related activities already underway at almost all sites where SNF would be stored. Even in those alternatives where there would be large changes in nonrenewable resource use at one or more sites (Regionalization by geography or Centralization), on a national scale, increases at the selected regional or central site would be compensated for by changes at nonselected sites, so the net change is very small.

Reasonably foreseeable projects that could contribute to cumulative impacts are identified for each of the DOE and naval sites in Appendices A, B, C, D, and F. For the major DOE sites, these projects are primarily associated with environmental restoration and waste management activities, one of the priorities being given to site management, and are being covered by the Waste Management Programmatic EIS and site-specific EISs. It is expected that SNF management activities would have consistently smaller impacts than the environmental restoration and waste management activities, and that the overall impact of SNF management would not contribute significantly to cumulative impacts on either a regional or a nationwide basis.

The transport of DOE and naval SNF over highways and railways is only one of the sources of radiological dose to the general public. The potential transport of commercial SNF for disposal in a repository, assumed to be in Nevada for purposes of analysis, the proposed transport of transuranic wastes to the Waste Isolation Pilot Plant in New Mexico, and the expected transport of radioisotopes used in medicine and other activities all would contribute to public exposures. Available historical data and projected future doses are summarized in Appendix I.

During analysis, the potential for significant cumulative impacts to other resources was considered; none were found. Cumulative impacts are described qualitatively because programmatic considerations do not require detailed information that depends on specific facility location or design. More detailed cumulative effects analysis will be performed for any actions that are proposed in the course of implementing programmatic SNF management decisions.

5.3.2 Site-Specific Cumulative Impacts

All of the sites contain facilities unrelated to SNF that may continue to operate throughout the duration of the SNF interim management program (approximately 40 years). Impacts from both construction and operation of SNF facilities would be cumulative with the impacts of existing and planned facilities or actions such as environmental restoration and waste management activities unrelated to SNF. Cumulative effects involving site-specific projects that are planned to occur simultaneously with SNF management activities at the major DOE sites are discussed in the site appendices. Not all planned facilities were factored into the assessment of cumulative impacts pending funding approval or resolution of DOE policy issues.

The following sections discuss cumulative impacts to those environmental resources identified in Appendices A through F. During analysis, the potential for significant cumulative impacts to other environmental resources (that is, geologic resources, aesthetic and scenic resources, and cultural resources) was evaluated; none were found.

5.3.2.1 Land Use. Implementation of any of the SNF alternatives at the major DOE sites would have a minimal cumulative impact with respect to either the available land onsite or to the continued mission of the sites. The largest proportion of any site that would be required for all sitewide activities is less than 1 percent of the total site area.

5.3.2.2 Socioeconomics. Depending on the economic status and outlook for an area, SNF activities coupled with other actions have the potential to strain or overburden the socioeconomic resources of certain areas, particularly if either the Regionalization or Centralization alternatives were selected with an expended core facility located at the site. For example, these cumulative effects could contribute to housing shortages, the need for additional schools, and increased demand for utilities and transportation.

Each site is anticipating an overall decline in site employment over the next few years; therefore, the existing work force could be reassigned to SNF management activities. However, it was assumed that the construction activities associated with the proposed SNF management alternatives would require the in-migration of construction workers. Although these construction activities are short-term with a duration of a few years, when addressed cumulatively with other reasonably foreseeable activities, there could be a socioeconomic impact in the communities surrounding the Hanford Site, Nevada Test Site, and Oak Ridge Reservation. For example, at the Hanford Site cumulative employment, housing requirements, and needs for schools would increase up to 1 percent over those based on present Hanford employment for SNF management activities only.

Impacts to socioeconomic resources associated with the implementation of proposed SNF actions at the Idabo National Engineering Laboratory, Savannab River Site, naval sites, and other generator sites are not expected to be sufficient to have a cumulative effect on the regional social infrastructure within each site's region of influence.

5.3.2.3 Air Quality. The available data in Appendices A through F indicate that the cumulative air emissions from the Savannab River Site, Idaho National Engineering Laboratory, and naval sites, including those from the proposed SNF management alternatives, would not exceed the limits for nonradioactive air pollutants and would not threaten to exceed the limits for nonradioactive pollutants or the 40 CFR Part 61 limit of 0.01 rem (10 millirem) per year for radioactive emissions.

5.3.2.4 Water Resources. Based on data available in Appendices A through F, the implementation of any of the SNF alternatives at the major DOE sites would result in minimal cumulative impacts to water resources under normal operations. The proposed SNF facilities and related management operations are designed to generate no liquid releases of wastewater to the subsurface or water resources containing radiological constituents or hazardous chemicals. The facilities would be constructed using state-of-the-art technologies, including secondary containment and leak detection and water balance monitoring equipment. Liquid effluent discharges from SNF activities will be monitored for the presence of radioactive and chemical constituents and determined suitable for land disposal as required under Federal and State regulations.

Water usage from SNF activities would also have a small cumulative effect on overall quantities of water available at the major DOE sites. The maximum increase over baseline water use would be approximately 5 percent for any of the proposed locations.

5.3.2.5 Biotic Resources. Construction of the proposed SNF facilities in addition to other planned activities could disturb as much as 9 hectares (24 acres) of terrestrial habitat at the Hanford Site and as much as 13 hectares (31 acres) of previously disturbed land at the Idaho National Engineering Laboratory. No impacts to biotic resources would be expected at the Savannab River Site or Oak Ridge Reservation. However, construction activities at the Nevada Test Site and Hanford Site could result in habitat loss for either Federal and state candidate species or federally listed threatened species. For example, at the Hanford Site the cumulative impact from planned activities including construction related to SNF management could result in habitat loss for Federal and state candidate species (for example, loggerhead shrike, sage sparrows, burrowing owls, pygmy rabbits). At the Nevada Test Site, the proposed SNF facilities would be constructed within the range of the desert tortoise, a federally listed threatened species. Therefore, the proposed SNF management activities in addition to other planned actions could result in a small cumulative loss of habitat for the desert tortoise.

5.3.2.6 Occupational and Public Health. The sources of radiation exposure to individuals consist of natural background radiation from cosmic, terrestrial, and internal body sources; medical radiation; and radiation from manmade sources, including consumer and industrial products, nuclear facilities, and weapons test fallout. At the Savannah River Site, for example, natural background radiation contributes about 82 percent of the dose received by an average member of the population within 80 kilometers (50 miles) of the site, medical exposure accounts for 15 percent of the annual dose, and the combined doses from weapons test fallout, consumer and industrial products, and air travel account for approximately 3 percent. DOE nuclear facilities at the Savannah River Site account for less than 0.1 percent of the total radiation exposure.

The radiological impacts from SNF management operations are exposures to both workers and the general public from normal operations and the risk of additional radiation exposures due to accidents. The major concerns with these exposures are whether the doses are sufficient to cause immediate harm and how much they will increase the probabilities, among the exposed population, of latent cancer fatalities, nonfatal cancers, and genetic effects. Of further concern is that these SNF management-related exposures are in addition to those exposures and risks affecting the same workers and members of the general public from other sources. The cumulative impact of both the SNF-related increment and other possible sources is also a concern.

Cumulative Impacts to the General Public—The principal regulatory limit affecting emissions from DOE and naval sites is the Clean Air Act standard (40 CFR Part 61, Subpart H for DOE; Subpart I for the Navy) for airborne radionuclide emissions from DOE facilities. This rule limits airborne emissions to those amounts that would not cause any member of the public to receive in any year an effective dose equivalent of more than 0.01 rem (10 millirem) per year. Implementation of any of the alternatives at any of the sites is not expected to result in normal releases exceeding this limit. The naval sites have demonstrated to the U.S. Environmental Protection Agency that, at 0.0001 rem (0.1 millirem) per year, they are at 1 percent of the limit and operation of SNF management facilities is not expected to change that conclusion. Data available for each of the sites (see Appendices A through F) indicate that over the 40-year planning period, the cumulative radioactive emissions from the existing, the potential SNF management activities, and reasonably foreseeable future site activities at any of the sites would not be expected to result in an additional latent cancer fatality among the general population surrounding the site, except for the Oak Ridge Reservation. With centralization at the Oak Ridge Reservation, operation of the proposed SNF management facilities over their expected 40-year lifetimes is estimated to result in a total population dose of approximately 2,500 person-rem. This equates to approximately two latent cancer fatalities over the period.

Cumulative Impacts on the Site Work Force—The cumulative impact of selection of either of the alternatives coupled with the existing and reasonably foreseeable actions has the potential to increase the radiological exposure to workers at the sites transporting and receiving the SNF. For both the transporting and receiving sites, the routine exposure to the workers is expected to increase because much of the dose to the workers is associated with SNF handling operations.

Because occupational worker exposures are easily monitored and controlled to levels a factor of 10 or more below the current standards, the overall average exposure per worker is expected to remain approximately constant at each of the SNF transporting and receiving sites with each of the alternatives. However, with options that involve more SNF activities, the number of SNF-related workers is expected to increase, thus increasing the collective radiation dose to the site work force. As reported in Appendices A through F and summarized in Appendix K, the increases in collective dose to the work force varies from site to site and with the alternatives. At the Oak Ridge Reservation, for example, the increases due to SNF-related actions range to 3,200 person-rem over the 40-year planning period. The maximum SNF-related increase is equivalent to approximately one additional latent cancer fatality among the workforce.

5.3.2.7 Transportation.

Radiological Impacts—Table 5-4 summarizes the existing and reasonably foreseeable actions assessed to determine the cumulative impact for transportation for the SNF alternatives. The cumulative radiological impacts of incident-free transportation of SNF are presented in terms of radiation-related latent cancer fatalities. These results are summarized in Table 5-5 and more details are contained in Appendix I. Over the 93-year period from 1943 through 2035, the total number of radiation-related latent cancer fatalities was estimated to be 290, or approximately three latent cancer fatalities per year. General transport of radioactive material accounted for about 90 percent of these radiation-related latent cancer fatalities. The radiation-related latent cancer fatalities would be indistinguishable from other cancer fatalities and would be 0.001 percent of the total number of cancer fatalities that would be expected to occur. The radiation-related latent cancer fatalities associated with the alternatives evaluated in this EIS would be 5×10^{-6} percent of the total number of cancer fatalities that would be expected to occur.

Traffic Accident Impacts—Fatalities involving the transport of radioactive materials for 1971 through 1993 were surveyed based on data in the Radioactive Material Incident Report database. This database contains information on radioactive materials transportation incidents

Table 5-4. Other activities included for assessment of cumulative impacts for transportation.

Activity	Description
Existing activities:	
Historical shipments	Historical shipments of SNF, Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site
General transportation	Nationwide transport of radioactive materials for medical, industrial, fuel cycle, and disposal purposes
Reasonably foreseeable activities:	
Geologic repository	Shipments of commercial SNF and defense high-level waste to the geologic repository at Yucca Mountain, Nevada
Waste Isolation Pilot Plant	Shipments of transuranic waste to the Waste Isolation Pilot Plant at Carlsbad, New Mexico (including a 5-year Test Phase and 20-year Disposal Phase)
Submarine reactor compartments	Shipments of reactor compartments from Puget Sound Naval Shipyard to Hanford
Return of isotope capsules	Shipments of cesium-137 isotope capsules to the Hanford Site
Uranium billets	Shipment of low-enriched uranium billets from the Hanford Site to the United Kingdom

Table 5-5. Summary of transportation radiological cumulative impacts.

Category of shipment[a]	Occupational latent cancer fatalities	General population latent cancer fatalities
Projected SNF shipments for all alternatives		
Truck	0.00060 to 0.40	0.00017 to 1.2
Train	0.00060 to 0.060	0.00017 to 0.085
Historical SNF[b]	0.080	0.055
General transportation (1943 to 2035)[c]	120	140
Reasonably foreseeable actions[d]		
Truck	4.4	25
Train	0.33	0.85
Total cancer fatalities[e]	130	160

a. See Table 5-4 and Appendix I for more details.

b. Shipments to Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site. Includes transport of naval SNF to the Idaho National Engineering Laboratory.

c. Shipments are a combination of truck and train.

d. Shipments to the geologic repository, the Waste Isolation Pilot Plant, and shipments of submarine reactor compartments, isotope capsules, and uranium billets

e. Numbers may not sum due to rounding.

and accidents from the U.S. Department of Transportation, U.S. Nuclear Regulatory Commission, DOE, state radiation control offices, and media coverage. From 1971 through 1993, 21 traffic accidents involving 36 fatalities have occurred. These fatalities resulted from traffic accidents and were not associated with the radioactive nature of the cargo. No radiological fatalities because of transportation accidents have ever occurred in the United States. During the same time period, over 1,000,000 persons were killed in traffic accidents in the United States.

For the alternatives evaluated in this EIS, about one traffic accident fatality was estimated to occur. During the 40-year time period from 1995 through 2035 evaluated in this EIS, approximately 1,600,000 persons would be killed in traffic accidents in the United States.

5.3.2.8 Energy/Utilities. Under certain SNF management alternatives, energy or utility requirements for SNF management in combination with other present for future projects, could stress or exceed the existing capacity at a site. The existing energy and capacity would be adequate for the SNF management alternatives at all sites with the possible exception of the Hanford Site and the Nevada Test Site.

If all SNF were transported to the Hanford Site under the Centralization alternative, then existing utilities, including water mains, power lines, sewage facilities, and telephone lines, would need to be extended to the project area. If the Centralization alternative was implemented in addition to other power-intensive activities (for example, operating a vitrification plant), existing capacity might be inadequate based on current consumption.

If the Centralization alternative were implemented at the Nevada Test Site, additional transmission lines might need to be constructed. In addition, a sewage treatment facility for the SNF management facility would have to be constructed at the Nevada Test Site if SNF management activities were implemented under the Regionalization and Centralization alternatives. Water supplies at the Nevada Test Site have been developed from local groundwater sources within the Ash Meadows Sub-basin. Existing withdrawals of groundwater from this sub-basin may have already exceeded its localized perennial yield (Appendix F). SNF management facilities at this site may result in the need for additional water.

5.3.2.9 Waste Generation. Waste volumes generated from SNF management activities depend on the alternative chosen. In general, the Regionalization and Centralization alternatives at the Idaho National Engineering Laboratory, and the alternatives at the Savannah River Site involving processing, would result in the largest cumulative impact on waste generation. Under some options, the total increase in waste generation could be four times the current facility baseline and require the construction of additional facilities.

To evaluate the adequacy of existing storage capacity, waste volumes generated from the SNF management alternatives were compared with current generation rates at the major DOE sites. At the Navy sites, the rate of low-level waste generation would be small and not stress existing capacity. No mixed, transuranic, or high-level waste would be generated from SNF activities at the Navy sites (Appendix D).

At the major DOE sites, increased low-level waste generated from SNF management activities would range from about 1 percent above baseline generation rates at the Oak Ridge Reservation to approximately four times above baseline at the Savannah River Site for centralization and processing options, respectively. Adequate storage capacity exists at all sites except at the Idaho National Engineering Laboratory, where beyond the year 2005 low-level waste storage capacity may be strained (Appendix B).

The increased volume of transuranic waste that could be generated from SNF management activities could exceed 100 percent above baseline at the Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site based on centralization and processing options. This percentage is high at both Nevada Test Site and the Oak Ridge Reservation because neither of these sites is currently generating transuranic waste and because both sites have projected that future transuranic waste volumes will only be produced by SNF management activities. However, adequate storage capacity exists at both sites.

The volume of high-level waste generated from SNF management activities has been estimated to range from approximately 21 percent to greater than 100 percent above current site baseline generation rates at the Idaho National Engineering Laboratory and the Savannah River Site, respectively. Again, the percentage is high at the Savannah River Site because essentially no high-level waste is currently being generated onsite, but with processing approximately 2 cubic meters per year of high-level waste could be generated. Adequate storage capacity exists at the sites. No high-level waste would be generated at either the Nevada Test Site or the Oak Ridge Reservation.

5.4 Adverse Effects That Cannot Be Avoided

Adverse impacts would result, no matter the alternative, from radiation exposure associated with maintaining facilities that are at or near the end of their design life, until completion of the construction of new facilities. However, these exposures would be kept within applicable regulatory requirements and other applicable guidelines and would be controlled to levels that are as low as reasonably achievable. Implementation of any alternative except the No Action alternative would increase the volume of radioactive waste, in particular, low-level waste generated at the major DOE sites. Under the action-based alternatives, where SNF is transported to other sites, there would be a small increased potential for exposure to the general population when the SNF is in transit.

Under the No Action alternative, there would be several adverse effects that could not be avoided. These include the continuation of the environmentally degraded state of the three major DOE sites because existing facilities would deteriorate further. Naval and research reactor SNF would be stored near population centers, potentially increasing the consequences of an SNF handling or management accident. This alternative also presents a greater personnel requirement for managing SNF interim storage facilities. (Under other alternatives, the apparently higher personnel requirement would be for additional management activities that would not be done under the No Action alternative—they are not just related to storage facilities.) In addition, the shutdown of research reactors that could not store SNF onsite would result in the loss of several hundred reactor operator and research positions.

Under Regionalization 4B and Centralization alternatives, one or more major DOE sites would transport all its SNF to another major DOE site, the facilities at the transport sites would be shut down, and facilities at the receiving site(s) would be built. This would cause the relocation of many jobs associated with SNF management and duplicate some existing facilities. While new facilities are generally required at each DOE site under many alternatives, there are existing facilities that can be used for storage at major sites that would be shut down prior to the end of their useful design life.

The construction and operation of any of the facilities under consideration for storage of SNF would result in some adverse impacts to the environment. Although location-dependent, changes in project design and other measures (for example, sound engineering practices during construction) would eliminate, avoid, or minimize these impacts. In general, most of the adverse impacts would be of short duration and would result from the construction of proposed facilities. For example, noise, atmospheric emissions, fugitive dust, sediment runoff, and solid waste would be expected to increase during construction. Section 5.7 discusses potential mitigation measures that could be used to control or minimize impacts to the environment. See Appendices A through F for site-specific discussion on adverse effects that cannot be avoided.

5.5 Relationship Between Short-Term Use of the Environment and the Maintenance and Enhancement of Long-Term Productivity

The implementation of any of the SNF management alternatives would cause some adverse impacts to the environment and permanently commit certain resources. This section describes the relationship between short-term influences from the implementation of an SNF management alternative and the associated long-term effects.

The proposed alternatives for SNF management would require the short-term use of multiple resources; for example, energy, materials of construction, and labor to achieve the objective of safely securing SNF to minimize the risk to workers, to the public, and to the environment. For example, if no action were taken, degradation of the fuel and SNF facilities would occur with the potential for releases to the environment. Releases to the environment could contaminate land near the point of storage, thereby reducing the potential future use. By consolidating and containing the SNF at specific locations, the potential for impacting the environment would be reduced at the other locations. After the implementation of a comprehensive SNF management strategy, those areas currently used for SNF management could be released to allow other productive use, such as for research or technology development.

The premature shutdown of research reactors due to a lack of sufficient SNF interim storage space under the No Action alternative could have an impact upon the national and regional communities in which they are located. Most of these reactors are the only regional source of radiopharmaceuticals and often they are important centers of medical and biological research. The sites where these reactors are located, many of them universities, are unique training facilities for students in many fields of research and development: materials science, environmental science, physics, biology, and electronics.

In the medical arena, research reactors have proven to be vital to cancer therapy, diagnostic imaging, studies of the biological effects of radiation, and other important medical applications. Demand for medically important radioisotopes would not decrease merely because the source was shut off. The continued demand for radioisotopes would be met by placing orders with remaining reactors, which may be farther away from the place where they are needed. Many medically important isotopes (for example, iodine-131) have such short half-lives that the amount transported must include enough to allow for radioactive decay during shipment. Therefore, shutdown of reactors would result in the need to produce and transport larger quantities of radiopharmaceuticals.

Shutdown of research reactors could produce an impact on commercial enterprises that are engaged in the doping of silicon crystals through neutron irradiation. The doped silicon chips are widely used in electronic components such as the computers used in automobile engines.

Graduates trained at these facilities contribute to a wide variety of nuclear industries and to Government agencies involved with (a) monitoring nuclear technology, for example, regulatory agencies, Federal and international inspections, (b) hardware for inspections, and (c) remote monitoring.

Development of new SNF interim management facilities would commit lands to those uses from the time of construction through cessation of operations. At that time, these facilities could be converted to other uses or decontaminated, decommissioned, and the site restored to its original land use. Existing SNF management facilities could also be converted to other uses or the lands restored following their decommissioning.

See Appendices A through F for site-specific discussions on the relationship between short-term use of the environment and the maintenance and enhancement of long-term productivity.

5.6 Irreversible and Irretrievable Commitment of Resources

The irreversible and irretrievable commitment of resources resulting from the construction and operation of SNF management facilities would involve materials that could not be recovered or recycled, or resources that would be consumed or reduced to unrecoverable forms. For example, the construction and operation of an SNF facility at any of the locations under consideration would consume irretrievable amounts of electrical energy, fuel, construction materials, and miscellaneous chemicals. Some construction materials are recyclable and, therefore, should not be considered irreversible and irretrievable commitments of resources. Furthermore, some of the resources would be irretrievable because of the nature of the commitment or the cost of reclamation. For example, human resources used for the construction and operation of the proposed SNF facilities would be irretrievably lost since these resources would be unavailable for use in other work activity areas. On the whole, however, SNF management is not particularly resource intensive. See Appendices A through F for site-specific discussions on irreversible and irretrievable commitments of resources.

5.7 Potential Mitigation Measures

This section summarizes measures that DOE[a] could implement to avoid or reduce impacts to the environment. Possible mitigation measures are generally the same for all alternatives and are summarized by resource category below. Although the environmental effects described in Sections 5.1 through 5.3 may not require mitigation, the range of potential mitigation actions is described below. For all sites, impacts to land use and aesthetic and scenic resources would be small; therefore, mitigation measures for these attributes would not be required.

5.7.1 Pollution Prevention

Implementation of the SNF management alternatives would generate waste with the potential for releases to air and water. To control both the volume and toxicity of waste generated and to reduce impacts on the environment, pollution prevention practices would be implemented.

DOE is responding to Executive Order 12856, Federal Compliance with Right to Know Laws and Pollution Prevention Requirements, and associated DOE orders and guidelines by reducing the use of toxic chemicals; improving emergency planning, response, and accident notification; and encouraging the development and use of clean technologies and the testing of innovative pollution prevention technologies. Pollution prevention programs have been implemented at each site. Program components include waste minimization, source reduction and recycling, and procurement practices that preferentially procure products made from recycled materials. Portions of the pollution prevention program have been implemented at the existing DOE and naval sites for nearly 10 years. For example, the waste minimization program at the Savannah River Site has decreased the amount of all waste types generated by material substitutions.

Implementation of the pollution prevention plans minimizes the amount of waste generated during SNF management activities.

5.7.2 Socioeconomics

The SNF management alternatives would require additional workers for construction, stabilization, monitoring, and maintenance of SNF. This would produce a socioeconomic effect depending on the available site work force, regional labor pool, and community infrastructure. Minor socioeconomic impacts would be expected from implementation of the SNF management alternatives;

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a. Because this is an EIS issued by the DOE, it contains language concerning compliance with applicable environmental requirements, taking appropriate mitigative measures to reduce environmental impacts, and other matters phrased in the context of DOE as the party taking the actions. As a cooperative agency, and because Navy sites are also evaluated in this EIS, the Navy will also assure compliance with applicable environmental requirements and take other appropriate measures for its facilities in a consistent and appropriate fashion.

the mitigation measures described below could be used to further minimize the effect on the community.

Construction and operation-related impacts resulting from increased labor and capital requirements could be reduced by coordinating with local communities and county planning agencies. Effective planning would address changes in community services, housing, infrastructure, utilities, and transportation. DOE would coordinate, in an appropriate manner, with the local and regional planning agencies to address impacts on the work force and community infrastructure. This could be facilitated through the development of citizen advisory boards. The timing of certain activities that have been proposed to proceed concurrently could also be adjusted to minimize socioeconomic impacts.

5.7.3 Cultural Resources

Impacts to cultural resources could occur during construction and earth-moving activities associated with the SNF management alternatives. Areas of proposed ground disturbance would be assessed for the potential to contain important archaeological and paleontological resources. Each DOE operations office is responsible for establishing and maintaining mitigation agreements including actions to be taken in the event of discovery of archaeological resources or human remains during construction. These agreements will be negotiated with their potentially affected tribes and state historic preservation officers. These agreements would be referenced in future site-specific National Environmental Policy Act documentation when appropriate. An example of a possible mitigation measure for archaeological resources would be avoidance or data recovery prior to construction. Other measures would be necessary to mitigate potential impacts to values of Native American or Native Hawaiian populations, including involvement in the selection of a mitigation strategy for impacts to archaeological sites, spiritual geographical features, and land use. This could include the SNF Program's participation in liaison programs to understand Native American or Native Hawaiian concerns.

For paleontological resources, assessments could include literature searches, surface surveys, and consultation with recognized paleontological experts in the region or limited test excavations in geologically similar disturbed areas. If significant paleontological resources were identified, a mitigation plan for recovery, stabilization, and caring of the resources would be implemented before construction.

For example, at the Hanford Site, certain site activities would have the potential to adversely affect prehistoric archaeological sites. In this case, the specific activity plans would be reviewed to determine potential effects before initiation of activities. The activity will then be designed to avoid these sites. If avoidance of these sites would not be possible, mitigation measures would be developed in conjunction with the appropriate state agencies and Native American tribes.

To avoid impacts during operation such as unauthorized artifact collection, workers could be educated through programs and briefing sessions to inform personnel of applicable laws and regulations for site protection. These educational programs would stress the importance of cultural resources and specifics of the laws and regulations for site protection.

5.7.4 Soils

Soils could be affected from implementation of the SNF management alternatives if there were leaks or a release to soils as a result of SNF activities. DOE would appropriately remediate any soils contaminated from SNF management activities.

5.7.5 Air Resources

Certain actions under the SNF management alternatives would impact air quality. For example, the construction of new facilities could negatively impact air quality through the emission of fugitive dusts and from pollutants from diesel- and gasoline-powered equipment. The increase in offsite ambient levels would be small because of the large distance to the nearest public access, and use of the mitigation measures described below would further minimize the potential impact.

DOE would meet applicable regulations regarding the maintenance of air quality from both radiological and nonradiological emission sources. DOE does not foresee impacts to air quality from SNF management that would warrant measures beyond those employed consistent with good construction, engineering, and operations, and management practices.

5.7.6 Water Resources

The implementation of some of the SNF management alternatives would require larger volumes of water for the stabilization of SNF. DOE would control water consumption through the appropriate application of water recycling, water conservation measures and equipment, stormwater catchment basins, and worker training programs. Constant process monitoring and mass-balance and design to current standards, including double-wall confinement of all vessels and piping, would be included in design and operating standards by DOE to limit potential operational releases from a SNF processing or storage facility to essentially zero.

5.7.7 Ecological Resources

Implementation of the SNF management alternatives could impact terrestrial resources, wetlands, aquatic resources, and threatened and endangered species either directly by earth-moving activities that disturb habitat or indirectly through construction activities that result in increased runoff into wetlands or aquatic environments.

To avoid potential impacts to endangered, candidate, or state-identified sensitive species, preconstruction surveys would be completed to determine the presence of these species or their habitat. If protected species or primary habitat for these species are located near or within an area to be disturbed, DOE would evaluate the project design and other program activities to determine if modifications would avoid negative impacts. DOE would consult with the U.S. Fish and Wildlife Service to develop the most appropriate action-specific mitigation measures.

Wetland habitat would be delineated in accordance with applicable U.S. Army Corps of Engineers procedures and wetlands located near proposed activities would be avoided. However, if avoidance were not possible, specific mitigation measures could be developed in consultation with the U.S. Army Corps of Engineers. For example, mitigation could include construction of new wetland acreage equivalent to the acreage of disturbed wetland habitat or enhancement of existing wetland habitat at another location onsite.

5.7.8 Noise

Construction and operation from SNF management would result in the generation of noise consistent with light industrial activity. DOE does not foresee noise impacts from SNF management that would warrant mitigation measures beyond those employed consistent with good construction engineering, operational, and management practices.

Noise impacts to the public and other noise-sensitive receptors could be reduced by providing noise buffer areas between sources and receptors, constructing noise walls and other attenuation structures, and limiting the emissions to daytime periods.

5.7.9 Traffic and Transportation

The number of workers in SNF management activities under some of the alternatives would add to the current work force and to additional commuting traffic. At sites with increasing traffic concerns, roads could be widened with the addition of lanes or implementation of traffic demand management. DOE would also consider using high-occupancy vehicles (such as vans or buses), implementing car-pooling or ride-sharing programs, or staggering schedules to reduce the potential for increased traffic congestion. See Section 5.7.12 for discussion of transportation accident mitigation.

5.7.10 Occupational and Public Health and Safety

Implementation of the SNF management alternatives would increase the potential for radiation exposure either through direct exposure or through air emissions. Although these effects are small, as discussed in Section 5.2, the as low as reasonably achievable principle would be used for controlling radiation exposure of workers and the public. Pollution prevention practices would be implemented to avoid or reduce production of potentially harmful substances. Waste minimization would be practiced to reduce the toxicity and volume of secondary wastes to be managed. Furthermore, sites would update their current worker training, emergency planning, emergency preparedness, and emergency response programs as needed to address new SNF management actions for the protection of both workers and the public.

5.7.11 Site Utilities and Support Services

The SNF management alternatives would put increased demands on utilities at the sites. Under certain alternatives, additional transmission lines or substations may need to be added to the infrastructure and, at the Nevada Test Site, a sewage treatment facility for the SNF management facility would need to be constructed. However, DOE would reduce the need for certain utilities (such as water and electricity) through the implementation of resource conservation, pollution prevention, and energy efficiency measures.

5.7.12 Accidents

The potential exists for an accident associated with either the handling or transportation of SNF with the consequence being a significant release of radioactive or other hazardous materials to the environment. Although the probability is very small, as discussed in Section 5.2, each of the locations considered for SNF management have emergency action plans and equipment to respond to accidents and other emergencies to limit the magnitude of potential impacts from any accident. These plans include training of workers, local emergency response agencies (such as fire departments), and the public; communication systems and protocols; readiness drills; and mutual aid agreements. The plans would be updated to cover any new SNF facilities and activities. DOE would coordinate activities with state and local agencies to establish and implement an appropriate emergency response training program for potential accidents.

5.8 Environmental Justice

In February 1994, Executive Order 12898, titled *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (FR 1994), was released to Federal agencies. This order directs Federal agencies to incorporate environmental justice as part of their missions. As such, Federal agencies are specifically directed to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations. Appendix L of this EIS provides an assessment of the areas surrounding the 10 sites under consideration for the management of SNF under all programmatic alternatives considered in this volume. Because DOE is still in the process of developing guidance, the approach used in this analysis might depart somewhat from the guidance eventually issued.

The overall review indicated that the potential impacts calculated for each discipline under each of the alternative sites considered for the management of all or some portion of DOE SNF (or naval SNF only) present no significant risk and do not constitute a reasonably foreseeable adverse impact to the surrounding population. This includes both the impacts of facility operations and the transport of SNF, and the risk of reasonably foreseeable accident scenarios postulated for both, all of which are small. Therefore, the impacts of the programmatic management of DOE SNF under all alternatives evaluated in this EIS do not constitute a disproportionately high and adverse impact on any particular segment of the population, minorities or low-income communities included.

Characterization of the numbers and location of minority and low-income populations is dependent on how these populations are defined and what assumptions are used in conducting the analysis. As discussed in Appendix L, at the time this EIS and the Draft Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (Draft FRR SNF EIS) were prepared, the Federal Interagency Working Group on environmental justice had not issued final guidance on the definitions of minority and low-income populations, or the approach to be used in analyzing environmental justice, as directed by the Executive Order (FR 1994). Final internal DOE guidance on environmental justice also has not been adopted. As a result, both the definitions and assumptions used by and within agencies for conducting environmental justice analyses can vary and the resulting demographic results can differ on a case-by-case basis. For example, this EIS and the Draft FRR SNF EIS present demographic characterizations derived from the same United States Census Bureau database, but these documents used different definitions and assumptions. Several of the same candidate interim SNF management sites were evaluated in both documents. As discussed in Appendix L, variations in these definitions and assumptions led to differences in the characterization of minority and low-income populations surrounding these potential interim SNF management sites. Nevertheless, although the characterizations differ, the impacts resulting from the proposed action under all alternatives present no significant risk to the population as a whole. Therefore, no disproportionately high and adverse effects would be expected for any particular segment of the population, including minority and low-income populations, regardless of which set of definitions and assumptions were applied.

6. LIST OF PREPARERS

This EIS was prepared under the supervision of the DOE Idaho Operations Office. The organizations and individuals who contributed to the preparation of this document are listed below accompanied by each person's project role and level of experience and training. Table 6-1 at the end of this section summarizes, for each contributor, the chapters of the EIS for which inputs were prepared.

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EIT, 1987, State of Washington
DoD Nuclear Fluid Systems Mechanical Engineering Qualification
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JD, 1985, University of New Mexico
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FEIS Analytical Lead - Consultations, Laws, Requirements

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Analytical Lead - Environmental Justice

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Years of Experience: 13
Analytical Lead-Occupational Health and Safety

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Analytical Lead-Traffic and Transportation, Transportation Accidents

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JD, 1989, Creighton University
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DEIS Analytical Lead—Consultations, Laws, and Requirements

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Analytical Lead-Land Use

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BS, 1977, Engineering, University of Iowa
MS, 1980, Mechanical Engineering, University of Nebraska
Years of Experience: 15
Volume 1 Decision Process

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Years of Experience: 16
Analytical Lead-Accident Analysis

Ralph W. Russell, Environmental Engineer
BS, 1970, Chemical Engineering, Texas A&M University
Years of Experience: 18
Analytical Lead-Air Resources, Air Quality

Roger Twitchell, Physical Scientist
BS, 1977, Botany, Weber State College
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Analytical Lead-Cultural Resources, Ecological Resources

C. Brooks Weingartner, Environmental Engineer
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Edward Gorczyca Environmental Scientist	BA, Chemistry Years of Experience: 10	Site Lead-Nevada Test Site
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Table 6-1. Contributors to Volume 1 of the DOE Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement.

	Chapter										Appendix											
Contributor	S	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K	L
Department of Energy																						
Thomas L. Wichmann	×	×	×	×		×					×	×	×	×	×	×				×	×	
Kathleen B. Whitaker	×	×	×	×			×	×	×													
Robert C. Stump	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×		×		
Mary V. Willcox	×	×	×	×	×	×					×	×	×	×	×	×			×	×	×	
Robert Brown											×	×	×	×	×	×						
Robert Creed, Jr.											×	×	×	×	×	×						×
Denise M. Glore								×														
Jan Hagers						×																×
John A. Herritt											×	×	×	×	×	×						
Mark W. Howard											×	×	×	×	×	×			×			
Vicki L. Johnson	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×		×	×	
Mary McKnight								×														
Paul Martin											×	×	×	×	×	×						
John E. Medema											×	×	×	×	×	×						
William A. Owca				×																		
Mark S. Pellechi											×	×	×	×	×	×						
Ralph W. Russell											×	×	×	×	×	×						
Roger Twitchell								×			×	×	×	×	×	×						
C. Brooks Weingartner											×	×	×	×	×	×						

Table 6-1. (continued).

Contributor	Chapter										Appendix											
	S	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K	L
Science Applications International Corporation																						
Dee H. Walker	×	×	×	×																×		
Barry Nichols	×	×	×	×		×													×	×	×	
Robert D. Thomson	×	×	×	×	×	×															×	
Ken Bulmahn				×	×	×														×		
Robert Cole				×		×		×	×													
Mark A. Dagel						×																
Sandy Enyeart						×																
Thomas D. Enyeart				×	×	×						×							×			
George A. Freund	×																					
R. Kingsley House											×	×	×		×							
Scot R. Imus					×	×																
Irene Johnson											×	×	×									
Robert A. Kelly	×	×	×	×	×	×															×	
Anne Lundahl						×																
Steven J. Maheras				×	×	×													×			
Diane Morton		×	×																			
Mark D. Otis						×																
Douglas Outlaw		×		×		×													×	×	×	
Howard Pippen						×													×			
Angela Sewall						×																
Donald C. Slaughterbeck						×					×	×	×	×	×	×						

Table 6-1. (continued).

Contributor	Chapter										Appendix											
	S	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K	L
Patricia Swain						×																
Jane Tallman						×													×			
Jeffrey Weiler					×		×	×	×								×	×				
Tom Wierman						×													×		×	
Price L. Worrell							×										×	×				
William Wuest						×	×															
Ecology and Environment, Inc.																						
Wendy Green								×														
Halliburton NUS																						
Robert Abernethy												×										
Edward Agoston													×									
Adel A. Bakr												×	×									
Fred R. Bingaman, III												×				×						
Teresa L. Brandt															×	×						
James T. Chaconas																×						
Steven J. Connor												×	×									
William J. Craig													×									
Karin Crandall													×									
James Cross																×						
James Doenges												×										
J. Peyton Doub																×						
Kevin S. Dunn																×						

Table 6-1. (continued).

Contributor	Chapter S	1	2	3	4	5	6	7	8	9	Appendix A	B	C	D	E	F	G	H	I	J	K	L
Alan A. Eckmyre													×									
Keven T. Folk																×						
Edward Gorczyca																×						
Lawrence L. Greenfield																×						
Kristine A. Gunther												×	×									
Ernest C. Harr, Jr.															×	×						
Richard H. Holder						×	×					×	×		×	×						
Dale T. Huls													×									
Kerry P. Humphrey																×						
William Hurt												×										
Merance A. Jacaruso																×						
Thomas L. Jentz															×							
Kathy A. Landkrohn																×						
Jasper G. Maltese																×						
Richard A. Martineit															×							
Kevin M. Meehan												×	×									
Louise S. Moore													×		×							
Philip R. Moore												×	×									
Aparajita S. Morrison												×										
John Nichols												×										
Richard S. Nugent													×									
David G. Olsen																×						
Richard F. Orthen, Jr.													×									

Table 6-1. (continued).

	Chapter										Appendix											
Contributor	S	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K	L
Ricky C. Petty																×						
Hans Renner															×							
John G. Ruff																×						
Julie B. Schilling																×						
Robert Schlegel																×						
Timothy J. Schott																×						
Julie A. Sechen																×						
Michael Septoff												×										
Ronald Smith													×									
Barry Sullivan																×						
Robin A. Summerhill																×						
Rao S. Tammara												×			×	×						
Alan L. Toblin																×						
Steven M. Varner																×						
Lata R. Venkateshwara																×						
Gilbert H. Waldman																×						
Robert H. Werth												×	×			×						
Pacific Northwest Laboratory																						
Rosanne L. Aabert											×											
John C. Abbott											×											
John M. Alvis, Jr.											×											
Larry K. Berg											×											

Table 6-1. (continued).

	Chapter										Appendix											
Contributor	S	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K	L
Frances M. Berting											×											
Charles A. Brandt											×											
Mitchel E. Cunningham											×											
Colbert E. Cusbing											×											
Phillip M. Daling											×											
James F. Donaghue											×											
Elizabeth A. Flores											×											
Stephen Gajewski											×											
Clifford S. Glantz											×											
Richard J. Guenther											×											
George V. Last											×											
John P. McDonald											×											
Emmett Moore											×											
Iral C. Nelson											×											
Ronald C. Phillips											×											
Kathleen Rhoads											×											
Chikashi Sato											×											
Dillard B. Shipler											×											
Donna J. Stucky											×											
Betty Tegner											×											
Gene Whelan											×											
Mona K. Wright											×											

Table 6-1. (continued).

Contributor	Chapter S	1	2	3	4	5	6	7	8	9	Appendix A	B	C	D	E	F	G	H	I	J	K	L
Naval Nuclear Propulsion Program																						
Donald P. Alf														×								
Donald P. Doherty														×								
Richard A. Guida	×	×	×	×	×	×	×	×	×		×			×			×	×	×	×	×	
Craig S. Hansen	×	×	×	×	×	×	×	×	×		×			×			×	×	×	×	×	
Raymond F. Kulbitskas														×								
Michael A. Kuprenas	×	×	×	×	×	×	×	×	×		×			×			×	×	×	×	×	
Lisa S. Megargle	×	×	×	×	×	×	×	×	×		×			×			×	×	×	×	×	
Barry K. Miles														×								
Andrew N. Richardson														×								
Jeffrey M. Steele														×								
Robert H. Steele														×								

7. CONSULTATIONS, LAWS, AND REQUIREMENTS

7.1 Laws and Requirements

This section identifies and summarizes the major laws, regulations, executive orders, and DOE orders that may apply to the programmatic alternatives for SNF.

Section 7.1.1 discusses the major Federal statutes that impose environmental protection and compliance requirements upon DOE. In addition, there may be other Federal, state, and local measures applicable to the SNF Management Program because Federal law delegates enforcement or implementation authority to state or local agencies. These state- and local-specific requirements are addressed in the site-specific appendices. Section 7.1.2 addresses environmentally-related presidential executive orders that clarify issues of national policy and set guidelines under which Federal agencies, including DOE, must act. DOE implements its responsibilities for protection of public health, safety, and the environment through a series of departmental orders that are mandatory for operating contractors of DOE facilities. Section 7.1.3 discusses those DOE orders related to environmental, health, and safety protection. Hazardous and radioactive materials transportation regulations are summarized in Section 7.1.4.

7.1.1 Federal Environmental Statutes and Regulations

National Environmental Policy Act of 1969, as amended (42 USC §4321 et seq.) The National Environmental Policy Act establishes a national policy promoting awareness of the environmental consequences of the activity of humans on the environment and promoting consideration of the environmental impacts during the planning and decisionmaking stages of a project. The National Environmental Policy Act requires all agencies of the Federal Government to prepare a detailed statement on the environmental effects of proposed major Federal actions that may significantly affect the quality of the human environment.

This EIS has been prepared in response to these National Environmental Policy Act requirements and policies. It discusses reasonable alternatives and their potential environmental consequences of proposed SNF activities at various locations in the country and has been prepared in accordance with the Council on Environmental Quality Regulations for implementing the procedural provisions of the National Environmental Policy Act Implementing Procedures (40 CFR Parts 1500 through 1508) and DOE National Environmental Policy Act Implementing Procedures (10 CFR Part 1021).

Atomic Energy Act of 1954, as amended (42 USC §2011 et seq.). The Atomic Energy Act of 1954 authorizes DOE to establish standards to protect health or minimize dangers to life or property with respect to activities under its jurisdiction. Through a series of DOE orders, DOE has established an extensive system of standards and requirements to ensure safe operation of its facilities.

The Atomic Energy Act and the Reorganization Plan No. 3 of 1970 [5 USC (app. at 1343)] and other related statutes gave the U.S. Environmental Protection Agency responsibility and authority for developing generally applicable environmental standards for protection of the general environment from radioactive material. The U.S. Environmental Protection Agency has promulgated several regulations under this authority, among which are the Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes, at 40 CFR Part 191.

Nuclear Waste Policy Act of 1982, as amended, (42 USC §10101-10270). The Act authorizes the Federal agencies to develop a geologic repository for the permanent disposal of SNF and high-level radioactive waste. The Act specifies the process for selecting a repository site and constructing, operating, closing, and decommissioning the repository. The Act also establishes programmatic guidance for these activities.

Clean Air Act, as amended (42 USC §7401 et seq.). The Clean Air Act, as amended, is intended to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." Section 118 of the Clean Air Act, as amended, requires that each Federal agency, such as DOE, with jurisdiction over any property or facility that might result in the discharge of air pollutants, comply with "all Federal, state, interstate, and local requirements" with regard to the control and abatement of air pollution.

The Act requires the U.S. Environmental Protection Agency to establish National Ambient Air Quality Standards as necessary to protect public health, with an adequate margin of safety, from any known or anticipated adverse effects of a regulated pollutant (42 USC §7409). The Act also requires establishment of national standards of performance for new or modified stationary sources of atmospheric pollutants (42 USC §7411) and requires specific emission increases to be evaluated so as 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 U.S. Environmental Protection Agency in 40 CFR Parts 50 through 99. In particular, radionuclide emissions and hazardous air pollutants are regulated under the National Emission Standard for Hazardous Air Pollutants Program (see 40 CFR Part 61 and 40 CFR Part 63).

Safe Drinking Water Act, as amended [42 USC §300 (F) et seq.]. The primary objective of the Safe Drinking Water Act, as amended, is to protect the quality of the public water supplies and all sources of drinking water. The implementing regulations, administered by the U.S. Environmental Protection Agency unless delegated to the states, establish standards applicable to public water systems. They promulgate maximum contaminant levels, including those for radioactivity, in public water systems, which are defined as public water systems that serve at least 15 service connections used by year-round residents or regularly serve at least 25 year-round residents. Safe Drinking Water Act requirements have been promulgated by the U.S. Environmental Protection Agency in 40 CFR Parts 100 through 149. For radionuclides, the regulations in effect now specify that the average annual concentration of beta particle and photon radioactivity from manmade radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 0.004 rem (4 millirem)/year. The maximum contaminant level for gross alpha particle activity is 15 picocuries per liter. The U.S. Environmental Protection Agency proposed revisions to limits on regulating radionuclides July 18, 1991. The proposed rule has not been finalized. For purposes of analysis, however, the more conservative standards were used. Other programs established by the Safe Drinking Water Act include the Sole Source Aquifer Program, the Wellhead Protection Program, and the Underground Injection Control Program.

Clean Water Act, as amended (33 USC §1251 et seq.). The Clean Water Act, which amended the Federal Water Pollution Control Act, was enacted to "restore and maintain the chemical, physical and biological integrity of the Nation's water." The Clean Water Act prohibits the "discharge of toxic pollutants in toxic amounts" to navigable waters of the United States. Section 313 of the Clean Water Act, as amended, 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 Clean Water Act supplies guidelines and limitations for effluent discharges from point-source discharges and provides authority for the U.S. Environmental Protection Agency to implement the National Pollutant Discharge Elimination System permitting program. The National Pollutant Discharge Elimination System program is administered by the Water Management Division of the U.S. Environmental Protection Agency pursuant to regulations in 40 CFR Part 122 et seq. Idaho has not applied for National Pollutant Discharge Elimination System authority from the U.S. Environmental Protection Agency. Thus, all National Pollutant Discharge Elimination System permits required for the Idaho National Engineering Laboratory are obtained by DOE through the U.S. Environmental Protection Agency Region 10 (40 CFR Part 122 et seq.).

Sections 401 and 405 of the Water Quality Act of 1987 added Section 402(p) to the Clean Water Act. Section 402(p) requires that the Environmental Protection Act establish regulations for issuing permits for stormwater discharges associated with industrial activity. Stormwater discharges associated with industrial activity are permitted through the National Pollutant Discharge Elimination System. General Permit requirements are published at 40 CFR Part 122.

Resource Conservation and Recovery Act, as amended (42 USC §6901 et seq.). The treatment, storage, or disposal of hazardous and nonhazardous waste is regulated under the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act and the Hazardous and Solid Waste Amendments of 1984. Pursuant to Section 3006 of the Act, any state that seeks to administer and enforce a hazardous waste program pursuant to the Resource Conservation and Recovery Act may apply for U.S. Environmental Protection Agency authorization of its program. The U.S. Environmental Protection Agency regulations implementing the Resource Conservation and Recovery Act are found in 40 CFR Parts 260 through 280. These regulations define hazardous wastes and specify hazardous waste transportation, handling, treatment, storage, and disposal requirements.

The regulations imposed on a generator or a treatment, storage, and/or disposal facility vary according to the type and quantity of material or waste generated, treated, stored, and/or disposed of. The method of treatment, storage, and/or disposal also impacts the extent and complexity of the requirements (see also Section 7.2.5).

Comprehensive Environmental Response, Compensation, and Liability Act, as amended (42 USC §9601 et seq.). The Comprehensive Environmental Response, Compensation, and Liability Act, as amended, provides a statutory framework for the cleanup of waste sites containing hazardous substances and—as amended by the Superfund Amendments and Reauthorization Act—provides an emergency response program in the event of a release (or threat of a release) of a hazardous substance to the environment. Using the Hazard Ranking System, Federal and private sites are ranked and may be included on the National Priorities List. The Comprehensive Environmental Response, Compensation, and Liability Act, as amended, requires such Federal facilities having such sites to undertake investigations and remediation as necessary. The Act also includes requirements for reporting releases of certain hazardous substances in excess of specified amounts to state and Federal agencies.

Emergency Planning and Community Right-to-Know Act of 1986 (42 USC §11001 et seq.) (also known as "SARA Title III"). Under Subtitle A of this Act, Federal facilities, including those owned by DOE, provide various information (such as inventories of specific chemicals used or stored and releases that occur from these sites) to the State Emergency Response Commission and to the Local Emergency Planning Committee to ensure that emergency plans are sufficient to respond to unplanned releases of hazardous substances. Implementation of the provisions of this Act began voluntarily in 1987, and inventory and annual emissions reporting began in 1988 based on 1987 activities and information. DOE also requires compliance with Title III as matter of Agency policy. The requirements for this Act were promulgated by the U.S. Environmental Protection Agency in 40 CFR Parts 350 through 372.

Toxic Substances Control Act (15 USC §2601 et seq.). The Toxic Substances Control Act provides the U.S. Environmental Protection Agency with the authority to require testing of chemical substances, both new and old, entering the environment, and regulates them where necessary. The law complements and expands existing toxic substance laws such as §112 of the Clean Air Act and §307 of the Clean Water Act. The Toxic Substances Control Act came about because there were no general Federal regulations for the potential environmental or health effects of the thousands of new chemicals developed each year before they were introduced into the public or commerce. The Toxic Substances Control Act also regulates the treatment, storage, and disposal of certain toxic substances, specifically polychlorinated biphenyls, chlorofluorocarbons, asbestos, dioxins, certain metal-working fluids, and hexavalent chromium. The asbestos regulations under the Toxic Substances Control Act were ultimately overturned. However, regulations pertaining to asbestos removal, storage, and disposal are promulgated through the National Emission Standard for Hazardous Air Pollutants Program (40 CFR Part 61, Subpart M). For chlorofluorocarbons, Title VI of the Clean Air Act Amendments of 1990 requires a reduction of chlorofluorocarbons beginning 1991, and prohibits production beginning 2000.

Pollution Prevention Act of 1990 (42 USC §13101 et seq.). The Pollution Prevention Act of 1990 establishes a national policy for waste management and pollution control that focuses first on source reduction, followed sequentially by environmentally safe recycling, treatment, and lastly, disposal. Disposal or releases to the environment should only occur as a last resort. In response, DOE has committed to participation in the Superfund Amendments and Reauthorization Act Section 313, U.S. Environmental Protection Agency 33/50 Pollution Prevention Program. The goal, for facilities already involved in Section 313 compliance, is to achieve a 33 percent reduction in the release of 17 priority chemicals by 1997, from a 1993 baseline. On August 3, 1993, Executive Order 12856 was issued, expanding the 33/50 program such that DOE must reduce its total releases of all toxic chemicals by 50 percent by December 31, 1999. The DOE is also requiring each DOE site to establish site-specific goals to reduce generation of all waste types.

Federal Facility Compliance Act. The Federal Facility Compliance Act, enacted on October 6, 1992, waives sovereign immunity for fines and penalties for Resource Conservation and Recovery Act violations at Federal facilities. However, a provision postpones fines and penalties after 3 years for mixed waste storage prohibition violations at DOE sites and requires DOE to prepare plans for developing the required treatment capacity for mixed waste stored or generated at each facility. Each plan must be approved by the host state or the U.S. Environmental Protection Agency, after consultation with other affected states, and a consent order must be issued by the regulator requiring compliance with the plan. The Federal Facility Compliance Act further provides that the DOE will not be subject to fines and penalties for land disposal restriction storage prohibition violations for mixed waste as long as it is in compliance with such an approved plan and consent order and meets all other applicable regulations.

National Historic Preservation Act, as amended (16 USC §470 et seq.). The National Historic Preservation Act, as amended, provides that sites with significant national historic value be placed on the *National Register of Historic Places*. There are no permits or certifications required under the Act. However, if a particular Federal activity may impact a historic property resource, consultation with the Advisory Council on Historic Preservation will generally generate a Memorandum of Agreement, including stipulations that must be followed to minimize adverse impacts. Coordinations with the State Historic Preservation officer are also undertaken to ensure that potentially significant sites are properly identified and appropriate mitigative actions are implemented.

Archaeological Resource Protection Act, as amended (16 USC §470aa et seq.). This Act requires a permit for any excavation or removal of archaeological resources from public or Indian lands. Excavations must be undertaken for the purpose of furthering archaeological knowledge in the public interest, and resources removed are to remain the property of the United States. Consent must be obtained from the Indian tribe owning lands on which a resource is located before issuance of a permit, and the permit must contain terms or conditions requested by the tribe.

Native American Grave Protection and Repatriation Act of 1990 (25 USC §3001). This law directs the Secretary of Interior to guide responsibilities in repatriation of Federal archaeological collections and collections held by museums receiving Federal funding that are culturally affiliated to Native American tribes. Major actions to be taken under this law include (a) establishing a review committee with monitoring and policy-making responsibilities, (b) developing regulations for repatriation, including procedures for identifying lineal descent or cultural affiliation needed for claims, (c) oversight of museum programs designed to meet the inventory requirements and deadlines of this law, and (d) developing procedures to handle unexpected discoveries of graves or grave goods during activities on Federal or tribal land.

American Indian Religious Freedom Act of 1978 (42 USC §1996). This act reaffirms Native American religious freedom under the First Amendment and sets United States policy to protect and preserve the inherent and constitutional right of American Indians to believe, express, and exercise their traditional religions. The act requires that Federal actions avoid interfering with access to sacred locations and traditional resources that are integral to the practice of religions.

Religious Freedom Restoration Act of 1993 (42 USC §2000bb et seq.). This Act prohibits the Government, including Federal departments, from substantially burdening the exercise of religion unless the Government demonstrates a compelling governmental interest and the action furthers a compelling Government interest and is the least restrictive means of furthering that interest.

Endangered Species Act, as amended (16 USC §1531 et seq.). The Endangered Species Act, as amended, 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. Departments of Commerce and the Interior. Section 7 of the Act requires consultation with the U.S. Fish and Wildlife Service to determine whether endangered and threatened species or their critical habitats are known to be in the vicinity of the proposed action.

Migratory Bird Treaty Act, as amended (16 USC §703 et seq.). The Migratory Bird Treaty Act, as amended, is intended to protect birds that have common migration patterns between the

United States and Canada, Mexico, Japan, and Russia. It regulates the harvest of migratory birds by specifying things such as the mode of harvest, hunting seasons, and bag limits. The Act stipulates that it is unlawful at any time, by any means, or in any manner to "kill . . . any migratory bird." Although no permit for this project is required under the Act, DOE is required to consult with the U.S. Fish and Wildlife Service regarding impacts to migratory birds and to evaluate ways to avoid or minimize these effects in accordance with the U.S. Fish and Wildlife Service Mitigation Policy.

Bald and Golden Eagle Protection Act, as amended (16 USC §668-668d). The Bald and Golden Eagle Protection Act makes it unlawful to take, pursue, molest, or disturb bald (American) and golden eagles, their nests, or their eggs anywhere in the United States (Section 668, 668c). A permit must be obtained from the U.S. Department of the Interior to relocate a nest that interferes with resource development or recovery operations.

Wild and Scenic Rivers Act, as amended (16 USC 1271 et seq. 71:8301 et seq.). The Wild and Scenic Rivers Act, as amended, protects certain selected rivers of the Nation, which possess outstanding scenic, recreational, geological, fish and wildlife, historical, cultural, or other similar values. These rivers are to be preserved in a free-flowing condition to protect water quality and other vital national conservation purposes. The purpose of the Act is to institute a national wild and scenic rivers system, to designate the initial rivers that are a part of that system, and to develop standards for the addition of new rivers in the future.

Occupational Safety and Health Act of 1970, as amended (29 USC §651 et seq.). The Occupational Safety and Health Act establishes standards to enhance safe and healthful working conditions in places of employment throughout the United States. The Act is administered and enforced by the Occupational Safety and Health Administration, a U.S. Department of Labor agency. While the Occupational Safety and Health Administration and the U.S. Environmental Protection Agency both have a mandate to reduce exposures to toxic substances, the Occupational Safety and Health Administration's jurisdiction is limited to safety and health conditions that exist in the workplace environment. In general, under the Act, it is the duty of each employer to furnish all employees a place of employment free of recognized hazards likely to cause death or serious physical harm. Employees have a duty to comply with the occupational safety and health standards and all rules, regulations, and orders issued under the Act. Occupational Safety and Health Administration regulations (published in Title 29 of the Code of Federal Regulations) establish specific standards telling employers what must be done to achieve a safe and healthful working environment. DOE places emphasis on compliance with these regulations at DOE facilities and prescribes through DOE orders the Occupational Safety and Health Act standards that contracts shall meet, as applicable to their work at Government-owned, contractor-operated facilities (DOE Order 5480.1B, 5483.1A). DOE keeps and makes available the various records of minor illnesses, injuries, and work-related deaths as required by Occupational Safety and Health Administration regulations.

Noise Control Act of 1972, as amended (42 USC §4901 et seq.). Section 4 of the Noise Control Act of 1972, as amended, directs all Federal agencies to carry out "to the fullest extent within their authority" programs within their jurisdictions in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health and welfare.

7.1.2 Executive Orders

Executive Order 12088 (Federal Compliance with Pollution Control Standards) (October 13, 1978), as amended by Executive Order 12580 (January 23, 1987) Federal Compliance with Pollution Control Standards, directs Federal agencies, including DOE, to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the Clean Air Act, the Noise Control Act, the Clean Water Act, the Safe Drinking Water Act, the Toxic Substances Control Act (15 USC §2061 et seq.), and the Resource Conservation and Recovery Act.

Executive Order 11593 (National Historic Preservation) (May 13, 1971) directs Federal agencies, including DOE, to locate, inventory, and nominate properties under their jurisdiction or control to the *National Register of Historic Places* if those properties qualify. This process requires DOE to provide the Advisory Council on Historic Preservation the opportunity to comment on the possible impacts of the proposed activity on any potential eligible or listed resources.

Executive Order 11514 (National Environmental Policy Act) directs Federal agencies to continually monitor and control their activities to protect and enhance the quality of the environment and to develop procedures to ensure that fullest practicable provision of timely public information and understanding of the Federal plans and programs with environmental impact to obtain the views of interested parties. The DOE has issued regulations (10 CFR Part 1021) and DOE Order 5440.1E for compliance with this executive order.

Executive Order 11988 (Floodplain Management) directs Federal agencies to establish procedures to ensure that the potential effects of flood hazards and floodplain management are considered for any action undertaken in a floodplain and that floodplain impacts be avoided to the extent practicable.

Executive Order 11990 (Protection of Wetlands) directs governmental agencies to avoid, to the extent practicable, any short- and long-term adverse impacts on wetlands wherever there is a practicable alternative.

Executive Order 12344 (Naval Nuclear Propulsion Program) [enacted as permanent law by Public Law 98-525 (42 USC §7158)] prescribes the authority and responsibility of the Naval Nuclear Propulsion Program, a joint Navy/DOE organization, for matters pertaining to Naval nuclear propulsion. These responsibilities include all environmental and occupational safety and health aspects of the program.

Executive Order 12580 (Superfund Implementation) delegates to the heads of executive departments and agencies the responsibility for undertaking remedial actions for releases, or threatened releases that are not on the National Priority List and removal actions other than emergencies where the release is from any facility under the jurisdiction or control of executive departments and agencies.

Executive Order 12856 (Right to Know Laws and Pollution Prevention Requirements) This order directs all Federal agencies to reduce and report toxic chemicals entering any wastestream; improve emergency planning, response, and accident notification; and encourage clean technologies and testing of innovative prevention technologies. The executive order also provides that Federal agencies are persons for purposes of the Emergency Planning and Community Right-to-Know Act (SARA Title III), which obliges agencies to meet the requirements of the Act.

Executive Order 12898 (Environmental Justice) This order directs Federal agencies to achieve environmental justice by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions. The order creates an Interagency Working Group on Environmental Justice and directs each Federal agency to develop strategies within prescribed time limits to identify and address environmental justice concerns. The order further directs each Federal agency to collect, maintain, and analyze information on the race, national origin, income level, and other readily accessible and appropriate information for areas surrounding facilities or sites expected to have a substantial environmental, human health, or economic effect on the surrounding populations, when such facilities or sites become the subject of a substantial Federal environmental administrative or judicial action and to make such information publicly available.

Executive Order 12114 (Environmental Effects Abroad of Major Federal Actions) This order declares that Federal agencies are required to prepare environmental analyses for "major Federal actions significantly affecting the environment of the global commons outside the jurisdiction of any nation (e.g., the ocean or Antarctica)." According to the Executive Order, major Federal actions significantly affecting the environment of foreign countries may also require environmental analyses under certain circumstances. The procedural requirements imposed by the Executive Order are analogous to those under the National Environmental Policy Act.

7.1.3 Department of Energy Regulations and Orders

Through the authority of the Atomic Energy Act, DOE is responsible for establishing a comprehensive health, safety, and environmental program for its facilities. The regulatory mechanisms through which DOE manages its facilities are the promulgation of regulations and the issuance of DOE orders.

The DOE regulations are generally found in Title 10 of the Code of Federal Regulations. These regulations address such areas as energy conservation, administrative requirements and procedures, nuclear safety, and classified information. For purposes of this EIS, relevant regulations include 10 CFR Part 820, Procedures for DOE Nuclear Activities; 10 CFR Part 830.120, Quality Assurance; 10 CFR Part 834, Radiation Protection of the Public and the Environment (proposed); 10 CFR Part 835, Occupational Radiation Protection; 10 CFR Part 1021, Compliance with the National Environmental Policy Act; and 10 CFR Part 1022, Compliance with Floodplains/Wetlands Environmental Review Requirements.

DOE orders generally set forth policy and the programs and internal procedures for implementing those policies. The major DOE orders pertaining to the eventual construction and operation of SNF facilities within the DOE Complex are listed in Table 7-1. The following sections provide a brief discussion of selected orders:

DOE Order 5440.1E, National Environmental Policy Act Compliance Program. This order establishes authorities and responsibilities of DOE officials and sets forth internal procedures for implementing the National Environmental Policy Act. This order was issued by DOE on November 10, 1992.

DOE Order 5480.1B, Environment Safety and Health Program for Department of Energy Operations. This order establishes the Environment, Safety and Health Program for DOE operations.

7.1.4 Hazardous and Radioactive Materials Transportation Regulations

Transportation of hazardous and radioactive materials, substances, and wastes are governed by the U.S. Department of Transportation, U.S. Nuclear Regulatory Commission, and U.S. Environmental Protection Agency regulations. These regulations may be found in 49 CFR Parts 171 through 178, 49 CFR Parts 383 through 397, 10 CFR Part 71, and 40 CFR Part 262, respectively.

U.S. Department of Transportation regulations contain requirements for identifying a material as hazardous or radioactive. These regulations interface with those of the U.S. Nuclear Regulatory Commission or U.S. Environmental Protection Agency regulations for identifying material, but the U.S. Department of Transportation hazardous material regulations govern the hazard communication (such as marking, hazard labelling, vehicle placarding, and emergency response telephone number) and shipping requirements (such as required entries on shipping papers or U.S. Environmental Protection Agency waste manifests).

Table 7-1. DOE orders relevant to the DOE Spent Nuclear Fuel Management Program.

DOE Order	Subject
1300.2A	Department of Energy Technical Standards Program (5-19-92)
1360.2B	Unclassified Computer Security Program (5-18-92)
1540.2	Hazardous Material Packaging for Transport-Administrative Procedures (9-30-86; Chg. 1, 12-19-88)
3790.1B	Federal Employee Occupational Safety and Health Program (1-7-93)
4330.4B	Maintenance Management Program (2-10-94)
4700.1	Project Management System (3-6-87; Chg. 1, 6-2-92)
5000.3B	Occurrence Reporting and Processing of Operations Information (1-19-93; Chg. 1, 7-2-93)
5400.1	General Environmental Protection Program (11-9-88; Chg. 1, 6-29-90)
5400.2A	Environmental Compliance Issue Coordination (1-31-89; Chg.1, 1-7-93)
5400.4	Comprehensive Environmental Response, Compensation, and Liability Act Requirements (10-6-89)
5400.5	Radiation Protection of the Public and the Environment (2-8-90; Chg. 2, 1-7-93)
5440.1E	National Environmental Policy Act Compliance Program (11-10-92)
5480.1B	Environment, Safety and Health Program for DOE Operations (9-23-86; Chg. 5, 5-10-93)
5480.3	Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes (7-9-85)
5480.4	Environmental Protection, Safety, and Health Protection Standards (5-15-84; Chg. 4, 1-7-93)
5480.6	Safety of Department of Energy-Owned Nuclear Reactors (09-23-86)
5480.7A	Fire Protection (2-17-93)
5480.8A	Contractor Occupational Medical Program (6-26-92; Chg. 1, 10-19-92)
5480.9A	Construction Project Safety and Health Management (4-13-94)
5480.10	Contractor Industrial Hygiene Program (6-26-85)
5480.11	Radiation Protection for Occupational Workers (12-21-88; Chg. 3, 6-17-92)
5480.15	Department of Energy Laboratory Accreditation Program for Personnel Dosimetry (12-14-87)
5480.17	DOE Site Safety Representatives (10-05-88)
5480.18B	Nuclear Facility Training Accreditation Program (08-31-94)
5480.19	Conduct of Operations Requirements for DOE Facilities (7-9-90; Chg. 1, 5-18-92)

Table 7-1. (continued).

DOE Order	Subject
5480.20	Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Nonreactor Nuclear Facilities (2-20-91; Chg. 1, 6-19-91)
5480.21	Unreviewed Safety Questions (12-24-91)
5480.22	Technical Safety Requirements (2-25-92; Chg. 1, 9-15-92)
5480.23	Nuclear Safety Analysis Reports (4-30-92; Chg. 1, 3-10-94)
5480.24	Nuclear Criticality Safety (8-12-92)
5480.28	Natural Phenomena Hazards Mitigation (1-15-93)
5480.31	Startup and Restart of Nuclear Facilities (9-15-93)
5481.1B	Safety Analysis and Review System (9-23-86; Chg. 1, 5-19-87)
5482.1B	Environment, Safety, and Health Appraisal Program (9-23-86; Chg. 1, 11-18-91)
5483.1A	Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned, Contractor-Operated Facilities (6-22-83)
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements (2-21-81; Chg. 7, 10-17-90)
5500.1B	Emergency Management System (4-30-91; Chg. 1, 2-27-92)
5500.2B	Emergency Categories, Classes, and Notification and Reporting Requirements (4-30-91; Chg. 1, 2-27-92)
5500.3A	Planning and Preparedness for Operational Emergencies (4-30-91; Chg. 1, 2-27-92)
5500.4A	Public Affairs Policy and Planning Requirements for Emergencies (6-8-92)
5500.7B	Emergency Operating Records Protection Program (10-23-91)
5500.10	Emergency Readiness Assurance Program (4-30-91; Chg. 1, 2-27-92)
5630.11B	Safeguards and Security Program (8-2-94)
5630.12A	Safeguards and Security Inspection and Assessment Program (6-23-92)
5700.6C	Quality Assurance (8-21-91)
5820.2A	Radioactive Waste Management (9-26-88)
6430.1A	General Design Criteria (4-6-89)

U.S. Nuclear Regulatory Commission regulations applicable to radioactive materials transportation are found in 10 CFR Part 71, which includes detailed packaging design requirements and package certification testing requirements. Complete documentation of design and safety analysis and results of the required testing is submitted to the U.S. Nuclear Regulatory Commission to certify the package for use. This certification testing involves the following components: heat, physical drop onto an unyielding surface, water submersion, puncture by dropping package onto a rigid spike, and gas tightness. Some of the required tests simulate maximum reasonably foreseeable accident conditions.

U.S. Environmental Protection Agency regulations pertaining to hazardous waste transportation are found in 40 CFR Part 262. These regulations deal with the use of the U.S. Environmental Protection Agency waste manifest, which is the shipping paper for transporting Resource Conservation and Recovery Act hazardous waste.

7.1.5 Applicability of the Resource Conservation and Recovery Act to Spent Nuclear Fuel

Historically, DOE chemically reprocessed SNF to recover valuable products and fissionable materials, and as such, the SNF was not a solid waste under the Resource Conservation and Recovery Act.

World events have resulted in significant changes in DOE's direction and operations. In particular, in April 1992 DOE announced the phase-out of reprocessing for the recovery of special nuclear materials. With these changes, DOE's focus on most of its SNF has changed from reprocessing and recovery of materials to storage and ultimate disposition. This in turn has created uncertainty in regard to the regulatory status of some of DOE's SNF relative to the Resource Conservation and Recovery Act.

DOE has initiated discussion with the U.S. Environmental Protection Agency on the potential applicability of the Resource Conservation and Recovery Act to SNF. Further discussions with U.S. Environmental Protection Agency Headquarters and regional offices and state regulators are ongoing to develop a path forward toward meeting any Resource Conservation and Recovery Act requirements that might apply.

7.2 Consultation

The National Environmental Policy Act requires that Federal, state, and local agencies with jurisdiction or special expertise regarding any environmental impact be consulted and involved in the National Environmental Policy Act process. Agencies involved include those with authority to issue applicable permits, licenses, and other regulatory approvals, as well as those responsible for protecting significant resources (for example, endangered species, critical habitats, or historic resources). These agencies will be sent copies of the Final EIS.

Consultations with Federal and state agencies and native America tribes were initiated by DOE. Table 7-2 shows the dates and locations of the meetings held. Volume 2, Appendix B, contains meeting correspondence generated as a result of these meetings.

Table 7-2. Meetings held in response to agency or nation comments on the Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Draft Environmental Impact Statement.

Agency or nation	Location	Date
Defense Nuclear Facilities Safety Board	Washington, D.C.	November 9, 1994
U.S. Environmental Protection Agency	Washington, D.C.	December 15, 1994
Center for Disease Control	Conference call	November 22, 1994
Council on Environmental Quality	Washington, D.C.	December 21, 1994
Seneca Nation of New York	New York	January 10, 1995
Shoshone-Bannock Tribes of Idaho	Fort Hall, Idaho	December 2,21, and 29, 1994 January 10, 1995 February 13, 1995

8. INDEX

Subjects are indexed by section, figure, table, and appendix designations only.

-D-

-E-

-F-

-G-

-T-

-U-

-V-, -W-

-X-, -Y-, -Z-

no entries

9. REFERENCES

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Appendix A: Hanford Site Spent Nuclear Fuel Management Program

(under separate cover)

Appendix B: Idaho National Engineering Laboratory Spent Nuclear Fuel Management Program

(under separate cover)

Appendix C: Savannah River Site Spent Nuclear Fuel Managment Program

(under separate cover)

Appendix D: Naval Spent Nuclear Fuel Management

(under separate cover)

Appendix E: Spent Nuclear Fuel Management Programs at Other Generator/Storage Locations

(under separate cover)

Appendix F: Nevada Test Site and Oak Ridge Reservation Spent Nuclear Fuel Management Programs

(under separate cover)

Appendix G
Acronyms/Abbreviations

CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EA	environmental assessment
ECF	Expended Core Facility
EIS	Environmental Impact Statement
HS	Hanford Site
INEL	Idaho National Engineering Laboratory
MEI	maximally exposed individiual
MTHM	metric tons of heavy metal
NNPP	Naval Nuclear Propulsion Program
NTS	Nevada Test Site
ORR	Oak Ridge Reservation
PEIS	Programmatic Environmental Impact Statement
PUREX	Plutonium Uranium Extraction
SNF	spent nuclear fuel
SRS	Savannah River Site
TRIGA	training, research, and isotope reactors built by General Atomics

Appendix H
Glossary

Terms in this glossary are defined based on the context in which they are used in this EIS.

100-year flood A flood event of such magnitude it occurs, on average, every 100 years (equates to a 1 percent probability of occurring in any given year).

500-year flood A flood event of such magnitude it occurs, on average, every 500 years (equates to a 0.2 percent probability of occurring in any given year).

abnormal condition Any deviation from normal conditions.

accident An unplanned sequence of events that results in undesirable consequences.

actinide Any of a series of chemically similar, mostly synthetic, radioactive elements with atomic numbers ranging from actinium-89 through lawrencium-103.

alpha-emitter A radioactive substance that decays by releasing an alpha particle.

alpha-low-level waste Waste that was previously classified as transuranic waste but has a transuranic concentration lower than the currently established limit for transuranic waste. Low-level waste requires additional controls and special handling. This waste stream cannot be accepted for onsite disposal under the current waste acceptance criteria; therefore, it is special-case waste.

alpha particle A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus that has a mass number of 4 and an electrostatic charge of +2.

as low as reasonably achievable (ALARA) A process by which a graded approach is applied to maintaining dose levels to workers and the public, and releases of radioactive materials to the environment as low as reasonably achievable.

atomic number The number of positively charged protons in the nucleus of an atom and the number of electrons on an electrically neutral atom.

background radiation Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material), and global fallout as it exists in the environment from the testing of nuclear explosive devices.

baseline For purposes of this EIS, the conditions projected to exist in June 1995, the scheduled date for the Record of Decision, against which the environmental consequences of the various alternatives are evaluated.

beta-emitter A radioactive substance that decays by releasing a beta particle.

beta particle A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron.

boiling water reactor A type of nuclear reactor that uses fission heat to generate steam in the reactor to drive turbines and generate electricity.

breeder reactor A type of nuclear reactor that creates more fissionable fuel than it uses.

by-product material (a) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material, and (b) the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content [Atomic Energy Act 11(e)]. By-product material is exempt from regulation under the Resource Conservation and Recovery Act.

calcination The process of converting high-level waste to unconsolidated granules or powder (also called calcining).

calcine The material produced by a calcination.

canning The process of placing spent nuclear fuel in canisters to retard corrosion, contain radioactive releases, or control geometry.

capable fault In part, a capable fault is one that may have had movement at or near the ground surface at least once within the past 35,000 years, or has had recurring movement within the past 500,000 years. Further definition can be found in 10 CFR 100, Appendix A.

characterization The determination of waste composition and properties, whether by review of process knowledge, nondestructive examination or assay, or sampling and analysis, generally done for the purpose of determining appropriate storage, treatment, handling, transport, and disposal requirements.

cladding The outer jacket of fuel elements and targets usually made of aluminum, stainless steel, or zirconium alloy, used to prevent fuel corrosion and retain fission products during reactor operation, or to prevent releases into the environment during storage.

co-located workers Workers in a fixed population outside the day-to-day process safety management controls of a given facility area. In practice, this fixed population is normally the workers at an independent facility area located some distance from the reference facility area.

committed dose equivalent (H_{50}) The dose equivalent to organs or tissues of reference that will be received from an intake of radioactive material by an individual during the 50-year period following the intake. The International Commission on Radiological Protection defines this as the committed equivalent dose.

committed effective dose equivalent ($H_{E,50}$) The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues. The International Commission on Radiological Protection defines this as the committed effective dose.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) A Federal law (also known as "Superfund") that provides a comprehensive framework to deal with past or abandoned hazardous materials. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) provides for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment that could endanger public health, welfare, or the environment, as well as the cleanup of inactive hazardous waste disposal sites. CERCLA has jurisdiction over any release or threatened release of any "hazardous substance" to the environment. Under CERCLA, the definition of "hazardous" is much broader than under the Resource Conservation and Recovery Act, and the hazardous substance need not be a waste. If a site meets the CERCLA requirements for designation, it is ranked along with other "Superfund" sites and listed on the National Priorities List. This ranking and listing is the U.S. Environmental Protection Agency's way of determining which sites have the highest priority for cleanup.

contact-handled waste Packaged waste whose external surface dose rate does not exceed 200 millirem per hour.

contamination The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.

coolant A gas or liquid circulated through a nuclear reactor to remove or transfer heat.

core The central portion of a nuclear reactor containing the fuel elements, moderator, neutron poisons, and support structures.

curie (Ci) The basic unit used to describe the intensity of radioactivity in a sample of material. The curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium. A curie is also a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second.

decay, radioactive The decrease in the amount of any radioactive material with the passage of time, due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, often accompanied by gamma radiation (see half-life, radioactive).

decommissioning The process of removing a facility from operation, followed by decontamination, entombment, dismantlement, or conversion to another use.

decontamination The actions taken to reduce or remove substances that pose a substantial present or potential hazard to human health or the environment, such as radioactive contamination from facilities, soil, or equipment by washing, chemical action, mechanical cleaning, or other techniques.

degraded (spent nuclear fuel) Spent nuclear fuel whose external cladding has cracked, pitted, corroded, or potentially allows the leakage of radioactive materials.

DOE orders Requirements internal to the U.S. Department of Energy (DOE) that establish DOE policy and procedures, including those for compliance with applicable laws.

DOE site boundary A geographic boundary within which public access is controlled and activities are governed by the U.S. Department of Energy (DOE) and its contractors, not by local authorities. Based on the definition of exclusion zone, a public road traversing a DOE site is considered to be within the DOE site boundary if DOE or the site contractor has the capability to control the road at any time necessary.

dosage The concentration-time profile for exposure to toxicological hazards.

dose (or radiation dose) A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined elsewhere in this glossary.

driver fuel These fuel tubes or assemblies usually contain enriched uranium, plutonium, or thorium materials, which can be fissioned (or split) by neutrons. Because this fuel drives neutron bombardment of targets in a production or research reactor, these fuels are called drivers.

dry storage Storage of spent nuclear fuel in environments where the fuel is not immersed in liquid for purposes of cooling and/or shielding.

effective dose equivalent (EDE) The sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated. It includes the dose from radiation sources internal and/or external to the body and is expressed in units of rem. The International Commission on Radiation Protection defines this as the effective dose.

enriched uranium Uranium that has greater amounts of the fissionable isotope uranium-235 than occurs naturally. Naturally occurring uranium is 0.72 percent uranium-235.

environmental monitoring The process of sampling and analysis of environmental media in and around a facility being monitored for the purpose of (a) confirming compliance with performance objectives, and (b) early detection of any contamination entering the environment to facilitate timely remedial action.

existing facilities Facilities that are projected to exist as of the Record of Decision for this EIS, scheduled for June 1995.

external accident Accidents initiated by manmade energy sources not associated with operation of a given facility. Examples include airplane crashes, induced fires, transportation accidents adjacent to a facility, and so forth.

facility worker Any worker whose day-to-day activities are controlled by process safety management programs and a common emergency response plan associated with a facility or facility area. This definition includes any individual within a facility/facility area or its 0.4-mile exclusion zone. This definition can also include those transient individuals or small populations outside the exclusion zone but inside the radius defined by the maximally exposed co-located worker if reasonable efforts to account for such people have been made in the facility or facility area emergency plan. For facility accident analyses, the facility worker is defined as an individual located 100 meters (328 feet) downwind of the facility location where an accidental release occurs.

fissile material Although sometimes used as a synonym for fissionable material, this term has acquired a more restricted meaning; namely, any material fissionable by thermal (slow) neutrons. The three primarily fissile materials are uranium-233, uranium-235, and plutonium-239.

fission The splitting of a nucleus into at least two other nuclei and the release of a relatively large amount of energy. Two or three neutrons are usually released during this type of transformation.

fission products The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the fission fragments' radioactive decay.

fissionable material Commonly used as a synonym for fissile material, the meaning of this term has been extended to include material that can be fissioned by fast neutrons, such as uranium-238.

gamma-emitter A radioactive substance that decays by releasing gamma radiation.

gamma ray (gamma radiation) High-energy, short wavelength electromagnetic radiation (a packet of energy) emitted from the nucleus. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded against by dense materials, such as lead or uranium. Gamma rays are similar to x-rays, but are usually more energetic.

geologic repository A system that is intended to be used for, or may be used for, the disposal of radioactive waste or spent nuclear fuel in excavated geologic media. A geologic repository includes (a) the geologic repository operations area, and (b) the portion of the geologic setting that provides isolation. A near-surface disposal area is not a geologic repository.

groundwater Generally, all water contained in the ground. Water held below the water table available to freely enter wells.

grouting Grouting is the process of immobilizing or fixing solid forms of waste so they can be more safely stored or disposed.

half-life The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years. Also called physical half-life.

hazardous chemical A term defined under the Occupational Safety and Health Act and the Emergency Planning and Community Right-to-Know Act as any chemical that is a physical hazard or a health hazard.

hazardous material A substance or material, including a hazardous substance, which has been determined by the U.S. Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce.

hazardous substance Any substance that when released to the environment in an uncontrolled or unpermitted fashion becomes subject to the reporting and possible response provisions of the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act.

hazardous waste Under the Resource Conservation and Recovery Act, a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (a) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversibile, illness; or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed. Source, special nuclear material, and by-product material, as defined by the Atomic Energy Act, are specifically excluded from the definition of solid waste.

heterogeneous Pertaining to a substance having different characteristics in different locations. A synonym is nonuniform.

high-efficiency particulate air (HEPA) filter A filter with an efficiency of at least 99.95 percent used to separate particles from air exhaust streams prior to releasing that air into the atmosphere.

high-level waste The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly from reprocessing and any solid waste derived from the liquid that contains a combination of transuranic and fission product nuclides in quantities that require permanent isolation. High-level waste may include other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation.

hot cell/hot cell facility A heavily shielded enclosure for handling and processing (by remote means or automatically), or storing highly radioactive materials.

hydrogeology The study of the geological factors relating to water.

hydrology The study of water, including groundwater, surface water, and rainfall.

incineration The efficient burning of combustible solid and liquid wastes to destroy organic constituents and reduce the volume of the waste. Incinerators are designed to burn with an extremely high efficiency. The greater the burning efficiency, the cleaner the air emission. Incineration of radioactive materials does not destroy the radionuclides but does significantly reduce the volume of these wastes. High-efficiency particulate air (HEPA) filters are used to prevent radionuclides and heavy metals from going out of the stack and into the atmosphere.

inconel A metal alloy containing nickel, chromium, and iron, which exhibits good resistance to corrosion in aqueous environments.

interim action (NEPA) An action that may be undertaken while work on a required program EIS is in progress, and the action is not covered by an existing program statement. An interim action may not be undertaken unless such action: (a) is justified independently of the program; (b) is itself accompanied by an adequate EIS or has undergone other NEPA review; and (c) will not prejudice the ultimate decision on the program. Interim action prejudices the ultimate decision on the program when it tends to determine subsequent development or limit alternatives.

intermittent surface water A stream, creek, or river that does not contain water during part or all of the year.

internal accidents Accidents that are initiated by man-made energy sources associated with the operation of a given facility. Examples include process explosions, fires, spills, criticalities, and so forth.

involved worker Workers that would be involved in a proposed action as opposed to workers that would be on the site of a proposed action but not involved in the action.

isotope One of two or more atoms with the same number of protons, but different numbers of neutrons, in their nuclei. Thus, carbon-12, carbon-13, and carbon-14 are isotopes of the element carbon, the numbers denoting the approximate atomic weights. Isotopes have very nearly the same chemical properties, but often different physical properties (for example, carbon-12 and -13 are stable, carbon-14 is radioactive).

life cycle The entire time period from generation to permanent disposal or elimination of waste.

liquid metal cooled breeder reactor A reactor that creates more fissionable material than it consumes and uses liquid metal as a coolant. Liquid sodium is a common metal used to cool this type of reactor.

liquid metal fast breeder reactor A reactor that operates using a type of fission known as fast fission where the neutrons that are used to split the atoms are not slowed down or moderated as is usually the case with normal fission. It creates more fissionable material than it consumes and uses liquid metal as a coolant. Liquid sodium is a common metal used to cool this type of reactor.

long-term storage The storage of hazardous waste (a) onsite (a generator site) for a period of 90-days or greater, other than in a satellite accumulation area, or (b) offsite in a properly managed treatment, storage, or disposal facility for any period of time.

low-level waste Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent nuclear fuel. 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 elements is less than 100 nanocuries per gram of waste.

major radionuclides The radioisotopes that together comprise 95 percent of the total curie content of a waste package by volume and have a half-life of at least 1 week. Radionuclides that are important to a facility's radiological performance assessment and/or a safety analysis and are listed in the facility's waste acceptance criteria are considered major radionuclides.

management (of spent nuclear fuel) Emplacing, operating, and administering facilities, transportation systems, and procedures to assure safe and environmentally responsible handling and storage of spent nuclear fuel pending (and in anticipation of) a decision on ultimate disposition.

maximally exposed co-located worker (MCW) A hypothetical individual defined to allow dose or dosage comparison with numerical criteria for co-located workers. This individual is located at whichever is the greater of 0.4 miles from the facility area boundary (that is, the exclusion zone boundary) or 75 percent of the distance to the nearest independent facility area (that is, the low population zone boundary). The MCW is irrelevant if the DOE site boundary is closer than the MCW location.

maximally exposed individual (MEI) A hypothetical individual defined to allow dose or dosage comparison with numerical criteria for the public. This individual is located at the point on the DOE site boundary nearest to the facility in question. Sometimes called maximally exposed offsite individual (MOI).

maximally exposed offsite individual (MOI) A hypothetical individual defined to allow dose or dosage comparison with numerical criteria for the public. This individual is located at the point on the DOE site boundary nearest to the facility in question. Sometimes called the maximally exposed individual (MEI).

maximum contaminant level (MCL) Under the Safe Drinking Water Act, the maximum permissible concentrations of specific constituents in drinking water that is delivered to any user of a public water system that serves 15 or more connections and 25 or more people. The standards set as maximum contaminant levels take into account the feasibility and cost of attaining the standard.

metric tons of heavy metal (MTHM) Quantities of unirradiated and spent nuclear fuel and targets are traditionally expressed in terms of metric tons of heavy metal (typically uranium), without the inclusion of other materials, such as cladding, alloy materials, and structural materials. A metric ton is 1,000 kilograms, which is equal to about 2,200 pounds.

millirem One thousandth of a rem (see rem).

mixed waste Waste that contains both hazardous waste under the Resource Conservation and Recovery Act and source, special nuclear, or by-product material subject to the Atomic Energy Act of 1954.

mitigation Those actions that avoid impacts altogether, minimize impacts, rectify impacts, reduce or eliminate impacts, or compensate for the impact.

nanocurie One billionth of a curie (see curie).

National Priorities List (NPL) A formal listing of the nation's most hazardous waste sites, as established under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), that have been identified for remediation.

natural phenomena accidents Accidents that are initiated by phenomena such as earthquakes, tornadoes, floods, and so forth.

near-surface disposal Disposal in the uppermost portion of the earth, approximately 30 meters. Near-surface disposal includes disposal in engineered facilities that may be built totally or partially above-grade provided that such facilities have protective earthen covers. A near-surface disposal facility is not considered a geologic repository.

nitrogen oxides (NO_x) Gases formed in great part from atmospheric nitrogen and oxygen when combustion takes place under conditions of high temperature and high pressure; considered a major air pollutant. Two major nitrogen oxides, nitric oxide (NO) and nitrogen dioxide (NO_2) are important airborne contaminants. In the presence of sunlight, nitric oxide combines with atmospheric oxygen to produce nitrogen dioxide, which in high enough concentrations can cause lung damage.

normal conditions All activities associated with a facility mission, whether operation, maintenance, storage, and so forth, which are carried out within a defined envelope. This envelope can be design process conditions, performance in accordance with procedure, and so forth.

normal operation All normal conditions and those abnormal conditions that frequency estimation techniques indicate occur with a frequency greater than 0.1 events per year.

NO_x A generic term used to describe the oxides of nitrogen (see nitrogen oxides).

nuclear criticality A self-sustaining chain reaction, which releases neutrons and energy, and generates radioactive by-product material.

nuclear fuel Materials that are fissionable and can be used in nuclear reactors to make energy.

nuclide A general term referring to all known isotopes, both stable (279) and unstable (about 5,000), of the chemical elements.

off-link doses Doses to members of the public within 800 meters (2,625 feet) of a road or railway.

offsite facility A facility located at a different site or location than the shipper.

on-link doses Doses to members of the public sharing a road or railway.

onsite The same or geographically contiguous property that may be divided by public or private right-of-way, provided the entrance and exit between the properties is at a cross-roads intersection, and access is by crossing as opposed to going along the right-of-way. Non-contiguous properties owned by the same person but connected by a right-of-way that he/she controls and to which the public does not have access is also considered onsite property.

onsite facilities Buildings and other structures, their functional systems and equipment, and other fixed systems and equipment installed onsite.

operator The organization that operates a facility.

passivation The process of making metals inactive or less chemically reactive. For example, to passivate the surface of steel by chemical treatment.

perennial stream A water course that flows year-round.

performance objectives Parameters within which a facility must perform to be considered acceptable.

permeability The degree of ease with which water can pass through a rock or soil.

playa The shallow central basin of a desert plain in which water gathers and then evaporates.

picocurie One trillionth of a curie (see curie).

pollutant migration The movement of a contaminant away from its initial source.

pollution prevention The use of any process, practice, or product that reduces or eliminates the generation and release of pollutants, hazardous substances, contaminants, and wastes, including those that protect natural resources through conservation or more efficient utilization.

polychlorinated biphenyls (PCBs) A class of chemical substances formerly manufactured as an insulating fluid in electrical equipment that is highly toxic to aquatic life. In the environment, PCBs exhibit many of the characteristics of dichloro diphenyl trichloroethane (DDT); they persist in the environment for a long time and accumulate in animals.

population dose The overall dose to the offsite population.

porosity (n) Porosity is an index of relative pore volume. It is the total unit volume of the soil or rock divided into the void volume.

pressurized water reactor A nuclear power reactor that uses water under pressure as a coolant. The water boiled to generate steam is in a separate system.

probable maximum flood The largest flood for which there is any reasonable expectancy in a specific area. The probable maximum flood is normally several times larger than the largest flood of record.

process knowledge The set of information that is used by trained and qualified individuals who are cognizant of the origin, use, and location of waste-generating materials and processes in sufficient detail so as to certify the identity of the waste.

processing (of spent nuclear fuel) Applying a chemical or physical process designed to alter the characteristics of the spent nuclear fuel matrix.

production reactor A nuclear reactor that is used to irradiate target material to produce special nuclear material or by-product material.

public Anyone outside the DOE site boundary at the time of an accident or during normal operation. With respect to accidents analyzed in this EIS, anyone outside the DOE site boundary at the time of an accident.

rad The special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram.

radiation (ionizing radiation) Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as it is used here, does not include nonionizing radiation such as radio- or microwaves, or visible, infrared, or ultraviolet light.

radiation worker A worker who is occupationally exposed to ionizing radiation and receives specialized training and radiation monitoring devices to work in such circumstances.

radioactive waste Waste that is managed for its radioactive content.

radioactivity The property or characteristic of material to spontaneously "disintegrate" with the emission of energy in the form of radiation. The unit of radioactivity is the curie (or becquerel).

radioisotope An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. Approximately 5,000 natural and artificial radioisotopes have been identified.

radiological survey The evaluation of the radiation hazard accompanying the production, use, or existence of radioactive materials under a specific set of conditions. Such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements or estimates of the levels of radiation that may be involved, and a sufficient knowledge of processes affecting these materials to predict hazards resulting from unexpected or possible changes in materials or equipment.

radionuclide See radioisotope.

Record of Decision (ROD) A public document that records the final decision(s) concerning a proposed action. The Record of Decision is based in whole or in part on information and technical analysis generated either during the Comprehensive Environmental Response, Compensation, and

Liability Act (CERCLA) process or the National Environmental Policy Act (NEPA) process, both of which take into consideration public comments and community concerns.

recycling Recycling techniques are characterized as use, reuse, and reclamation techniques (resource recovery). Use or reuse involves the return of a potential waste material either to the originating process as a substitute for an input material or to another process as an input material. Reclamation is the recovery of a useful or valuable material from a waste stream. Recycling allows potential waste materials to be put to a beneficial use rather than going to treatment, storage, or disposal.

regulated substances A general term used to refer to materials other than radionuclides that are regulated by Federal, state, (or possibly local) requirements.

rem The dosage of an ionizing radiation that will cause the same biological effect as 1 roentgen of x-ray or gamma-ray exposure.

remote-handled waste Packaged waste whose external surface dose rate exceeds 200 millirem per hour.

remote handling The handling of wastes from a distance so as to protect human operators from unnecessary exposure.

repository A permanent deep geologic disposal facility for high-level or transuranic wastes and spent nuclear fuel.

reprocessing (of spent nuclear fuel) Processing of reactor irradiated nuclear material (primarily spent nuclear fuel) to recover fissile and fertile material, in order to recycle such materials primarily for defense programs. Historically, reprocessing has involved aqueous chemical separations of elements (typically uranium or plutonium) from undesired elements in the fuel.

research reactor A nuclear reactor used for research and development.

Resource Conservation and Recovery Act (RCRA) A Federal law addressing the management of waste. Subtitle C of the law addresses hazardous waste under which a waste must either be "listed" on one of the U.S. Environmental Protection Agency's (EPA's) hazardous waste lists or meet one of EPA's four hazardous characteristics of ignitability, corrosivity, reactivity, or toxicity, as measured using the toxicity characterization leaching procedure (TCLP). Cradle-to-grave management of wastes classified as RCRA hazardous wastes must meet stringent guidelines for environmental protection as required by the law. These guidelines include regulation of transport, treatment, storage, and disposal of RCRA defined hazardous waste. Subtitle D of the law addresses the management of nonhazardous, nonradioactive, solid waste such as municipal wastes.

retrieval The process of recovering wastes that have been stored or disposed of onsite so they may be appropriately characterized, treated, and disposed of.

risk Quantitative expression of possible loss that considers both the probability that a hazard causes harm and the consequences of that event.

safety analysis report A report, prepared in accordance with DOE Orders 5481.1B and 5480.23, that summarize the hazards associated with the operation of a particular facility and defines minimum safety requirements.

sanitary waste Liquid or solid wastes that are generated as a result of routine operations of a facility and are not considered hazardous or radioactive.

saturated zone That part of the earth's crust in which all naturally occurring voids are filled with water.

scaling factor A multiplier that allows the inference of one radionuclide concentration from another that is more easily measured.

scientific notation A notation adopted by the scientific community to deal with very large and very small numbers by moving the decimal point to the right or left so that only one number above zero is to the left of the decimal point. Scientific notation uses a number times 10 and either a positive or negative exponent to show how many places to the left or right the decimal place has been moved. For example, in scientific notation, 120,000 would be written as 1.2×10^5, and 0.000012 would be written as 1.2×10^{-5}. In a variation of scientific notation often used in computer printouts, the multiplication sign and number 10 are replaced by the letter E. The above numbers would be written as 1.2E5 and 1.2E-5, respectively.

segregation The process of separating (or keeping separate) individual waste types and/or forms in order to facilitate their cost-effective treatment and storage or disposal.

seismicity The phenomenon of earth movements; seismic activity. Seismicity is related to the location, size, and rate of occurrence of earthquakes.

seiche A wave that oscillates in partially or totally enclosed bodies of water from a few minutes to a few hours, caused by seismic or atmospheric disturbances.

sole source aquifer A designation granted by the U.S. Environmental Protection Agency when groundwater from a specific aquifer supplies at least 50 percent of the drinking water for the area overlying the aquifer. Sole-source aquifers have no alternative source or combination of sources that could physically, legally, and economically supply all those who obtain their drinking water from the aquifer. Sole-source aquifers are protected from federally financially assisted activities determined to be potentially unhealthy for the aquifer.

solid waste Any garbage, refuse, or sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities. It does not include solid or dissolved material in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges, which are point sources subject to permits under Section 402 of the Federal Water Pollution Control Act, as amended, or source, special nuclear, or by-product material as defined by the Atomic Energy Act of 1954, as amended [Public Law 94-580, 1004(27) (Resource Conservation and Recovery Act)].

solvents Liquid chemicals, usually organic compounds, that are capable of dissolving another substance. Exposure to some organic solvents can produce toxic effects on body tissues and processes.

source material (a) Uranium, thorium, or any other material that is determined by the U.S. Nuclear Regulatory Commission pursuant to the provisions of the Atomic Energy Act of 1954, Section 61, to be source material; or (b) ores containing one or more of the foregoing materials, in such concentration as the U.S. Nuclear Regulatory Commission may by regulation determine from time-to-time [Atomic Energy Act 11(z)]. Source material is exempt from regulation under to Resource Conservation and Recovery Act.

SO_x A generic term used to describe the oxides of sulfur. The combination of sulfur oxides with water vapor produces acid rain (see sulfur oxides).

special-case commercial reactor spent nuclear fuel Complete or partial spent nuclear fuel assemblies from commercial nuclear power plants that were to be used to support DOE-sponsored research and development programs. This includes spent nuclear fuel from development reactors (Shippingport, Peach Bottom Unit 1, and Fort St. Vrain); spent nuclear fuel used for destructive and nondestructive examination and testing; spent nuclear fuel remaining at the West Valley Demonstration Project; and spent nuclear fuel remnants (Three-Mile Island Unit 2).

special nuclear material (a) Plutonium, or uranium enriched in the isotope 233 or in the isotope 235, and any other material that the U.S. Nuclear Regulatory Commission, pursuant to the provisions of the Atomic Energy Act of 1954, Section 51, determines to be special nuclear material; or (b) any material artificially enriched by any of tbe foregoing, but does not include source material. Special nuclear material is exempt from regulation under the Resource Conservation and Recovery Act (RCRA).

specimen A small sample of material (fuel or non-fuel) inserted into a reactor for testing to characterize the material's performance. Test specimens may be constructed of plant materials, reactor structural materials, or fuel materials.

spent nuclear fuel Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated. For the purposes of this EIS, spent nuclear fuel also includes uranium/neptunium target materials, blanket subassemblies, pieces of fuel, and debris.

stabilization (of spent nuclear fuel) Actions taken to further confine or reduce the hazards associated with spent nuclear fuel, as necessary for safe management and environmentally responsible storage for extended periods of time. Activities that may be necessary to stabilize spent nuclear fuel include canning, processing, and passivation.

stakeholder Any person or organization with an interest in or affected by DOE activities. Stakeholders may include representatives from Federal agencies, State agencies, Congress, Native American Tribes, unions, educational groups, industry, environmental groups, other groups, and members of the general public.

storage The collection and containment of waste or spent nuclear fuel in such a manner as not to constitute disposal of the waste or spent nuclear fuel for the purposes of awaiting treatment or disposal capacity (that is, not short-term accumulation).

subsurface The area below the land surface (including the vadose zone and aquifers).

sulfur oxides Pungent, colorless gases formed primarily by the combustion of fossil fuels; considered major air pollutants; sulfur oxides may damage the respiratory tract as well as vegetation (see SO_x).

target A tube, rod, or other form containing material that, on being irradiated in a nuclear reactor would produce a designed end product (that is, uranium-238 produces plutonium-239 and neptunium-237 produces plutonium-238).

total effective dose equivalent The sum of the external dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

transient A change in the reactor coolant system temperature and/or pressure. Transients can be caused by adding or removing neutron poisons, by increasing or decreasing the electrical load on the turbine generator, or by accident conditions.

transuranic waste Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, with half-lives greater than 20 years, per gram of waste, except for (a) high-level radioactive waste; (b) waste that the U.S. Department of Energy has determined, with the concurrence of the Administrator of the U.S. Environmental Protection Agency, does not need the degree of isolation required by 40 CFR 191; or (c) waste that the U.S. Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61.

transuranium radionuclide Any radionuclide having an atomic number greater than 92.

tsunami A huge ocean wave caused by an underwater earthquake or a volcanic eruption.

ultimate disposition The final step in which a material is either processed for some use or disposed of.

vadose zone The zone between the land surface and the water table. Saturated bodies, such as perched groundwater, may exist in the vadose zone. Also called the zone of aeration and the unsaturated zone.

vitrification The process of immobilizing waste material that results in a glass-like solid.

volatile organic compound (VOC) Chemical containing mainly carbon, hydrogen, and oxygen that readily evaporates at ambient temperature. Exposure to some organic compounds can produce toxic effects on body tissue and processes.

Volcanic Rift Zones Linear belts of basaltic vents marked by open fissures, monoclines, and small normal faults. Volcanic rift zones were produced during the propagation of vertical molten basaltic dikes that fed surface eruptions.

vulnerabilities Conditions or weaknesses that may lead to radiation exposure to the public, unnecessary or increased exposure to the workers, or release of radioactive materials to the environment. For example, some DOE facilities have had leakage from spent fuel storage pools, excessive corrosion of fuel causing increased radiation levels in the pool, or degradation of handling systems. Vulnerabilities are also caused by loss of institutional controls, such as cessation of facility funding or reductions in facility maintenance and control.

waste acceptance criteria (WAC) The requirements specifying the characteristics of waste and waste packaging acceptable to a waste receiving facility; and the documents and processes the generator needs to certify that waste meets applicable requirements.

waste certification A process by which a waste generator certifies that a given waste or waste stream meets the waste acceptance criteria of the facility to which the generator intends to transport waste for treatment, storage, or disposal. Certification is accomplished by a combination of waste characterization, documentation, quality assurance, and periodic audits of the certification program.

waste characterization See characterization.

Waste Isolation Pilot Plant (WIPP) A facility near Carlsbad, New Mexico, authorized to demonstrate safe disposal of defense-generated transuranic waste in a deep geologic medium.

waste management The planning, coordination, and direction of those functions related to generation, handling, treatment, storage, transport, and disposal of waste, as well as associated surveillance and maintenance activities.

waste management facility All contiguous land, structures, other appurtenances, and improvements on the land, used for treating, storing, or disposing of waste or spent nuclear fuel. A facility may consist of several treatment, storage, or disposal operational units (for example, one or more landfills, surface impoundments, or combinations of them).

waste management program A systematic approach to organize, direct, document, and assess activities associated with waste generation, treatment, storage, or disposal. A waste management program consists of all the functional elements, organizations, and activities that comprise the system needed to properly manage waste. These functions and activities can be performed by various organizations.

waste management systems assessment A systems assessment of the entire low-level waste management (or all of waste management) structure/program at a given site that considers treatment, storage, disposal, as well as onsite and offsite points of generation with an emphasis on optimization of all aspects of the operations, including, but not limited to, protection of human health and the environment, regulatory compliance, and cost effectiveness.

waste minimization An action that economically avoids or reduces the generation of waste by source reduction, reducing the toxicity of hazardous waste, improving energy usage, or recycling. These actions will be consistent with the general goal of minimizing present and future threats to human health, safety, and the environment.

water pool A type of facility usually used for the storage of irradiated nuclear materials and spent fuel. The water shields the material being stored while allowing it to be accessible for handling. Sometimes referred to as a water pit.

wet storage Storage of spent nuclear fuel in a pool of water, generally for the purposes of cooling and/or shielding.

CONTENTS

FIGURES

TABLES

Appendix I
Offsite Transportation of Spent Nuclear Fuel

I-1 INTRODUCTION

This appendix summarizes the methods and results of analysis for determining the environmental impacts of spent nuclear fuel (SNF) transportation on public highways and rail systems outside the boundaries of U.S. Department of Energy (DOE) sites (offsite). The impacts are presented by alternative and include doses and health effects.

This appendix does not address the impacts of SNF transport within the boundaries of DOE sites (onsite). Onsite transport impacts are addressed in site-specific Appendices A through F. This appendix addresses offsite shipments of naval-type SNF stored at the Idaho Chemical Processing Plant as of June 1995 to storage locations at other sites as identified by certain alternatives. Transport of naval SNF from shipyards and prototypes to the equivalent expended core facility at the alternative sites are addressed in this EIS in Appendix D in Volume 1, along with transport of naval test specimens.

This appendix also includes the impacts of shipments of foreign research reactor SNF from the six points of entry identified in the Implementation Plan for this EIS (Hampton Roads, Virginia; Charleston, South Carolina; Savannah, Georgia; Seattle-Tacoma, Washington; Portland, Oregon; and Oakland, California) and the points of entry at the Military Ocean Terminal at Sunny Point, North Carolina; and Galveston, Texas. The six points of entry identified in the Implementation Plan were chosen using the following criteria: (a) adequacy of harbor and dock characteristics to satisfy the cask-carrying ship requirements, (b) availability of safe and secure lag storage, (c) adequacy of overland transportation systems from points of entry to the storage sites, (d) experience in safe and secure handling of hazardous cargo, (e) emergency preparedness status at the point of entry and nearby communities, and (f) proximity of the proposed storage sites. The Military Ocean Terminal at Sunny Point, North Carolina, was chosen because it was recently used for foreign research reactor SNF shipments. Galveston, Texas was chosen as a point of entry because it was on the Gulf Coast and has container-handling experience. A full range of alternative points of entry, including these and other points of entry, is being evaluated in the Environmental Impact Statement on a Proposed Nuclear Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel,and no decision concerning the choice of points of entry will be made until both the Programmatic Spent Nuclear Fuel Management and the Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement and the Environmental Impact Statement on a Proposed Nuclear Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel are completed. The ocean-going portion of foreign research reactor SNF shipments and a detailed evaluation of point of entry activities are also not assessed in this appendix, but will be assessed in the *Draft Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel.*

The impacts of historical shipments of SNF to the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and the Nevada Test Site and cumulative transportation impacts are also discussed in this appendix. The historical impacts and cumulative impacts include shipments of naval SNF and test specimens.

I-2 TRANSPORTATION REGULATIONS

The regulatory standards for packaging and transport of SNF are designed to achieve four primary objectives:

- Protect persons and property from radiation emitted from packages during transportation, by specific limitations on the allowable radiation levels
- Provide proper containment of the SNF in the package (achieved by packaging design requirements based on performance-oriented packaging integrity tests and environmental criteria)
- Prevent nuclear criticality (an unplanned nuclear chain reaction that may occur as a result of concentrating too much fissile material in one place)
- Provide physical protection against theft and sabotage during transit.

The U.S. Department of Transportation regulates the transportation of hazardous materials (including SNF) in interstate and intrastate commerce by land, air, and on navigable water. As outlined in a 1979 Memorandum of Understanding with the U.S. Nuclear Regulatory Commission, the U.S. Department of Transportation specifically regulates the carriers of SNF and the conditions of transport, such as routing, handling and storage, and vehicle and driver requirements. The U.S. Department of Transportation also regulates the labeling, classification, and marking of all SNF packages.

The U.S. Nuclear Regulatory Commission regulates the packaging and transport of SNF for its licensees, which includes commercial shippers of SNF. In addition, under an agreement with the U.S. Department of Transportation, the U.S. Nuclear Regulatory Commission sets the standards for packages containing fissile materials and SNF.

The DOE, through its management directives, orders, and contractual agreements, assures the protection of public health and safety by imposing on its transportation activities standards equivalent to those of the U.S. Department of Transportation and the U.S. Nuclear Regulatory Commission. The DOE has authority, granted by a 1973 Memorandum of Understanding between the U.S. Department of Transportation and the Atomic Energy Commission, to certify DOE SNF packages. The DOE may design, procure, and certify its own SNF packages to be used by the DOE and its contractors if the packages provide equivalent safety to that provided in 10 CFR Part 71.

The U.S. Department of Transportation also has requirements that help to reduce transportation impacts. For example, there are requirements for drivers, routing, packaging, labeling, marking, and placarding. There are also requirements that specify the maximum dose rate associated with radioactive material shipments, which help to reduce incident-free transportation doses.

The Federal Emergency Management Agency is responsible for establishing policies for and coordinating civil emergency management, planning, and interaction with Federal executive agencies that have emergency response functions in the event of a SNF transportation incident. The Federal Emergency Management Agency coordinates Federal and state participation in developing emergency response plans and is responsible for the development of the interim Federal Radiological Emergency Response Plan. The Federal Radiological Emergency Response Plan is designed to coordinate Federal support to state and local governments, upon request, during the event of a SNF transportation incident.

The Interstate Commerce Commission is responsible for the regulation of the economic aspects of SNF transportation for land shipments. The Comission issues operating authorities to carriers and also monitors and approves freight rates.

Spent nuclear fuel is transported in Type B packages, which are designed and constructed to retain their radioactive contents in both normal and severe accident conditions.

Under normal conditions a cask must withstand:

- Hot [100°F (38°C)] and Cold [-40°F (-40°C)] temperatures
- External pressure changes from 3.5 to 20 pounds per square inch (24.5 to 140 kilopascal)
- Normal vibration experienced during transportation
- Simulated rainfall of 2 inches (5 centimeters) per hour for 1 hour
- Free drop from 1 to 4 feet (0.3 to 1.2 meters), depending on the package weight
- Compression loading (the greater of 5 times the weight of package or 1.85 pounds per square inch (12.75 kilopascal) times the vertical projected area of the package) applied uniformly to the top and bottom of the package for a period of 24 hours.
- Impact of a 13-pound (6-kilogram) steel cylinder with rounded ends dropped from 40 inches (1 meter) onto the most vulnerable surface of the cask.

Under accident conditions a cask must withstand:

- Free drop for 30 feet (9 meters) onto an unyielding surface in a way most likely to cause damage to the cask

- Free drop from 40 inches (1 meter) onto the end of a 6-inch-diameter (15-centimeter-diameter) vertical steel bar

- Exposure for not less than 30 minutes to temperatures of 1475°F (802°C)

- Immersion in at least 50 feet (15 meters) of water for 8 hours and, for criticality considerations, immersion in at least 3 feet (0.9 meters) of water for 8 hours in the attitude for which maximum leakage is expected.

Compliance with these requirements is demonstrated by using a combination of simple calculational methods, computer modeling techniques, or full-scale or scale-model testing of casks.

I-3 SNF TRANSPORTATION MODES AND ROUTES

I-3.1 SNF Transportation Routing Models

To assess incident-free and transportation accident impacts, route characteristics were determined for each of the origins and destinations associated with SNF shipments. Each origin represents a facility that generates or stores SNF that must be transported, and each destination represents a facility that stores SNF. For offsite transport, representative highway and rail routes were analyzed using the routing computer codes HIGHWAY (Johnson et al. 1993a) and INTERLINE (Johnson et al. 1993b). The routes were calculated conforming to current routing practices and applicable routing regulations and guidelines. Route characteristics include total shipment distance between each origin and destination and the fractions of travel in rural, suburban, and urban population density zones (see Table I-1). The HIGHWAY and INTERLINE routing computer codes are described below.

The HIGHWAY computer code predicts highway routes for transporting radioactive materials within the United States. The HIGHWAY database is a computerized road atlas that currently describes approximately 240,000 miles of roads. A complete description of the Interstate Highway System, United States highways, most of the principal state highways, and a number of local and community highways are identified in the database. The HIGHWAY computer code calculates routes that maximize the use of interstate highways. This feature allows the user to predict routes for transport of radioactive materials that conform to U.S. Department of Transportation regulations, as specified in 49 CFR Part 177, (CFR 1994a). The routes calculated conform to applicable guidelines and regulations; therefore, they represent routes that could be used. However, they may not be the actual routes used in the future. The code is updated periodically to reflect current road conditions, and it has been benchmarked against reported mileage and observations of commercial truck firms.

The INTERLINE computer code is designed to simulate routing of the United States rail system. The INTERLINE database consists of 94 separate subnetworks and represents various competing rail companies in the United States. The database used by INTERLINE was originally based on Federal Railroad Administration data and reflected the United States railroad system in 1974. The database has since been expanded and modified over the past two decades. The routes used for this study used the standard assumptions in the INTERLINE computer code that simulate the selection process railroads use to direct transport of radioactive material. Currently, there are no specific routing regulations for transporting radioactive material by rail. INTERLINE is updated periodically to reflect current track conditions, and it has been benchmarked against reported mileage and observations of commercial rail firms.

Table I-1. Transportation distances between facilities for spent nuclear fuel shipments.

Route		Miles	Rural (%)	Suburban (%)	Urban (%)
	Truck routes				
Idaho National Engineering Laboratory	Hanford Site	599.0	91.3	7.6	1.1
Idaho National Engineering Laboratory	Nevada Test Site	712.0	82.8	13.7	3.5
Idaho National Engineering Laboratory	Savannah River Site	2311.0	82.8	15.6	1.6
Idaho National Engineering Laboratory	Oak Ridge Reservation	2048.0	86.8	12.0	1.2
Idaho National Engineering Laboratory	Brookhaven National Laboratory	2437.0	81.7	15.9	2.5
Idaho National Engineering Laboratory	Argonne National Laboratory-East	1582.0	91.2	8.2	0.6
Idaho National Engineering Laboratory	Los Alamos National Laboratory	1144.0	88.7	9.8	1.4
Idaho National Engineering Laboratory	Sandia National Laboratories - Albuquerque	1168.0	88.6	9.8	1.6
Hanford Site	Nevada Test Site	1128.0	86.5	10.9	2.6
Hanford Site	Savannah River Site	2727.0	84.3	14.2	1.5
Hanford Site	Oak Ridge Reservation	2464.0	87.8	11.0	1.2
Hanford Site	Brookhaven National Laboratory	2853.0	83.3	14.5	2.3
Hanford Site	Argonne National Laboratory-East	1998.0	91.5	7.8	0.7
Hanford Site	Los Alamos National Laboratory	1560.0	89.8	8.8	1.3
Hanford Site	Sandia National Laboratories - Albuquerque	1584.0	89.7	8.8	1.4
Nevada Test Site	Savannah River Site	2414.0	83.1	15.1	1.8
Nevada Test Site	Oak Ridge Reservation	2151.0	86.9	11.5	1.6
Nevada Test Site	Brookhaven National Laboratory	2670.0	82.3	15.1	2.6
Nevada Test Site	Argonne National Laboratory-East	1815.0	91.0	8.0	1.0
Nevada Test Site	Los Alamos National Laboratory	997.0	93.2	5.7	1.1
Nevada Test Site	Sandia National Laboratoriea - Albuquerque	909.0	93.8	4.8	1.4
Savannah River Site	Oak Ridge Reservation	379.0	59.1	38.5	2.4
Savannah River Site	Brookhaven National Laboratory	897.0	58.4	36.6	4.9
Savannah River Site	Argonne National Laboratory-East	892.0	68.8	29.3	1.9
Savannah River Site	Los Alamoa National Laboratory	1742.0	80.0	17.9	2.1
Savannah River Site	Sandia National Laboratories - Albuquerque	1644.0	80.1	17.8	2.1
Savannah River Site	Lawrence Livermore National Laboratory	2750.0	80.1	16.8	3.1
Oak Ridge Reservation	Brookhaven National Laboratory	821.0	56.9	37.9	5.2

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Oak Ridge Reservation	Argonne National Laboratory-East	584.0	67.0	30.1	2.9
Oak Ridge Reservation	Los Alamos National Laboratory	1480.0	84.9	13.3	1.7
Oak Ridge Reservation	Sandia National Laboratories - Albuquerque	1382.0	85.4	12.9	1.7
	Train routes				
Idaho National Engineering Laboratory	Hanford Site	658.0	91.4	7.1	1.4
Idaho National Engineering Laboratory	Nevada Test Site	756.0	92.8	5.9	1.3
Idaho National Engineering Laboratory	Savannah River Site	2407.0	82.8	15.2	2.0
Idaho National Engineering Laboratory	Oak Ridge Reservation	2055.0	90.7	7.8	1.5
Idaho National Engineering Laboratory	Brookhaven National Laboratory	2607.0	71.3	22.6	6.1
Idaho National Engineering Laboratory	Argonne National Laboratory-East	1655.0	93.4	6.0	0.6
Idaho National Engineering Laboratory	Los Alamos National Laboratory	1179.0	92.2	6.8	1.0
Idaho National Engineering Laboratory	Sandia National Laboratories - Albuquerque	1247.0	91.0	7.6	1.4
Hanford Site	Nevada Test Site	1302.0	93.0	5.9	1.1
Hanford Site	Savannah River Site	2953.0	84.7	13.5	1.8
Hanford Site	Oak Ridge Reservation	2601.0	91.2	7.4	1.3
Hanford Site	Brookhaven National Laboratory	3153.0	75.1	19.7	5.2
Hanford Site	Argonne National Laboratory-East	2200.0	93.3	6.0	0.7
Hanford Site	Los Alamos National Laboratory	1725.0	92.5	6.5	0.9
Hanford Site	Sandia National Laboratories - Albuquerque	1793.0	91.7	7.1	1.2
Nevada Test Site	Savannah River Site	2839.0	84.5	13.5	1.9
Nevada Test Site	Oak Ridge Reservation	2487.0	91.4	7.2	1.5
Nevada Test Site	Brookhaven National Laboratory	3039.0	74.6	20.0	5.4
Nevada Test Site	Argonne National Laboratory-East	2348.0	92.8	6.4	0.8
Nevada Test Site	Los Alamos National Laboratory	1169.0	92.8	5.9	1.3
Nevada Test Site	Sandia National Laboratories - Albuquerque	1065.0	94.6	4.5	0.9
Savannah River Site	Oak Ridge Reservation	417.0	68.8	29.8	1.4
Savannah River Site	Brookhaven National Laboratory	1239.0	48.0	37.4	14.5
Savannah River Site	Argonne National Laboratory-East	976.0	64.3	31.6	4.0
Savannah River Site	Los Alamos National Laboratory	2252.0	80.3	17.5	2.1

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Savannah River Site	Sandia National Laboratories - Albuquerque	2315.0	79.9	18.1	2.1
Oak Ridge Reservation	Brookhaven National Laboratory	1152.0	39.5	44.7	15.8
Oak Ridge Reservation	Argonne National Laboratory-East	648.0	70.7	25.3	4.0
Oak Ridge Reservation	Los Alamos National Laboratory	1686.0	88.9	9.3	1.8
Oak Ridge Reservation	Sandia National Laboratories - Albuquerque	1749.0	87.9	10.3	1.8
	Truck routes				
Fort St. Vrain Nuclear Generating Station	Savannah River Site	1636.0	78.9	19.1	2.0
Fort St. Vrain Nuclear Generating Station	Hanford Site	1108.0	92.5	6.7	0.7
Fort St. Vrain Nuclear Generating Station	Idaho National Engineering Laboratory	692.0	92.3	7.1	0.5
Fort St. Vrain Nuclear Generating Station	Oak Ridge Reservation	1372.0	84.1	14.3	1.6
Fort St. Vrain Nuclear Generating Station	Nevada Test Site	852.0	90.2	7.9	1.9
	Train routes				
Fort St. Vrain Nuclear Generating Station	Savannah River Site	1853.0	77.3	20.1	2.7
Fort St. Vrain Nuclear Generating Station	Hanford Site	1218.0	94.8	4.6	0.6
Fort St. Vrain Nuclear Generating Station	Idaho National Engineering Laboratory	672.0	96.0	3.5	0.4
Fort St. Vrain Nuclear Generating Station	Oak Ridge Reservation	1526.0	87.0	10.9	2.1
Fort St. Vrain Nuclear Generating Station	Nevada Test Site	1104.0	95.4	3.8	0.8
	Truck routes				
Savannah River Site	Hampton Roads, VA	505.0	71.2	27.0	1.9
Savannah River Site	Seattle-Tacoma, WA	2900.0	85.1	13.8	1.2
Savannah River Site	Charleston, SC	209.0	73.1	24.8	2.2
Savannah River Site	Savannah, GA	265.0	78.8	20.8	0.5
Savannah River Site	Oakland, CA	2791.0	79.5	17.0	3.5
Savannah River Site	Portland, OR	2849.0	84.4	14.0	1.6
Savannah River Site	Military Ocean Terminal, Sunny Point, NC	250.0	82.5	17.2	0.3
Savannah River Site	Alexandria Bay, NY	1012.0	66.8	32.4	0.8
Savannah River Site	Galveston, TX	1000.0	70.5	27	2.5
Hanford Site	Hampton Roads, VA	2903.0	85.0	13.3	1.7

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Hanford Site	Seattle-Tacoma, WA	226.0	76.8	20.9	2.3
Hanford Site	Charleston, SC	2862.0	85.5	13.2	1.3
Hanford Site	Savannah, GA	2804.0	84.9	13.7	1.4
Hanford Site	Oakland, CA	875.0	78.1	17.8	4.1
Hanford Site	Portland, OR	236.0	86.0	10.7	3.4
Hanford Site	Military Ocean Terminal, Sunny Point, NC	2868.0	85.7	13.1	1.3
Hanford Site	Alexandria Bay, NY	2768.0	82.8	15.6	1.6
Hanford Site	Galveston, TX	2327.0	86.0	11.8	2.3
Idaho National Engineering Laboratory	Hampton Roads, VA	2487.0	83.7	14.5	1.8
Idaho National Engineering Laboratory	Seattle-Tacoma, WA	793.0	88.3	10.5	1.1
Idaho National Engineering Laboratory	Charleston, SC	2446.0	84.2	14.4	1.3
Idaho National Engineering Laboratory	Savannah, GA	2388.0	83.6	15.0	1.5
Idaho National Engineering Laboratory	Oakland, CA	963.0	84.5	11.0	4.4
Idaho National Engineering Laboratory	Portland, OR	721.0	90.2	8.1	1.6
Idaho National Engineering Laboratory	Military Ocean Terminal, Sunny Point, NC	2407.0	85.3	13.5	1.2
Idaho National Engineering Laboratory	Alexandria Bay, NY	2352.0	81.0	17.2	1.7
Idaho National Engineering Laboratory	Galveston, TX	1911.0	84.5	13.0	2.5
Oak Ridge Reservation	Hampton Roads, VA	548.0	70.3	27.3	2.3
Oak Ridge Reservation	Seattle-Tacoma, WA	2636.0	88.4	10.7	0.8
Oak Ridge Reservation	Charleston, SC	408.0	70.8	27.5	1.8
Oak Ridge Reservation	Savannah, GA	456.0	67.1	31.1	1.8
Oak Ridge Reservation	Oakland, CA	2563.0	86.3	10.7	3.0
Oak Ridge Reservation	Portland, OR	2585.0	87.7	11.0	1.3
Oak Ridge Reservation	Military Ocean Terminal, Sunny Point, NC	496.0	72.4	26.7	0.9
Oak Ridge Reservation	Alexandria Bay, NY	927.0	65.9	33.5	0.7
Oak Ridge Reservation	Galveston, TX	963.0	73.3	24.6	2.1
Nevada Test Site	Hampton Roads, VA	2590.0	83.9	14.0	2.1
Nevada Test Site	Seattle-Tacoma, WA	1322.0	85.5	12.1	2.4
Nevada Test Site	Charleston, SC	2549.0	84.5	14.0	1.6

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Nevada Test Site	Savannah, GA	2492.0	83.8	14.4	1.7
Nevada Test Site	Oakland, CA	719.0	81.9	10.6	7.5
Nevada Test Site	Portland, OR	1250.0	86.4	10.8	2.8
Nevada Test Site	Military Ocean Terminal, Sunny Point, NC	2457.0	83.0	15.0	2.0
Nevada Test Site	Alexandria Bay, NY	2619.0	82.0	16.0	1.9
Nevada Test Site	Galveston, TX	1862.0	85.4	11.5	3.2
	Train routes				
Savannah River Site	Hampton Roads, VA	529.0	74.3	24.1	1.6
Savannah River Site	Seattle-Tacoma, WA	3123.0	81.1	16.1	2.8
Savannah River Site	Charleston, SC	140.0	83.9	13.6	2.5
Savannah River Site	Savannah, GA	114.0	87.9	10.9	1.2
Savannah River Site	Oakland, CA	3192.0	79.2	16.7	4.1
Savannah River Site	Portland, OR	3154.0	82.0	15.4	2.6
Savannah River Site	Military Ocean Terminal, Sunny Point, NC	382.0	77.9	20.5	1.6
Savannah River Site	Alexandria Bay, NY	1281.0	53.8	35.5	10.7
Savannah River Site	Galveston, TX	1174.0	69.6	26.2	4.2
Hanford Site	Hampton Roads, VA	3187.0	83.8	13.6	2.7
Hanford Site	Seattle-Tacoma, WA	416.0	73.7	20.1	6.2
Hanford Site	Charleston, SC	3059.0	84.5	13.7	1.8
Hanford Site	Savannah, GA	3091.0	85.3	13.2	1.4
Hanford Site	Oakland, CA	986.0	78.5	15.8	5.7
Hanford Site	Portland, OR	239.0	82.1	13.4	4.5
Hanford Site	Military Ocean Terminal, Sunny Point, NC	3203.0	83.6	14.8	1.5
Hanford Site	Alexandria Bay, NY	2878.0	79.6	16.6	3.8
Hanford Site	Galveston, TX	2392.0	89.9	9.1	1.0
Idaho National Engineering Laboratory	Hampton Roads, VA	2641.0	81.8	15.2	3.0
Idaho National Engineering Laboratory	Seattle-Tacoma, WA	976.0	85.8	10.8	3.4
Idaho National Engineering Laboratory	Charleston, SC	2513.0	82.6	15.3	2.1
Idaho National Engineering Laboratory	Savannah, GA	2545.0	83.6	14.8	1.6
Idaho National Engineering Laboratory	Oakland, CA	1102.0	90.0	7.6	2.4

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Idaho National Engineering Laboratory	Portland, OR	785.0	92.6	5.8	1.6
Idaho National Engineering Laboratory	Military Ocean Terminal, Sunny Point, NC	2657.0	81.6	16.7	1.7
Idaho National Engineering Laboratory	Alexandria Bay, NY	2332.0	76.4	19.1	4.5
Idaho National Engineering Laboratory	Galveston, TX	1846.0	88.9	10.1	1.0
Oak Ridge Reservation	Hampton Roads, VA	689.0	62.2	36.3	1.6
Oak Ridge Reservation	Seattle-Tacoma, WA	2795.0	84.6	12.8	2.6
Oak Ridge Reservation	Charleston, SC	581.0	65.2	33.3	1.5
Oak Ridge Reservation	Savannah, GA	587.0	66.2	32.1	1.7
Oak Ridge Reservation	Oakland, CA	2686.0	89.4	8.5	2.1
Oak Ridge Reservation	Portland, OR	2827.0	85.5	12.1	2.4
Oak Ridge Reservation	Military Ocean Terminal, Sunny Point, NC	542.0	61.5	37.1	1.5
Oak Ridge Reservation	Alexandria Bay, NY	972.0	57.5	35.7	6.8
Oak Ridge Reservation	Galveston, TX	1053.0	70.5	26.2	3.3
Nevada Test Site	Hampton Roads, VA	3073.0	83.6	13.6	2.8
Nevada Test Site	Seattle-Tacoma, WA	1620.0	89.3	8.4	2.3
Nevada Test Site	Charleston, SC	2945.0	84.3	13.7	2.0
Nevada Test Site	Savannah, GA	2977.0	85.2	13.2	1.5
Nevada Test Site	Oakland, CA	860.0	75.1	17.7	7.2
Nevada Test Site	Portland, OR	1429.0	93.5	5.3	1.2
Nevada Test Site	Military Ocean Terminal, Sunny Point, NC	3089.0	83.4	14.9	1.7
Nevada Test Site	Alexandria Bay, NC	2763.0	79.2	16.7	4.0
Nevada Test Site	Galveston, TX	1955.0	92.0	7.2	0.8
	Truck routes				
Savannah River Site	Cornell University	896.0	66.5	32.3	1.2
Savannah River Site	Georgia Institute of Technology	197.0	61.1	34.5	4.4
Savannah River Site	Idaho State University	2248.0	82.7	15.7	1.5
Savannah River Site	Iowa State University	1175.0	77.9	21.0	1.2
Savannah River Site	Kansas State University	1121.0	72.3	25.1	2.7
Savannah River Site	Manhattan College	830.0	62.1	35.2	2.7
Savannah River Site	Massachusetts Institute of Technology	1040.0	53.2	39.7	7.0
Savannah River Site	North Carolina State University	318.0	68.0	31.4	0.6
Savannah River Site	Ohio State University	708.0	69.6	29.6	0.7

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Savannah River Site	Oregon State University	2937.0	83.7	14.6	1.7
Savannah River Site	Pennsylvania State University	849.0	69.6	29.5	0.9
Savannah River Site	Purdue University	768.0	70.0	29.2	0.8
Savannah River Site	Reed College	2849.0	84.4	14.0	1.6
Savannah River Site	Rensselaer Polytechnic Institute	955.0	64.3	34.5	1.2
Savannah River Site	Rhode Island Nuclear Science Center	1009.0	55.0	38.5	6.5
Savannah River Site	State University of New York - Buffalo	1001.0	68.8	29.8	1.5
Savannah River Site	Texas A&M University	1099.0	70.6	26.7	2.7
Savannah River Site	University of Arizona	1926.0	79.4	19.1	1.6
Savannah River Site	University of California - Irvine	2406.0	79.6	17.9	2.5
Savannah River Site	University of Florida	496.0	73.4	26.0	0.6
Savannah River Site	University of Illinois	803.0	73.9	24.6	1.5
Savannah River Site	University of Lowell	1045.0	53.1	40.2	6.8
Savannah River Site	University of Maryland	589.0	65.9	31.0	3.1
Savannah River Site	University of Michigan	903.0	62.7	34.8	2.5
Savannah River Site	University of Missouri - Columbia	858.0	70.6	27.0	2.3
Savannah River Site	University of Missouri - Rolla	835.0	71.2	26.9	1.9
Savannah River Site	University of New Mexico	1653.0	80.1	17.7	2.1
Savannah River Site	University of Texas	1169.0	71.4	26.6	1.9
Savannah River Site	University of Utah	2127.0	82.3	16.0	1.7
Savannah River Site	University of Virginia	478.0	73.1	25.9	1.0
Savannah River Site	University of Wisconsin	1038.0	67.9	29.4	2.8
Savannah River Site	Washington State University	2699.0	84.8	14.1	1.2
Savannah River Site	Worcester Polytechnic Institute	1002.0	54.2	38.8	7.1
	Train routes				
Savannah River Site	Cornell University	1098.0	61.2	33.7	5.1
Savannah River Site	Georgia Institute of Technology	221.0	65.5	28.3	6.2
Savannah River Site	Idaho State University	2323.0	81.7	16.2	2.1
Savannah River Site	Iowa State University	1281.0	66.8	28.4	4.8
Savannah River Site	Kansas State University	1274.0	69.3	27.0	3.7
Savannah River Site	Manhattan College	1156.0	51.1	37.0	11.9
Savannah River Site	Massachusetts Institute of Technology	1223.0	50.6	36.6	12.8
Savannah River Site	North Carolina State University	385.0	78.6	20.1	1.3
Savannah River Site	Ohio State University	726.0	73.6	25.0	1.4

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Savannah River Site	Oregon State University	3381.0	84.4	13.7	1.9
Savannah River Site	Pennsylvania State University	963.0	65.5	29.6	4.9
Savannah River Site	Purdue University	903.0	64.6	32.4	3.0
Savannah River Site	Reed College	3154.0	82.0	15.4	2.6
Savannah River Site	Rensselaer Polytechnic Institute	1044.0	52.3	34.9	12.8
Savannah River Site	Rhode Island Nuclear Science Center	1252.0	50.6	37.0	12.4
Savannah River Site	State University of New York - Buffalo	1051.0	65.1	30.8	4.1
Savannah River Site	Texas A&M University	1194.0	66.5	29.1	4.4
Savannah River Site	University of Arizona	2245.0	79.4	17.5	3.1
Savannah River Site	University of California - Irvine	3180.0	82.1	15.3	2.6
Savannah River Site	University of Florida	328.0	84.7	13.6	1.7
Savannah River Site	University of Illinois	1028.0	67.7	28.6	3.7
Savannah River Site	University of Lowell	1239.0	51.6	37.2	11.2
Savannah River Site	University of Maryland	669.0	67.8	27.6	4.6
Savannah River Site	University of Michigan	913.0	68.2	29.2	2.5
Savannah River Site	University of Missouri - Columbia	1011.0	66.6	29.5	4.0
Savannah River Site	University of Missouri - Rolla	966.0	65.3	30.7	4.0
Savannah River Site	University of New Mexico	2315.0	79.9	18.1	2.1
Savannah River Site	University of Texas	1314.0	71.8	23.6	4.6
Savannah River Site	University of Utah	2378.0	80.3	17.5	2.2
Savannah River Site	University of Virginia	637.0	75.1	22.8	2.2
Savannah River Site	University of Wisconsin	1092.0	62.7	32.0	5.3
Savannah River Site	Washington State University	2864.0	81.4	16.0	2.5
Savannah River Site	Worcester Polytechnic Institute	1176.0	52.1	35.8	12.1
	Truck routes				
Hanford Site	Cornell University	2730.0	82.7	15.4	1.9
Hanford Site	Georgia Institute of Technology	2550.0	85.6	13.0	1.4
Hanford Site	Idaho State University	546.0	90.2	8.1	1.7
Hanford Site	Iowa State University	1703.0	92.6	6.6	0.8
Hanford Site	Kansas State University	1624.0	92.8	6.5	0.7
Hanford Site	Manhattan College	2786.0	85.0	13.5	1.5
Hanford Site	Massachusetts Institute of Technology	2986.0	81.5	17.0	1.6
Hanford Site	North Carolina State University	2862.0	83.2	15.5	1.3
Hanford Site	Ohio State University	2342.0	88.3	10.6	1.1

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Hanford Site	Oregon State University	324.0	79.5	16.3	4.2
Hanford Site	Pennsylvania State University	2578.0	86.2	12.7	1.1
Hanford Site	Purdue University	2111.0	90.0	8.9	1.1
Hanford Site	Reed College	236.0	86.0	10.7	3.4
Hanford Site	Rensselaer Polytechnic Institute	2819.0	82.0	16.1	1.9
Hanford Site	Rhode Island Nuclear Science Center	2965.0	81.2	15.9	2.9
Hanford Site	State University of New York - Buffalo	2534.0	84.8	13.4	1.8
Hanford Site	Texas A&M University	2212.0	88.7	9.7	1.6
Hanford Site	University of Arizona	1699.0	80.2	14.7	5.0
Hanford Site	University of California - Irvine	1270.0	79.3	14.5	6.2
Hanford Site	University of Florida	2894.0	84.1	14.6	1.4
Hanford Site	University of Illinois	2033.0	91.2	8.0	0.8
Hanford Site	University of Lowell	2991.0	81.4	17.1	1.5
Hanford Site	University of Maryland	2753.0	84.7	13.8	1.5
Hanford Site	University of Michigan	2227.0	87.0	11.8	1.2
Hanford Site	University of Missouri - Columbia	1870.0	90.6	8.3	1.1
Hanford Site	University of Missouri - Rolla	2082.0	88.4	10.2	1.4
Hanford Site	University of New Mexico	1593.0	89.7	8.8	1.5
Hanford Site	University of Texas	2216.0	87.0	11.5	1.5
Hanford Site	University of Utah	643.0	87.5	10.6	1.9
Hanford Site	University of Virginia	2757.0	86.1	12.4	1.5
Hanford Site	University of Wisconsin	1943.0	88.2	10.8	1.0
Hanford Site	Washington State University	361.0	87.3	11.6	1.1
Hanford Site	Worcester Polytechnic Institute	2948.0	82.2	16.3	1.5
	Train routes				
Hanford Site	Cornell University	2842.0	81.0	15.4	3.6
Hanford Site	Georgia Institute of Technology	2732.0	86.3	12.3	1.4
Hanford Site	Idaho State University	602.0	92.2	6.6	1.2
Hanford Site	Iowa State University	1788.0	93.7	5.6	0.7
Hanford Site	Kansas State University	1743.0	95.4	4.1	0.6
Hanford Site	Manhattan College	3070.0	77.0	19.1	3.9
Hanford Site	Massachusetts Institute of Technology	3105.0	77.5	18.7	3.8
Hanford Site	North Carolina State University	3172.0	83.8	14.6	1.7
Hanford Site	Ohio State University	2482.0	86.1	11.0	2.9

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Hanford Site	Oregon State University	340.0	70.6	22.2	7.2
Hanford Site	Pennsylvania State University	2760.0	79.3	16.7	4.0
Hanford Site	Purdue University	2359.0	90.8	8.0	1.1
Hanford Site	Reed College	239.0	82.1	13.4	4.5
Hanford Site	Rensselaer Polytechnic Institute	2934.0	78.6	17.3	4.0
Hanford Site	Rhode Island Nuclear Science Center	3166.0	76.0	19.6	4.4
Hanford Site	State University of New York - Buffalo	2637.0	81.7	14.6	3.7
Hanford Site	Texas A&M University	2954.0	85.2	11.2	3.7
Hanford Site	University of Arizona	1804.0	80.2	14.5	5.4
Hanford Site	University of California - Irvine	1528.0	88.2	8.6	3.2
Hanford Site	University of Florida	3138.0	85.5	13.0	1.5
Hanford Site	University of Illinois	2158.0	93.0	6.0	1.0
Hanford Site	University of Lowell	3095.0	77.6	18.6	3.9
Hanford Site	University of Maryland	2900.0	82.6	13.7	3.8
Hanford Site	University of Michigan	2369.0	85.7	11.4	2.9
Hanford Site	University of Missouri - Columbia	1948.0	94.1	5.3	0.6
Hanford Site	University of Missouri - Rolla	2246.0	89.1	9.3	1.6
Hanford Site	University of New Mexico	1796.0	91.5	7.2	1.2
Hanford Site	University of Texas	2473.0	89.8	8.9	1.3
Hanford Site	University of Utah	774.0	89.6	8.8	1.7
Hanford Site	University of Virginia	2902.0	83.9	13.4	2.7
Hanford Site	University of Wisconsin	2210.0	88.9	9.2	1.9
Hanford Site	Washington State University	251.0	86.0	9.4	4.5
Hanford Site	Worcester Polytechnic Institute	3089.0	77.2	18.7	4.1
	Truck routes				
Idaho National Engineering Laboratory	Cornell University	2314.0	80.9	17.1	2.1
Idaho National Engineering Laboratory	Georgia Institute of Technology	2134.0	84.2	14.4	1.4
Idaho National Engineering Laboratory	Idaho State University	65.0	83.7	12.5	3.9
Idaho National Engineering Laboratory	Iowa State University	1287.0	92.5	6.8	0.7
Idaho National Engineering Laboratory	Kansas State University	1208.0	92.8	6.7	0.5

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Idaho National Engineering Laboratory	Manhattan College	2370.0	83.6	14.8	1.6
Idaho National Engineering Laboratory	Massachusetts Institute of Technology	2570.0	79.6	18.7	1.6
Idaho National Engineering Laboratory	North Carolina State University	2446.0	81.5	17.2	1.3
Idaho National Engineering Laboratory	Ohio State University	1926.0	87.3	11.6	1.1
Idaho National Engineering Laboratory	Oregon State University	809.0	87.2	10.7	2.2
Idaho National Engineering Laboratory	Pennsylvania State University	2162.0	84.9	14.0	1.1
Idaho National Engineering Laboratory	Purdue University	1695.0	89.3	9.6	1.1
Idaho National Engineering Laboratory	Reed College	721.0	90.2	8.1	1.6
Idaho National Engineering Laboratory	Rensselaer Polytechnic Institute	2403.0	80.1	17.9	2.0
Idaho National Engineering Laboratory	Rhode Island Nuclear Science Center	2549.0	79.3	17.5	3.2
Idaho National Engineering Laboratory	State University of New York - Buffalo	2118.0	83.2	14.8	2.0
Idaho National Engineering Laboratory	Texas A&M University	1796.0	87.7	10.5	1.7
Idaho National Engineering Laboratory	University of Arizona	1301.0	83.8	12.9	3.3
Idaho National Engineering Laboratory	University of California - Irvine	942.0	79.8	13.8	6.4
Idaho National Engineering Laboratory	University of Florida	2478.0	82.6	16.0	1.4
Idaho National Engineering Laboratory	University of Illinois	1617.0	90.8	8.5	0.7
Idaho National Engineering Laboratory	University of Lowell	2575.0	79.5	18.9	1.5
Idaho National Engineering Laborstory	University of Maryland	2337.0	83.3	15.2	1.6
Idaho National Engineering Laboratory	University of Michigan	1811.0	85.6	13.2	1.2
Idaho National Engineering Laborstory	University of Missouri - Columbia	1454.0	90.0	8.9	1.1
Idaho National Engineering Laboratory	University of Missouri - Rolla	1666.0	87.3	11.3	1.5
Idaho National Engineering Laboratory	University of New Mexico	1177.0	88.6	9.8	1.6

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Idaho National Engineering Laboratory	University of Texas	1800.0	85.7	12.7	1.6
Idaho National Engineering Laboratory	University of Utah	227.0	77.7	18.9	3.4
Idaho National Engineering Laboratory	University of Virginia	2341.0	85.0	13.5	1.5
Idaho National Engineering Laboratory	University of Wisconsin	1612.0	89.8	9.2	1.0
Idaho National Engineering Laboratory	Washington State University	652.0	91.9	7.3	0.8
Idaho National Engineering Laboratory	Worcester Polytechnic Institute	2532.0	80.4	18.0	1.6
	Train routes				
Idaho National Engineering Laboratory	Cornell University	2296.0	78.1	17.6	4.2
Idaho National Engineering Laboratory	Georgia Institute of Technology	2186.0	84.5	13.9	1.6
Idaho National Engineering Laboratory	Idaho State University	56.0	82.5	13.2	4.3
Idaho National Engineering Laboratory	Iowa State University	1242.0	93.9	5.4	0.7
Idaho National Engineering Laboratory	Kansas State University	1197.0	96.3	3.2	0.4
Idaho National Engineering Laboratory	Manhattan College	2524.0	73.5	21.9	4.6
Idaho National Engineering Laboratory	Massachusetts Institute of Technology	2559.0	74.1	21.5	4.4
Idaho National Engineering Laboratory	North Carolina State University	2626.0	81.8	16.4	1.8
Idaho National Engineering Laboratory	Ohio State University	1936.0	84.1	12.5	3.4
Idaho National Engineering Laboratory	Oregon State University	878.0	87.2	9.7	3.1
Idaho National Engineering Laboratory	Pennsylvania State University	2214.0	75.9	19.4	4.7
Idaho National Engineering Laboratory	Purdue University	1813.0	90.1	8.7	1.2
Idaho National Engineering Laboratory	Reed College	785.0	92.6	5.8	1.6
Idaho National Engineering Laboratory	Rensselaer Polytechnic Institute	2388.0	75.3	19.9	4.8
Idaho National Engineering Laboratory	Rhode Island Nuclear Science Center	2620.0	72.4	22.5	5.1

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Idaho National Engineering Laboratory	State University of New York - Buffalo	2091.0	78.7	16.9	4.4
Idaho National Engineering Laboratory	Texas A&M University	1920.0	89.6	9.4	1.0
Idaho National Engineering Laboratory	University of Arizona	1376.0	90.8	7.3	1.9
Idaho National Engineering Laboratory	University of California - Irvine	982.0	85.4	10.0	4.5
Idaho National Engineering Laboratory	University of Florida	2592.0	83.8	14.6	1.6
Idaho National Engineering Laboratory	University of Illinois	1612.0	92.9	6.0	1.1
Idaho National Engineering Laboratory	University of Lowell	2549.0	74.2	21.3	4.5
Idaho National Engineering Laboratory	University of Maryland	2354.0	80.1	15.5	4.4
Idaho National Engineering Laboratory	University of Michigan	1823.0	83.4	13.0	3.6
Idaho National Engineering Laboratory	University of Missouri - Columbia	1402.0	94.4	5.1	0.5
Idaho National Engineering Laboratory	University of Missouri - Rolla	1619.0	92.6	6.1	1.3
Idaho National Engineering Laboratory	University of New Mexico	1250.0	90.8	7.8	1.4
Idaho National Engineering Laboratory	University of Texas	1927.0	88.8	9.8	1.4
Idaho National Engineering Laboratory	University of Utah	228.0	80.7	15.6	3.7
Idaho National Engineering Laboratory	University of Virginia	2357.0	81.8	15.1	3.1
Idaho National Engineering Laboratory	University of Wisconsin	1664.0	87.5	10.3	2.2
Idaho National Engineering Laboratory	Washington State University	876.0	92.2	6.2	1.6
Idaho National Engineering Laboratory	Worcester Polytechnic Institute	2544.0	73.8	21.5	4.7
	Truck routes				
Oak Ridge Reservation	Cornell University	821.0	65.7	33.2	1.1
Oak Ridge Reservation	Georgia Institute of Technology	202.0	53.2	45.1	1.8
Oak Ridge Reservation	Idaho State University	1985.0	86.8	12.0	1.2
Oak Ridge Reservation	Iowa State University	900.0	75.2	23.4	1.5
Oak Ridge Reservation	Kansas State University	857.0	78.6	19.2	2.2

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Oak Ridge Reservation	Manhattan College	754.0	60.9	36.4	2.7
Oak Ridge Reservation	Massachusetts Institute of Technology	965.0	51.6	41.1	7.4
Oak Ridge Reservation	North Carolina State University	408.0	54.5	43.7	1.8
Oak Ridge Reservation	Ohio State University	400.0	67.7	31.1	1.2
Oak Ridge Reservation	Oregon State University	2674.0	86.8	11.7	1.5
Oak Ridge Reservation	Pennsylvania State University	774.0	69.1	30.1	0.8
Oak Ridge Reservation	Purdue University	460.0	68.6	30.2	1.3
Oak Ridge Reservation	Reed College	2585.0	87.7	11.0	1.3
Oak Ridge Reservation	Rensselaer Polytechnic Institute	879.0	63.4	35.5	1.1
Oak Ridge Reservation	Rhode Island Nuclear Science Center	933.0	53.4	39.8	6.8
Oak Ridge Reservation	State University of New York - Buffalo	744.0	61.9	35.6	2.5
Oak Ridge Reservation	Texas A&M University	1004.0	81.5	17.2	1.3
Oak Ridge Reservation	University of Arizona	1782.0	83.2	15.1	1.7
Oak Ridge Reservation	University of California - Irvine	2209.0	86.0	10.9	3.0
Oak Ridge Reservation	University of Florida	546.0	65.4	33.1	1.5
Oak Ridge Reservation	University of Illinois	516.0	68.0	29.9	2.2
Oak Ridge Reservation	University of Lowell	970.0	51.4	41.5	7.1
Oak Ridge Reservation	University of Maryland	537.0	70.2	27.2	2.6
Oak Ridge Reservation	University of Michigan	595.0	57.8	38.5	3.7
Oak Ridge Reservation	University of Missouri - Columbia	594.0	79.0	19.5	1.5
Oak Ridge Reservation	University of Missouri - Rolla	571.0	80.2	19.0	0.9
Oak Ridge Reservation	University of New Mexico	1391.0	85.4	12.9	1.7
Oak Ridge Reservation	University of Texas	1026.0	76.9	20.9	2.2
Oak Ridge Reservation	University of Utah	1864.0	86.6	12.1	1.3
Oak Ridge Reservation	University of Virginia	402.0	72.8	26.4	0.8
Oak Ridge Reservation	University of Wisconsin	730.0	66.1	30.0	3.9
Oak Ridge Reservation	Washington State University	2435.0	88.3	10.8	0.9
Oak Ridge Reservation	Worcester Polytechnic Institute	927.0	52.5	40.0	7.5
	Train routes				
Oak Ridge Reservation	Cornell University	935.0	60.9	32.8	6.3
Oak Ridge Reservation	Georgia Institute of Technology	228.0	47.1	50.9	2.0
Oak Ridge Reservation	Idaho State University	1996.0	89.9	8.5	1.6
Oak Ridge Reservation	Iowa State University	954.0	71.7	22.0	6.3
Oak Ridge Reservation	Kansas State University	948.0	82.2	14.7	3.1

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Oak Ridge Reservation	Manhattan College	1164.0	54.3	39.1	6.6
Oak Ridge Reservation	Massachusetts Institute of Technology	1199.0	56.1	37.7	6.2
Oak Ridge Reservation	North Carolina State University	511.0	60.9	36.9	2.2
Oak Ridge Reservation	Ohio State University	406.0	66.9	27.8	5.3
Oak Ridge Reservation	Oregon State University	3055.0	90.0	8.4	1.6
Oak Ridge Reservation	Pennsylvania State University	822.0	55.2	37.4	7.3
Oak Ridge Reservation	Purdue University	495.0	74.4	22.6	3.0
Oak Ridge Reservation	Reed College	2827.0	85.5	12.1	2.4
Oak Ridge Reservation	Rensselaer Polytechnic Institute	1028.0	55.9	36.8	7.3
Oak Ridge Reservation	Rhode Island Nuclear Science Center	1259.0	53.5	39.0	7.5
Oak Ridge Reservation	State University of New York - Buffalo	731.0	57.7	34.9	7.4
Oak Ridge Reservation	Texas A&M University	1013.0	80.0	18.6	1.5
Oak Ridge Reservation	University of Arizona	2103.0	85.1	12.9	2.0
Oak Ridge Reservation	University of California - Irvine	2615.0	88.0	9.5	2.5
Oak Ridge Reservation	University of Florida	634.0	68.2	29.9	1.9
Oak Ridge Reservation	University of Illinois	592.0	75.4	21.3	3.3
Oak Ridge Reservation	University of Lowell	1189.0	56.2	37.4	6.4
Oak Ridge Reservation	University of Maryland	582.0	53.9	40.4	5.6
Oak Ridge Reservation	University of Michigan	591.0	63.3	30.1	6.6
Oak Ridge Reservation	University of Missouri - Columbia	695.0	82.5	14.2	3.3
Oak Ridge Reservation	University of Missouri - Rolla	640.0	82.3	14.4	3.3
Oak Ridge Reservation	University of New Mexico	1749.0	87.9	10.3	1.8
Oak Ridge Reservation	University of Texas	1045.0	75.7	22.1	2.1
Oak Ridge Reservation	University of Utah	2051.0	88.0	10.3	1.7
Oak Ridge Reservation	University of Virginia	451.0	53.6	44.1	2.3
Oak Ridge Reservation	University of Wisconsin	765.0	67.1	25.5	7.4
Oak Ridge Reservation	Washington State University	2536.0	85.3	12.4	2.3
Oak Ridge Reservation	Worcester Polytechnic Institute	1183.0	55.2	37.9	6.9
	Truck routes				
Nevada Test Site	Cornell University	2547.0	81.7	16.1	2.2
Nevada Test Site	Georgia Institute of Technology	2238.0	84.4	13.8	1.7
Nevada Test Site	Idaho State University	649.0	82.5	13.8	3.6
Nevada Test Site	Iowa State University	1520.0	92.0	6.8	1.2
Nevada Test Site	Kansas State University	1312.0	92.5	6.4	1.1

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Nevada Test Site	Manhattan College	2603.0	84.1	14.0	1.8
Nevada Test Site	Massachusetts Institute of Technology	2802.0	80.5	17.7	1.8
Nevada Test Site	North Carolina State University	2549.0	81.9	16.5	1.6
Nevada Test Site	Ohio State University	2098.0	85.8	12.3	2.0
Nevada Test Site	Oregon State University	1245.0	81.8	13.5	4.7
Nevada Test Site	Pennsylvania State University	2395.0	85.3	13.3	1.4
Nevada Test Site	Purdue University	1928.0	89.3	9.2	1.5
Nevada Test Site	Reed College	1250.0	86.4	10.8	2.8
Nevada Test Site	Rensselaer Polytechnic Institute	2636.0	81.0	16.9	2.2
Nevada Test Site	Rhode Island Nuclear Science Center	2782.0	80.1	16.6	3.2
Nevada Test Site	State University of New York - Buffalo	2350.0	83.8	14.0	2.2
Nevada Test Site	Texas A&M University	1852.0	85.6	11.9	2.5
Nevada Test Site	University of Arizona	723.0	85.0	11.1	3.9
Nevada Test Site	University of California - Irvine	364.0	76.1	11.6	12.4
Nevada Test Site	University of Florida	2582.0	82.9	15.4	1.7
Nevada Test Site	University of Illinois	1850.0	90.6	8.3	1.1
Nevada Test Site	University of Lowell	2808.0	80.3	17.9	1.8
Nevada Test Site	University of Maryland	2509.0	82.3	15.5	2.2
Nevada Test Site	University of Michigan	2044.0	86.1	12.4	1.5
Nevada Test Site	University of Missouri - Columbia	1557.0	89.9	8.5	1.6
Nevada Test Site	University of Missouri - Rolla	1769.0	87.4	10.7	1.8
Nevada Test Site	University of New Mexico	918.0	93.8	4.8	1.5
Nevada Test Site	University of Texas	1662.0	86.5	10.5	3.0
Nevada Test Site	University of Utah	487.0	85.0	11.4	3.6
Nevada Test Site	University of Virginia	2444.0	85.2	13.0	1.8
Nevada Test Site	University of Wisconsin	1857.0	90.5	8.2	1.3
Nevada Test Site	Washington State University	1286.0	86.6	11.1	2.4
Nevada Test Site	Worcester Polytechnic Institute	2765.0	81.2	17.0	1.8
	Train routes				
Nevada Test Site	Cornell University	2727.0	80.7	15.5	3.8
Nevada Test Site	Georgia Institute of Technology	2618.0	86.1	12.3	1.6
Nevada Test Site	Idaho State University	700.0	93.6	5.4	1.0
Nevada Test Site	Iowa State University	1674.0	94.0	5.1	0.9
Nevada Test Site	Kansas State University	1628.0	95.8	3.5	0.7

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Nevada Test Site	Manhattan College	2956.0	76.6	19.3	4.1
Nevada Test Site	Massachusetts Institute of Technology	2990.0	77.0	19.0	4.0
Nevada Test Site	North Carolina State University	3058.0	83.6	14.7	1.8
Nevada Test Site	Ohio State University	2367.0	86.0	11.0	3.1
Nevada Test Site	Oregon State University	1400.0	79.8	14.7	5.4
Nevada Test Site	Pennsylvania State University	2646.0	78.9	16.9	4.2
Nevada Test Site	Purdue University	2245.0	90.9	7.8	1.3
Nevada Test Site	Reed College	1429.0	93.5	5.3	1.2
Nevada Test Site	Rensselaer Polytechnic Institute	2820.0	78.2	17.5	4.3
Nevada Test Site	Rhode Island Nuclear Science Center	3051.0	75.6	19.9	4.6
Nevada Test Site	State University of New York - Buffalo	2522.0	81.4	14.7	3.9
Nevada Test Site	Texas A&M University	1967.0	92.0	6.6	1.4
Nevada Test Site	University of Arizona	818.0	90.6	7.4	2.0
Nevada Test Site	University of California -Irvine	424.0	78.0	13.8	8.2
Nevada Test Site	University of Florida	3024.0	85.3	13.1	1.6
Nevada Test Site	University of Illinois	2044.0	93.2	5.6	1.2
Nevada Test Site	University of Lowell	2980.0	77.2	18.8	4.1
Nevada Test Site	University of Maryland	2786.0	82.3	13.7	4.0
Nevada Test Site	University of Michigan	2255.0	85.5	11.3	3.2
Nevada Test Site	University of Missouri - Columbia	1833.0	94.4	4.8	0.7
Nevada Test Site	University of Missouri - Rolla	2050.0	93.0	5.7	1.4
Nevada Test Site	University of New Mexico	1065.0	94.6	4.5	0.9
Nevada Test Site	University of Texas	2358.0	89.9	8.7	1.4
Nevada Test Site	University of Utah	528.0	98.0	1.8	0.2
Nevada Test Site	University of Virginia	2788.0	83.7	13.4	2.9
Nevada Test Site	University of Wisconsin	2096.0	88.9	9.0	2.1
Nevada Test Site	Washington State University	1520.0	93.2	5.6	1.2
Nevada Test Site	Worcester Polytechnic Institute	2975.0	76.8	18.9	4.3
	Truck routes				
West Valley Demonstration Plant	Savannah River Site	883.0	70.3	28.5	1.2
West Valley Demonstration Plant	Hanford Site	2556.0	84.6	13.7	1.7
West Valley Demonstration Plant	Idaho National Engineering Laboratory	2140.0	83.0	15.2	1.8

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
West Valley Demonstration Plant	Oak Ridge Reservation	766.0	62.2	36.0	1.8
West Valley Demonstration Plant	Nevada Test Site	2373.0	83.7	14.3	2.0
Babcock & Wilcox	Savannah River Site	455.0	71.0	28.2	0.9
Babcock & Wilcox	Hanford Site	2738.0	85.9	12.7	1.4
Babcock & Wilcox	Idaho National Engineering Laboratory	2322.0	84.7	13.8	1.5
Babcock & Wilcox	Oak Ridge Reservation	350.0	65.4	33.8	0.8
Babcock & Wilcox	Nevada Test Site	2491.0	84.0	14.5	1.5
	Train routes				
West Valley Demonstration Plant	Savannah River Site	1217.0	62.8	32.4	4.9
West Valley Demonstration Plant	Hanford Site	2654.0	78.3	18.0	3.7
West Valley Demonstration Plant	Idaho National Engineering Laboratory	2108.0	74.9	20.5	4.7
West Valley Demonstration Plant	Oak Ridge Reservation	889.0	64.5	30.1	5.5
West Valley Demonstration Plant	Nevada Test Site	2554.0	80.8	15.1	4.0
Babcock & Wilcox	Savannah River Site	661.0	76.8	21.5	1.6
Babcock & Wilcox	Hanford Site	2879.0	84.2	13.1	2.7
Babcock & Wilcox	Idaho National Engineering Laboratory	2333.0	82.1	14.8	3.2
Babcock & Wilcox	Oak Ridge Reservation	386.0	48.0	49.6	2.4
Babcock & Wilcox	Nevada Test Site	2765.0	84.0	13.1	2.9
Three Mile Island	Idaho National Engineering Laboratory	2315.0	75.8	19.6	4.6
	Truck routes				
Pleasanton, CA	Idaho National Engineering Laboratory	969.0	84.0	12.2	3.8
Pleasanton, CA	Hanford Site	881.0	77.5	19.1	3.4
Pleasanton, CA	Savannah River Site	2768.0	80.1	16.8	3.1
Pleasanton, CA	Oak Ridge Reservation	2532.0	87.0	10.5	2.5
Pleasanton, CA	Nevada Test Site	687.0	84.3	9.6	6.1
Gaithersburg, MD	Idaho National Engineering Laboratory	2316.0	83.9	14.9	1.2
Gaithersburg, MD	Hanford Site	2732.0	85.3	13.5	1.2
Gaithersburg, MD	Savannah River Site	597.0	66.8	30.7	2.5
Gaithersburg, MD	Oak Ridge Reservation	536.0	70.6	27.4	2.0
Gaithersburg, MD	Nevada Test Site	2488.0	82.9	15.2	1.9

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
San Ramon, CA	Idaho National Engineering Laboratory	962.0	84.4	12.0	3.6
San Ramon, CA	Hanford Site	874.0	77.9	18.9	3.2
San Ramon, CA	Savannah River Site	2775.0	80.0	16.9	3.1
San Ramon, CA	Oak Ridge Reservation	2538.0	86.8	10.5	2.6
San Ramon, CA	Nevada Test Site	694.0	83.7	9.9	6.3
Midland, MI	Idaho National Engineering Laboratory	1902.0	82.9	15.8	1.3
Midland, MI	Hanford Site	2318.0	84.7	14.0	1.3
Midland, MI	Savannah River Site	1036.0	58.9	37.9	3.2
Midland, MI	Oak Ridge Reservation	719.0	52.7	42.7	4.6
Midland, MI	Nevada Test Site	2135.0	83.6	14.8	1.6
San Diego, CA	Idaho National Engineering Laboratory	976.0	78.8	17.1	4.1
San Diego, CA	Hanford Site	1352.0	76.3	16.0	7.7
San Diego, CA	Savannah River Site	2345.0	81.0	17.0	2.0
San Diego, CA	Oak Ridge Reservation	2193.0	84.1	13.8	2.1
San Diego, CA	Nevada Test Site	398.0	73.9	19.8	6.3
Denver, CO	Idaho National Engineering Laboratory	717.0	91.2	7.9	0.9
Denver, CO	Hanford Site	1133.0	91.8	7.2	1.0
Denver, CO	Savannah River Site	1613.0	79.2	18.9	1.9
Denver, CO	Oak Ridge Reservation	1340.0	84.5	14.1	1.5
Denver, CO	Nevada Test Site	819.0	90.7	7.5	1.8
McClellan AFB, CA	Idaho National Engineering Laboratory	875.0	88.6	8.8	2.6
McClellan AFB, CA	Hanford Site	830.0	80.5	17.0	2.6
McClellan AFB, CA	Savannah River Site	2780.0	84.4	13.7	1.9
McClellan AFB, CA	Oak Ridge Reservation	2517.0	87.8	10.5	1.6
McClellan AFB, CA	Nevada Test Site	735.0	81.1	11.2	7.6
	Train routes				
Pleasanton, CA	Idaho National Engineering Laboratory	965.0	85.6	10.4	4.0
Pleasanton, CA	Hanford Site	1002.0	77.5	16.0	6.4
Pleasanton, CA	Savannah River Site	3170.0	79.6	16.5	3.8
Pleasanton, CA	Oak Ridge Reservation	3029.0	83.5	13.4	3.1
Pleasanton, CA	Nevada Test Site	838.0	76.2	17.4	6.3
Gaithersburg, MD	Idaho National Engineering Laboratory	2335.0	80.5	15.4	4.0
Gaithersburg, MD	Hanford Site	2881.0	83.0	13.6	3.4
Gaithersburg, MD	Savannah River Site	659.0	68.4	27.7	3.8

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Gaithersburg, MD	Oak Ridge Reservation	819.0	59.4	37.3	3.3
Gaithersburg, MD	Nevada Test Site	2767.0	82.7	13.7	3.6
San Ramon, CA	Idaho National Engineering Laboratory	965.0	85.6	10.4	4.0
San Ramon, CA	Hanford Site	1002.0	77.5	16.0	6.4
San Ramon, CA	Savannah River Site	3170.0	79.6	16.6	3.8
San Ramon, CA	Oak Ridge Reservation	3029.0	83.5	13.4	3.1
San Ramon, CA	Nevada Test Site	838.0	76.2	17.4	6.3
Midland, MI	Idaho National Engineering Laboratory	1961.0	82.3	14.2	3.5
Midland, MI	Hanford Site	2507.0	84.7	12.4	2.9
Midland, MI	Savannah River Site	996.0	65.9	31.2	2.9
Midland, MI	Oak Ridge Reservation	645.0	58.4	37.3	4.3
Midland, MI	Nevada Test Site	2392.0	84.5	12.4	3.1
San Diego, CA	Idaho National Engineering Laboratory	1076.0	82.6	11.4	6.0
San Diego, CA	Hanford Site	1622.0	86.2	9.5	4.3
San Diego, CA	Savannah River Site	3274.0	81.3	15.6	3.1
San Diego, CA	Oak Ridge Reservation	2709.0	86.8	10.0	3.1
San Diego, CA	Nevada Test Site	518.0	73.4	15.9	10.7
Denver, CO	Idaho National Engineering Laboratory	708.0	94.7	4.6	0.6
Denver, CO	Hanford Site	1254.0	94.1	5.2	0.7
Denver, CO	Savannah River Site	2125.0	77.0	20.5	2.6
Denver, CO	Oak Ridge Reservation	1560.0	85.0	12.6	2.3
Denver, CO	Nevada Test Site	1140.0	94.6	4.4	0.9
McClellan AFB, CA	Idaho National Engineering Laboratory	853.0	90.3	7.8	1.9
McClellan AFB, CA	Hanford Site	890.0	81.0	14.3	4.7
McClellan AFB, CA	Savannah River Site	3160.0	79.4	16.7	3.9
McClellan AFB, CA	Oak Ridge Reservation	2747.0	87.8	10.2	2.0
McClellan AFB, CA	Nevada Test Site	827.0	75.4	17.7	6.9

I-3.2 Spent Nuclear Fuel Shipments

In the transportation analyses, SNF was divided into a number of categories: (a) commercial, (b) DOE research, (c) foreign research reactor, (d) graphite, (e) N Reactor, (f) naval-type, (g) Savannah River Site production reactor, and (h) university research reactor. More details on these fuel types may be found in Appendix J of Volume 1 of this EIS. The estimated number of SNF shipments are presented by fuel type, origin-destination pair, and transport mode for each alternative in Tables I-2 and I-3 (Heiselmann 1995). Each shipment, whether by truck or rail, was assumed to consist of one shipping container. However, the size of shipping container was variable, depending on the type of SNF and the transport mode (truck or rail). At this time, insufficient data exist to determine the transport mode for all shipments. Therefore, the number of truck or rail shipments was based on either 100 percent transport by truck or 100 percent transport by rail to bound potential impacts.

The shipments in this appendix include offsite transport of naval-type SNF stored at the Idaho Chemical Processing Plant as of June 1995 to storage locations at other sites as identified in the alternatives. Transport of naval SNF from shipyards and prototypes to the equivalent Expended Core Facility at the alternative sites are addressed in Appendix D of Volume I of this EIS, along with transport of naval test specimens.

This appendix also includes transport of foreign research reactor SNF from the six points of entry identified in the Implementation Plan for this EIS (Hampton Roads, Virginia; Charleston, South Carolina; Savannah, Georgia; Seattle-Tacoma, Washington; Portland, Oregon; and Oakland, California) to sites as identified in the alternatives. Impacts of shipments to the Military Ocean Terminal at Sunny Point, North Carolina, were analyzed because this terminal was recently used for foreign research reactor SNF shipments. Impacts of shipments to Galveston, Texas, were analyzed because this point of entry is on the Gulf Coast and has container-handling experience. The ocean-going portion of foreign research reactor SNF shipments and a detailed evaluation of point of entry activities are not assessed in this EIS, but will be assessed in the Environmental Impact Statement on a Proposed Nuclear Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel.

The No Action alternative considers only transport of naval SNF and test specimens. These shipments are addressed in Appendix D of Volume 1 of this EIS. For the Decentralization alternative, university research reactor, foreign research reactor, and non-DOE research reactor SNF would be transported to the Idaho National Engineering Laboratory or the Savannah River Site.

For the 1992/1993 Planning Basis alternative, commercial, DOE research, and graphite SNF would be transported to the Idaho National Engineering Laboratory or the Savannah River Site. University research reactor, foreign research reactor, and non-DOE research reactor SNF would also continue to be transported to the Idaho National Engineering Laboratory or the Savannah River Site.

For the Regionalization alternatives, SNF would be consolidated based on fuel type or geography. More shipments of SNF would occur than for the 1992/1993 Planning Basis alternative and all types of SNF would be transported. For the Regionalization by Fuel Type alternative, N-Reactor SNF, naval-type SNF, and Savannah River Site production reactor SNF and targets would not be transported. Generally, aluminum SNF would be transported to the Savannah River Site and stainless steel SNF would be transported to the Idaho National Engineering Laboratory. For the Regionalization by Geography alternative, SNF from west of the Mississippi River would be transported to the Hanford Site, the Idaho National Engineering Laboratory, or the Nevada Test Site. SNF from east of the Mississippi River would be transported to the Savannah River Site or the Oak Ridge Reservation.

For the Centralization alternatives, all SNF would be transported to the Hanford Site, the Idaho National Engineering Laboratory, the Savannah River Site, the Oak Ridge Reservation, or the Nevada Test Site. The primary difference between these alternatives, in terms of shipments, is the transport of N-Reactor SNF, naval-type SNF, and Savannah River Site production reactor SNF and targets. For Centralization at the Idaho National Engineering Laboratory, the Savannah River Site, the Oak Ridge Reservation, or the Nevada Test Site, N-Reactor SNF would be transported from the Hanford Site. For Centralization at the Hanford Site, the Idaho National Engineering Laboratory, the Oak Ridge Reservation, or the Nevada Test Site, Savannah River Site production reactor SNF and targets would be transported. For Centralization at the Hanford Site, the Savannah River Site, the Oak Ridge Reservation, or the Nevada Test Site, naval-type SNF would be transported from the Idaho National Engineering Laboratory. For Centralization at the Oak Ridge Reservation or the Nevada Test Site, N-Reactor SNF, naval-type SNF, and Savannah River Site production reactor SNF and targets would be transported.

Table I-2. Spent nuclear fuel shipments for the Decentralization, 1992/1993 Planning Basis, Regionalization by Fuel Type, and Centralization alternatives.

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization HS		Centralization SRS		Centralization INEL		Centralization ORR		Centralization NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Naval-Type																	
INEL	HS							383	104								
	NTS															383	104
	ORR													383	104		
	SRS									383	104						
Savannah River Production																	
SRS	HS							484	97								
	INEL											484	97				
	ORR													484	97		
	NTS															484	97
ORR	SRS					1	1										
Hanford Production																	
HS	INEL											1192	605				
	SRS									1192	605						
	ORR													1192	605		
	NTS															1192	605
ORR	INEL					1	1										

Table I-2. (continued).

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Graphite																	
FSV	HS							244	35								
	INEL			244	35	244	35					244	35				
	SRS									244	35						
	ORR													244	35		
	NTS															244	35
INEL	HS							162	23								
	SRS									162	23						
	ORR													162	23		
	NTS															162	23
Domestic non-DOE																	
AFRRI	HS							3	3								
	INEL			3	3	3	3					3	3				
	SRS	3	3							3	3						
	ORR													3	3		
	NTS															3	3

Table I-2. (continued).

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
USGS	HS							6	6								
	INEL	6	6	6	6	6	6					6	6				
	SRS									6	6						
	ORR													6	6		
	NTS															6	6
Domestic non-DOE																	
NIST	HS							185	185								
	INEL											185	185				
	SRS	185	185	185	185	185	185			185	185						
	ORR													185	185		
	NTS															185	185
USAF	HS							3	3								
	INEL	3	3	3	3	3	3					3	3				
	SRS									3	3						
	ORR													3	3		
	NTS															3	3

Table I-2. (continued).

		Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
Origin	Destination	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
DOW	HS							3	3								
	INEL	3	3	3	3	3	3					3	3				
	SRS									3	3						
	ORR													3	3		
	NTS															3	3
GE	HS							4	4								
	INEL	4	4	4	4							4	4				
	SRS					4	4			4	4						
	ORR													4	4		
	NTS															4	4
GA	HS							8	8								
	INEL	8	8	8	8	8	8					8	8				
	SRS									8	8						
	ORR													8	8		
	NTS															8	8

Table I-2. (continued).

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
AERO	HS							3	3								
	INEL	3	3	3	3	3	3					3	3				
	SRS									3	3						
	ORR													3	3		
	NTS															3	3
Universities																	
Universities	HS							519	519								
	INEL	261	261	261	261	116	116					519	519				
	SRS	258	258	258	258	403	403			519	519						
	ORR													519	519		
	NTS															519	519
Commercial																	
WVDP	HS							83	4								
	INEL			83	4	83	4					83	4				
	SRS									83	4						
	ORR													83	4		
	NTS															83	4

Table I-2. (continued).

		Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
Origin	Destination	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
B&W	HS							2	2								
	INEL			2	2	2	2					2	2				
	SRS									2	2						
	ORR													2	2		
	NTS															2	2
ORR	HS							7	2								
	INEL					7	2					7	2				
	SRS									7	2						
	NTS															7	2
SRS	HS							27	5								
	INEL					27	5					27	5				
	ORR													27	5		
	NTS															27	5
HS	INEL					6	2					6	2				
	SRS									6	2						
	ORR													6	2		
	NTS															6	2

Table I-2. (continued).

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Commercial																	
ANL-E	HS							1	1								
	INEL					1	1					1	1				
	SRS									1	1						
	ORR													1	1		
	NTS															1	1
INEL	HS							370	74								
	SRS									370	74						
	ORR													370	74		
	NTS															370	74
DOE Research																	
ORR	HS							113	24								
	INEL					46	10					113	24				
	SRS			67	14	67	14			113	24						
	NTS															113	24

Table I-2. (continued).

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
BNL	HS							71	14								
	INEL			35	7							71	14				
	SRS			35	7	71	14			71	14						
	ORR													71	14		
	NTS															71	14
SNL	HS							27	6								
	INEL			12	3	12	3					27	6				
	SRS			15	3	15	3			27	6						
	ORR													27	6		
	NTS															27	6
LANL	HS							17	4								
	INEL			17	4							17	4				
	SRS					17	4			17	4						
	ORR													17	4		
	NTS															17	4

Table I-2. (continued).

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
ANL-E	HS							10	2								
	INEL			10	2	10	2					10	2				
	SRS									10	2						
	ORR													10	2		
	NTS															10	2
HS	INEL			5	1	518	39					518	39				
	SRS									518	39						
	ORR													518	39		
	NTS															518	39
INEL	HS							1003	165								
	SRS					114	23			1003	165						
	ORR													1003	165		
	NTS															1003	165
SRS	HS							353	71								
	INEL					94	19					353	71				
	ORR													353	71		
	NTS															353	71

Table I-2. (continued).

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization: HS		Centralization: SRS		Centralization: INEL		Centralization: ORR		Centralization: NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Foreign																			
Points of Entry	HS							1008	1008										
	SRS	546	546	546	546	838	838			1008	1008								
	INEL	462	462	462	462	170	170					1008	1008						
	ORR													1008	1008				
	NTS															1008	1008		
	TOTAL	1,742	1,742	2,267	1,824	3,078	1,926	5,099	2,375	5,951	2,848	4,897	2,655	6,695	2,995	6,815	3,021		

<u>Acronyms</u>

AERO	Aerotest San Ramon, CA
AFRRI	Armed Forces Radiobiology Research Institute Bethesda, MD
ANL-E	Argonne National Laboratory-East
B&W	Babcock & Wilcox Company Lynchburg, VA
BNL	Brookhaven National Laboratory
DOE	Department of Energy
DOW	Dow North America Midland, MI
FSV	Fort St. Vrain Nuclear Generating Station
GA	General Atomics San Diego, CA
GE	General Electric Pleasanton, CA
HS	Hanford Site
INEL	Idaho National Engineering Laboratory
LANL	Los Alamos National Laboratory
NIST	National Institute of Standards and Technology Gaithersburg, MD
NTS	Nevada Test Site
ORR	Oak Ridge Reservation
SNL	Sandia National Laboratories
SRS	Savannah River Site
USAF	United States Air Force McClellan, CA
USGS	United States Geological Survey Denver, CO
WVDP	West Valley Demonstration Project

Table I-3. Spent nuclear fuel shipments for the Regionalization by Geography alternatives.

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Naval-Type													
INEL	HS	383	104					383	104				
	NTS					383	104					383	104
	ORR												
	SRS												
Savannah River Production													
SRS	HS												
	INEL												
	ORR							484	97	484	97	484	97
	NTS												
ORR	SRS												
Hanford Production													
HS	INEL			1192	605					1192	605		
	SRS												
	ORR												
	NTS					1192	605					1192	605
ORR	INEL												

Table I-3. (continued).

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Graphite													
FSV	HS	244	35					244	35				
	INEL			244	35					244	35		
	SRS												
	ORR												
	NTS					244	35					244	35
INEL	HS	162	23					162	23				
	SRS												
	ORR												
	NTS					162	23					162	23
Domestic non-DOE													
AFRRI	HS												
	INEL												
	SRS	3	3	3	3	3	3						
	ORR							3	3	3	3	3	3
	NTS												

Table I-3. (continued).

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
USGS	HS	6	6					6	6				
	INEL			6	6					6	6		
	SRS												
	ORR												
	NTS					6	6					6	6
Domestic non-DOE													
NIST	HS												
	INEL												
	SRS	185	185	185	185	185	185						
	ORR							185	185	185	185	185	185
	NTS												
USAF	HS	3	3					3	3				
	INEL			3	3					3	3		
	SRS												
	ORR												
	NTS					3	3					3	3

Table I-3. (continued).

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
DOW	HS												
	INEL												
	SRS	3	3	3	3	3	3						
	ORR							3	3	3	3	3	3
	NTS												
GE	HS	4	4					4	4				
	INEL			4	4					4	4		
	SRS												
	ORR												
	NTS					4	4					4	4
GA	HS	8	8					8	8				
	INEL			8	8					8	8		
	SRS												
	ORR												
	NTS					8	8					8	8

Table I-3. (continued).

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
AERO	HS	3	3					3	3				
	INEL			3	3					3	3		
	SRS												
	ORR												
	NTS					3	3					3	3
Universities													
Universities	HS	209	209					209	209				
	INEL			209	209					209	209		
	SRS	310	310	310	310	310	310						
	ORR							310	310	310	310	310	310
	NTS					209	209					209	209
Commercial													
WVDP	HS												
	INEL												
	SRS	83	4	83	4	83	4						
	ORR							83	4	83	4	83	4
	NTS												

Table I-3. (continued).

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
B&W	HS												
	INEL												
	SRS	2	2	2	2	2	2						
	ORR							2	2	2	2	2	2
	NTS												
ORR	HS												
	INEL												
	SRS	7	2	7	2	7	2						
	NTS												
SRS	HS												
	INEL												
	ORR							27	5	27	5	27	5
	NTS												
HS	INEL			6	2					6	2		
	SRS												
	ORR												
	NTS					6	2					6	2

Table I-3. (continued).

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Commercial													
ANL-E	HS												
	INEL												
	SRS	1	1	1	1	1	1						
	ORR							1	1	1	I	1	1
	NTS												
INEL	HS	370	74					370	74				
	SRS												
	ORR												
	NTS					370	74					370	74
DOE Research													
ORR	HS												
	INEL												
	SRS	113	24	113	24	113	24						
	NTS												

Table I-3. (continued).

		Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
Origin	Destination	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
BNL	HS												
	INEL												
	SRS	71	14	71	14	71	14						
	ORR							71	14	71	14	71	14
	NTS												
SNL	HS	27	6					27	6				
	INEL			27	6					27	6		
	SRS												
	ORR												
	NTS					27	6					27	6
LANL	HS	17	4					17	4				
	INEL			17	4					17	4		
	SRS												
	ORR												
	NTS					17	4					17	4

Table I-3. (continued).

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
ANL-E	HS												
	INEL												
	SRS	10	2	10	2	10	2						
	ORR							10	2	10	2	10	2
	NTS												
HS	INEL			518	39					518	39		
	SRS												
	ORR												
	NTS					518	39					518	39
INEL	HS	1003	165					1003	165				
	SRS												
	ORR												
	NTS					1003	165					1003	165
SRS	HS												
	INEL												
	ORR							353	71	353	71	353	71
	NTS												

Table I-3. (continued).

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Foreign													
Points of Entry	HS	230	230					230	230				
	SRS	778	778	778	778	778	778						
	INEL			230	230					230	230		
	ORR							778	778	778	778	778	778
	NTS					230	230					230	230
	TOTAL	4,235	2,202	4,033	2,482	5,951	2,848	4,979	2,349	4,777	2,629	6,695	2,995

Acronyms

AERO	Aerotest San Ramon, CA
AFRRI	Armed Forces Radiobiology Research Institute Bethesda, MD
ANL-E	Argonne National Laboratory-East
B&W	Babcock & Wilcox Company Lynchburg, VA
BNL	Brookhaven National Laboratory
DOE	Department of Energy
DOW	Dow North America Midland, MI
FSV	Fort St. Vrain Nuclear Generating Station
GA	General Atomics San Diego, CA
GE	General Electric Pleasanton, CA
HS	Hanford Site
INEL	Idaho National Engineering Laboratory
LANL	Los Alamos National Laboratory
NIST	National Institute of Standards and Technology Gaithersburg, MD
NTS	Nevada Test Site
ORR	Oak Ridge Reservation
SNL	Sandia National Laboratories
SRS	Savannah River Site
USAF	United States Air Force McClellan, CA
USGS	United States Geological Survey Denver, CO
WVDP	West Valley Demonstration Project

I-4 INCIDENT-FREE TRANSPORTATION RISKS FOR SPENT NUCLEAR FUEL

I-4.1 Methodology

Radiological dose during normal, incident-free transportation of SNF results from exposure to the external radiation field that surrounds the shipping containers. The dose is a function of the number of people exposed, their proximity to the containers, their length of time of exposure, and the intensity of the radiation field surrounding the containers.

Radiological impacts were determined for crew workers and the general population during normal, incident-free transportation. For truck shipments, the crew were the drivers of the transport vehicle. For rail shipments, the crew were workers in close proximity to the shipping containers during inspection or classification of railcars. The general population was persons within 800 meters (2,625 feet) of the road or railway (off-link), persons sharing the road or railway (on-link), and persons at stops.

Collective doses for the crew and general population were calculated using the RADTRAN 4 computer code (Neuhauser and Kanipe 1992). SNF was assigned a dose rate of 14 millirem per hour at 1 meter (3.28 feet) from the shipping container. This dose rate yields a dose rate of 10 millirem per hour at 2 meters (6.56 feet) from the vehicle, which is the regulatory maximum based on an exclusive use vehicle (see Madsen et al. 1986). A dose rate of 1 millirem per hour at 1 meter (3.28 feet) was used for naval-type SNF shipments, based on measured dose rates from previous naval SNF shipments. Three population density zones (rural, suburban, and urban) were used. These zones correspond to mean population densities of 6,719, and 3,861 persons per square kilometer, respectively (Neuhauser and Kanipe 1992).

Calculating the collective doses is based on developing unit risk factors. Unit risk factors provide an estimate of the impact from transporting one shipment of radioactive material over a unit distance of travel in a given population density zone. The unit risk factors may be combined with routing information, such as the transport distances in various population density zones, to determine the risk for a single shipment (a shipment risk factor) between a given origin and destination. Cashwell et al. (1986) contains a detailed explanation of the use of unit risk factors.

Unit risk factors were developed based on travel within rural, suburban, and urban population zones using RADTRAN 4, using default data (see Neuhauser and Kanipe 1992). Table I-4 contains the unit risk factors for offsite truck and rail shipments of SNF. Table 1-5 contains the unit risk factors for offsite truck and rail shipments of naval-type SNF. Shipment risk factors were also developed for offsite shipments by combining the unit risk factors with routing information derived from the HIGHWAY and INTERLINE computer codes.

Table I-4. Incident-free unit risk factors for offsite truck and rail shipments of spent nuclear fuel.

Mode	Exposure group	Unit risk factors (person-rem per kilometer)[a]		
		Rural	Suburban	Urban
Truck				
	Occupational	4.6×10^{-5}	1.0×10^{-4}	1.7×10^{-4}
	General population			
	Off-link[b]	1.2×10^{-7}	1.6×10^{-5}	1.1×10^{-4}
	On-link[c]	5.0×10^{-6}	1.5×10^{-5}	1.5×10^{-4}
	Stops	1.2×10^{-4}	1.2×10^{-4}	1.2×10^{-4}
	General population total	1.3×10^{-4}	1.5×10^{-4}	3.8×10^{-4}
Rail				
	Occupational[d]	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}
	General population			
	Off-link[b]	1.7×10^{-7}	3.3×10^{-5}	2.9×10^{-4}
	On-link[c]	6.6×10^{-8}	8.5×10^{-7}	2.4×10^{-6}
	Stops[e]	4.8×10^{-6}	4.8×10^{-6}	4.8×10^{-6}
	General population total	5.0×10^{-6}	3.8×10^{-5}	3.0×10^{-4}

a. The methodology, equations, and data used to develop the unit risk factors are discussed in Madsen et al. (1986) and Neuhauser and Kanipe (1992). Cashwell et al. (1986) contains a detailed explanation of the use of unit risk factors.

b. Off-link general population were persons within 800 meters (2,625 feet) of the road or railway.

c. On-link general population were persons sharing the road or railway.

d. The nonlinear component of incident-free rail dose for crew workers because of railcar inspections and classifications is 0.011 person-rem per shipment. Ostmeyer (1986) contains a detailed explanation of the rail exposure model.

e. The nonlinear component of incident-free rail dose for the general population because of railcar inspections and classifications is 0.0087 person-rem per shipment. Ostmeyer (1986) contains a detailed explanation of the rail exposure model.

Table I-5. Incident-free unit risk factors for truck and rail shipments of naval-type spent nuclear fuel.

Mode	Exposure group	Unit risk factors (person-rem per kilometer)[a]		
		Rural	Suburban	Urban
Truck				
	Occupational	1.5×10^{-5}	3.3×10^{-5}	5.4×10^{-5}
	General population			
	Off-link[b]	8.8×10^{-9}	1.2×10^{-6}	7.7×10^{-6}
	On-link[c]	3.6×10^{-7}	1.0×10^{-6}	1.1×10^{-5}
	Stops	4.3×10^{-6}	4.3×10^{-6}	4.3×10^{-6}
	General population total	4.7×10^{-7}	6.5×10^{-6}	2.3×10^{-5}
Rail				
	Occupational[d]	7.2×10^{-7}	7.2×10^{-7}	7.2×10^{-7}
	General population			
	Off-link[b]	1.2×10^{-8}	2.3×10^{-6}	2.1×10^{-5}
	On-link[c]	4.7×10^{-9}	6.1×10^{-8}	1.7×10^{-7}
	Stops[e]	3.4×10^{-7}	3.4×10^{-7}	3.4×10^{-7}
	General population total	3.6×10^{-7}	2.7×10^{-6}	2.1×10^{-5}

a. The methodology, equations, and data used to develop the unit risk factors are discussed in Madsen et al. (1986) and Neuhauser and Kanipe (1992). Cashwell et al. (1986) contains a detailed explanation of the use of unit risk factors.

b. Off-link general population were persons within 800 meters (2,625 feet) of the road or railway.

c. On-link general population were persons sharing the road or railway.

d. The nonlinear component of incident-free rail dose for crew workers because of railcar inspections and classifications is 0.00080 person-rem per shipment. Ostmeyer (1986) contains a detailed explanation of the rail exposure model.

e. The nonlinear component of incident-free rail dose for the general population because of railcar inspections and classifications is 0.00062 person-rem per shipment. Ostmeyer (1986) contains a detailed explanation of the rail exposure model.

Incident-free nonradiological fatalities were also estimated using unit risk factors. These unit risk factors account for the fatalities associated with exhaust emissions, but the distances used to estimate the impacts must be doubled to reflect the round trip distance because these impacts occur whether or not the shipment contains radioactive material. Two sets of data were evaluated: (a) data from the *Non-Radiological Impacts of Transporting Radioactive Material* (Rao et al. 1982), and (b) data from the *Motor Vehicle-Related Air Toxics Study* (EPA 1993). In Rao et al. (1982), the nonradiological unit risk factor for trucks was 1.0×10^{-7} fatalities per kilometer and the nonradiological unit risk factor for trains was 1.3×10^{-7} fatalities per kilometer. These unit risk factors are applicable only in urban areas. In EPA (1993), the unit risk factor was calculated to be 7.2×10^{-11} fatalities per kilometer; this unit risk factor is applicable in all areas (i.e., rural, suburban, and urban). Based on the routes analyzed in this EIS, the unit risk factors from Rao et al. (1982) were found to overestimate impacts by about 20 to 30 times relative to the unit risk factors from EPA (1993). Therefore, the unit risk factors from Rao et al. (1982) were used as a conservative estimate of the incident-free nonradiological fatalities presented in this EIS. It should be noted that the unit risk factors from Rao et al. (1982) account for all fatalities, not just cancer fatalities. Other effects of chronic exposure to diesel exhaust emissions have been followed in occupationally exposed workers, but these data are insufficient to make a correlation between the effects and the exposure experienced (EPA 1993). Therefore, these impacts were not estimated in this EIS.

I-4.1.1 Maximally Exposed Individual Exposure Scenarios

Maximum individual doses were calculated using the RISKIND computer code (Yuan et al. 1993). The maximum individual doses for the routine transport offsite were estimated for transportation workers, as well as members of the general population. For rail shipments, the three general population scenarios were (a) a railyard worker working at a distance of 10 meters (32.8 feet) from the shipping container for 2 hours, (b) a resident living 30 meters (98.4 feet) from the rail line where the shipping container was being transported, and (c) a resident living 200 meters (656.2 feet) from a rail stop where the shipping container was sitting for 20 hours. For train shipments, the maximum exposed transportation worker was an individual in a railyard who spent a time- and distance-weighted average of 0.16 hours inspecting, classifying, and repairing railcars (Wooden 1986).

For offsite truck shipments, the three scenarios for the general population were: (a) a person caught in traffic and located 1 meter (3.28 feet) away from the surface of the shipping container for one-half hour, (b) a resident living 30 meters (98.4 feet) from the highway used to transport the shipping container, and (c) a service station worker working at a distance of 20 meters (65.6 feet) from the shipping container for 2 hours. The hypothetical maximum exposed individual radiological doses were accumulated over the 40-year period. However, for the situation involving an individual caught in traffic next to a truck, the radiological exposures were calculated for only one event because it was considered unlikely that the same individual would be caught in traffic next to all containers for all shipments. For truck shipments, the maximum exposed transportation worker is the driver who was assumed to drive shipments for up to 2,000 hours per year.

I-4.2 Results of Calculations

This section summarizes the results of the incident-free transportation analyses for SNF shipments that occur outside the boundaries of U.S. Department of Energy sites (offsite). These results do not include the impacts of SNF shipments within the boundaries of DOE sites (onsite). Onsite transportation impacts are addressed in site-specific Appendices A, B, C, D, and F of this EIS.

This section includes the impacts of offsite transport of naval-type SNF stored at the Idaho Chemical Processing Plant as of June 1995 to storage locations at other DOE sites, as identified in the alternatives. Shipments of naval SNF and test specimens are addressed in Appendix D of Volume 1 of this EIS.

I-4.2.1 Impacts from the No Action Alternative

Under the No Action alternative, the only offsite transport of SNF involves shipments of naval SNF and test specimens. These shipments are addressed in Appendix D of Volume 1 of this EIS.

I-4.2.2 Impacts from the Decentralization Alternative

For the Decentralization alternative, the incident-free transportation of SNF was estimated to result 0.11 to 0.34 fatalities over the 40-year period 1995 through 2035 (see Table I-6). The statistically estimated fatalities were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions. A range of fatalities occurs because of the option of using truck or rail transport for SNF shipments.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.023 to 0.082. The estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.041 to 0.24. The estimated number of nonradiological fatalities from vehicular emissions ranged from 0.017 to 0.044.

I-4.2.3 Impacts from the 1992/1993 Planning Basis Alternative

For the 1992/1993 Planning Basis alternative, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.11 to 0.42 over the 40-year period 1995 through 2035 (see Table I-7). These fatalities were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological

Table I-6. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Decentralization alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	48	1.8	93	3.4	20	0.73	160	5.9
Collective dose (person-rem)	59	16	130	37	15	5.0	200	58
Estimated latent cancer fatalities	0.024	0.0064	0.052	0.015	0.0060	0.0020	0.080	0.023
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	0.088	0.36	0.71	2.9
Collective dose (person-rem)	140	29	310	43	18	8.0	470	80
Estimated latent cancer fatalities	0.070	0.015	0.16	0.022	0.0090	0.0040	0.24	0.040
Estimated nonradiological fatalities[e]	0.0050	0.012	0.010	0.027	0.0023	0.0051	0.017	0.044

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-7. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the 1992/1993 Planning Basis alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	37	1.8	71	3.4	52	1.0	160	6.2
Collective dose (person-rem)	59	16	130	37	66	7.3	260	60
Estimated latent cancer fatalities	0.024	0.0064	0.052	0.015	0.026	0.0029	0.10	0.024
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	0.30	0.50	0.92	3.1
Collective dose (person-rem)	140	29	310	43	140	12	590	84
Estimated latent cancer fatalities	0.070	0.015	0.16	0.022	0.070	0.0060	0.30	0.042
Estimated nonradiological fatalities[e]	0.0050	0.012	0.010	0.027	0.0054	0.0065	0.020	0.046

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

fatalities from vehicular emissions. Again, a range of fatalities occurred because of the option of using truck or rail transport for SNF shipments.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.024 to 0.10. The estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.043 to 0.30. The estimated number of nonradiological fatalities from vehicular emissions ranged from 0.020 to 0.046.

I-4.2.4 Impacts from the Regionalization Alternative

I-4.2.4.1 Impacts from Regionalization by Fuel Type. For the Regionalization by Fuel Type, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.14 to 0.58 over the 40-year period 1995 through 2035 (see Table I-8). These fatalities were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions. The reason for a range of fatalities was because of the option of using truck or rail transport for SNF shipments.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.026 to 0.14. The estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.053 to 0.41. The estimated number of nonradiological fatalities from vehicular emissions ranged from 0.027 to 0.059.

I-4.2.4.2 Impacts from Regionalization by Geography. For the six Regionalization by Geography alternatives, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.10 for regionalization at the Idaho National Engineering Laboratory and Oak Ridge Reservation to 0.85 for regionalization at the Nevada Test Site and the Oak Ridge Reservation (see Tables I-9 through I-14). These fatalities were over the 40-year period 1995 through 2035 and were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was because of two factors: (a) the option of using truck or rail transport for SNF shipments, and (b) the six regionalization by geography alternatives.

For regionalization at the Idaho National Engineering Laboratory and Oak Ridge Reservation, the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.028. The estimated number of radiation-related latent cancer fatalities for the general population was 0.042. The estimated number of nonradiological fatalities from vehicular emissions was 0.034.

For regionalization at the Nevada Test Site and the Oak Ridge Reservation, the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.20. The estimated

Table I-8. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for Regionalization by Fuel Type (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	27	1.8	52	3.4	81	1.3	160	6.5
Collective dose (person-rem)	54	15	150	41	150	11	350	67
Estimated latent cancer fatalities	0.022	0.0060	0.060	0.016	0.060	0.0044	0.14	0.027
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	0.63	0.67	1.3	3.2
Collective dose (person-rem)	120	33	350	54	340	17	810	100
Estimated latent cancer fatalities	0.060	0.017	0.18	0.027	0.17	0.0085	0.41	0.050
Estimated nonradiological fatalities[e]	0.0051	0.014	0.012	0.037	0.0098	0.0081	0.027	0.059

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-9. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for Regionalization by Geography at the Hanford Site and Savannah River Site (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	20	1.8	38	3.4	100	2.3	160	7.5
Collective dose (person-rem)	60	17	99	31	150	13	310	61
Estimated latent cancer fatalities	0.024	0.0068	0.040	0.012	0.060	0.0052	0.12	0.024
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.1	1.1	1.7	3.7
Collective dose (person-rem)	140	30	230	44	330	18	700	92
Estimated latent cancer fatalities	0.070	0.015	0.012	0.022	0.17	0.0090	0.35	0.046
Estimated nonradiological fatalities[e]	0.0050	0.012	0.0076	0.031	0.010	0.0084	0.023	0.051

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-10. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for Regionalization by Geography at the Idabo National Engineering Laboratory and Savannah River Site (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	21	1.8	40	3.4	99	3.2	160	8.4
Collective dose (person-rem)	54	15	100	32	140	21	290	68
Estimated latent cancer fatalities	0.022	0.0060	0.040	0.013	0.056	0.0084	0.12	0.027
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.0	1.6	1.6	4.2
Collective dose (person-rem)	120	28	230	42	320	25	670	95
Estimated latent cancer fatalities	0.060	0.014	0.12	0.021	0.16	0.013	0.34	0.048
Estimated nonradiological fatalities[e]	0.0046	0.011	0.0081	0.028	0.0083	0.0087	0.021	0.048

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-11. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for Regionalization by Geography at the Nevada Test Site and Savannah River Site (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	14	1.8	27	3.4	120	4.5	160	9.7
Collective dose (person-rem)	56	17	110	31	330	34	500	82
Estimated latent cancer fatalities	0.022	0.0068	0.044	0.012	0.13	0.014	0.20	0.033
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.8	2.2	2.4	4.8
Collective dose (person-rem)	130	29	250	45	780	37	1200	110
Estimated latent cancer fatalities	0.065	0.015	0.13	0.023	0.39	0.019	0.60	0.055
Estimated nonradiological fatalities[e]	0.0053	0.012	0.0076	0.031	0.040	0.012	0.053	0.055

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-12. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for Regionalization by Geography at the Hanford Site and Oak Ridge Reservation (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	17	1.8	32	3.4	110	2.8	160	8.0
Collective dose (person-rem)	56	16	94	29	170	17	320	62
Estimated latent cancer fatalities	0.022	0.0064	0.038	0.012	0.068	0.0068	0.13	0.025
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.4	1.4	2.0	4.0
Collective dose (person-rem)	130	26	220	33	390	22	740	81
Estimated latent cancer fatalities	0.065	0.013	0.11	0.017	0.20	0.011	0.37	0.041
Estimated nonradiological fatalities[e]	0.0049	0.0087	0.0066	0.020	0.012	0.0090	0.024	0.038

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-13. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for Regionalization by Geography at the Idaho National Engineering Laboratory and Oak Ridge Reservation (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	17	1.8	34	3.4	110	3.7	160	8.9
Collective dose (person-rem)	50	15	95	29	170	24	320	68
Estimated latent cancer fatalities	0.020	0.0060	0.038	0.012	0.068	0.0096	0.13	0.027
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.3	1.8	1.9	4.4
Collective dose (person-rem)	110	23	220	30	380	30	710	83
Estimated latent cancer fatalities	0.055	0.012	0.11	0.015	0.19	0.015	0.36	0.042
Estimated nonradiological fatalities[e]	0.0046	0.0077	0.0071	0.017	0.010	0.0094	0.022	0.034

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-14. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for Regionalization by Geography at the Nevada Test Site and Oak Ridge Reservation (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	12	1.8	24	3.4	120	5.0	160	10
Collective dose (person-rem)	52	16	100	29	360	37	510	82
Estimated latent cancer fatalities	0.021	0.0064	0.040	0.012	0.14	0.015	0.20	0.033
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	2.1	2.5	2.7	5.1
Collective dose (person-rem)	120	25	240	33	840	42	1200	100
Estimated latent cancer fatalities	0.060	0.013	0.12	0.017	0.42	0.021	0.60	0.050
Estimated nonradiological fatalities[e]	0.0052	0.0083	0.0066	0.021	0.042	0.013	0.054	0.042

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

number of radiation-related latent cancer fatalities for the general population was 0.60. The estimated number of nonradiological fatalities from vehicular emissions was 0.054.

I-4.2.5 Impacts from the Centralization Alternatives

For the five Centralization alternatives, the incident-free transportation of spent nuclear fuel was estimated to result in total fatalities that ranged from 0.16 for centralization at the Oak Ridge Reservation to 1.7 for centralization at the Savannah River Site (see Tables I-15 through I-19). These fatalities were over the 40-year period 1995 through 2035 and were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was because of two factors: (a) the option of using truck or rail transport for SNF shipment and (b) the five Centralization options.

For centralization at the Oak Ridge Reservation, the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.042. The estimated number of radiation-related latent cancer fatalities for the general population was 0.067. The estimated number of nonradiological fatalities from vehicular emissions was 0.055.

For centralization at the Savannah River Site, the estimated number of radiation-related latent cancer fatalities for transportation workers was 0.42. The estimated number of radiation-related latent cancer fatalities for the general population was 1.2. The estimated number of nonradiological fatalities from vehicular emissions was 0.074.

I-4.2.6 Impacts of Using Alternate Points of Entry for Foreign Research Reactor Spent Nuclear Fuel Shipments

For incident-free transportation (radiological and vehicle-related), shipments from Jacksonville, Florida, and Wilmington, North Carolina, to the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site would yield lower impacts than shipments from Charleston, South Carolina, Galveston, Texas, Hampton Roads, Virginia, Savannah, Georgia, and the Military Ocean Terminal, Sunny Point, North Carolina, to these same sites.

Table I-15. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Hanford Site alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	16	1.8	32	3.4	110	2.9	160	8.1
Collective dose (person-rem)	100	26	220	56	430	32	750	110
Estimated latent cancer fatalities	0.040	0.010	0.088	0.022	0.17	0.013	0.30	0.044
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.5	1.4	2.1	4.0
Collective dose (person-rem)	250	38	560	56	990	45	1800	140
Estimated latent cancer fatalities	0.13	0.019	0.28	0.028	0.50	0.023	0.90	0.070
Estimated nonradiological fatalities[e]	0.0057	0.014	0.016	0.035	0.026	0.024	0.048	0.073

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-16. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Idaho National Engineering Laboratory alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	17	1.8	33	3.4	110	3.8	160	9.0
Collective dose (person-rem)	86	22	190	49	380	36	660	110
Estimated latent cancer fatalities	0.034	0.0088	0.076	0.020	0.15	0.014	0.26	0.044
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.4	1.9	2.0	4.5
Collective dose (person-rem)	210	33	490	49	880	49	1600	130
Estimated latent cancer fatalities	0.11	0.017	0.25	0.025	0.44	0.025	0.80	0.065
Estimated nonradiological fatalities[e]	0.0049	0.012	0.015	0.031	0.022	0.023	0.042	0.066

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-17. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Savannah River Site alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	14	1.8	27	3.4	120	4.5	160	9.7
Collective dose (person-rem)	53	15	140	40	840	60	1000	120
Estimated latent cancer fatalities	0.021	0.006	0.056	0.016	0.34	0.024	0.40	0.048
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	1.8	2.2	2.4	4.8
Collective dose (person-rem)	110	34	330	54	1900	85	2300	170
Estimated latent cancer fatalities	0.055	0.017	0.17	0.027	0.95	0.043	1.2	0.085
Estimated nonradiological fatalities[e]	0.0050	0.014	0.012	0.037	0.057	0.032	0.074	0.083

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-18. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Oak Ridge Reservation alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	12	1.8	24	3.4	120	5.0	160	10
Collective dose (person-rem)	42	13	130	36	750	58	920	110
Estimated latent cancer fatalities	0.017	0.0052	0.052	0.014	0.30	0.023	0.37	0.044
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	2.1	2.5	2.7	5.1
Collective dose (person-rem)	91	25	310	39	1800	68	2200	130
Estimated latent cancer fatalities	0.046	0.013	0.16	0.02	0.90	0.034	1.1	0.065
Estimated nonradiological fatalities[e]	0.0042	0.0091	0.0097	0.023	0.043	0.023	0.057	0.055

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-19. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Nevada Test Site alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	12	1.8	24	3.4	120	5.0	160	10
Collective dose (person-rem)	94	25	230	54	590	52	910	130
Estimated latent cancer fatalities	0.038	0.010	0.092	0.022	0.24	0.021	0.36	0.052
General population								
Maximum individual dose (rem)	0.21	0.87	0.41	1.7	2.2	2.5	2.8	5.1
Collective dose (person-rem)	230	37	540	56	1400	64	2200	160
Estimated latent cancer fatalities	0.12	0.019	0.27	0.028	0.70	0.032	1.1	0.080
Estimated nonradiological fatalities[e]	0.0066	0.013	0.016	0.037	0.059	0.028	0.082	0.078

a. Maheras (1995a).

b. Maheras (1995b).

c. Maheras (1995c).

d. DOE SNF includes special-case commercial, DOE research, other domestic research, graphite, N-Reactor, naval-type, and Savannah River production reactor SNF (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

I-5 SPENT NUCLEAR FUEL TRANSPORTATION ACCIDENT RISKS AND MAXIMUM REASONABLY FORESEEABLE CONSEQUENCES

I-5.1 Methodology

The offsite SNF transportation accident analysis considers the impacts of accidents during the transportation of SNF by truck or rail. SNF is transported in specially designed casks that meet U.S. Department of Transportation and U.S. Nuclear Regulatory Commission Type B packaging specifications in 10 CFR Part 71 (CFR 1994b).

Under accident conditions, impacts to human health and the environment may result from the release and dispersal of radioactive material. Because of the rigorous design specifications for SNF shipping casks, the U.S. Nuclear Regulatory Commission has estimated that casks will withstand 99.4 percent of truck or rail accidents without sustaining damage sufficient to breach the cask (Fischer et al. 1987). The 0.6 percent of accidents that could potentially breach the cask are represented by a spectrum of accident severities and radioactive release conditions. Accident analysis methodology has been developed by the U.S. Nuclear Regulatory Commission for calculating the probabilities and consequences from this spectrum of unlikely accidents, but it is not possible to predict where along the shipping route such accidents might occur.

To provide DOE and the public a reasonable assessment of SNF transportation accident impacts, two types of analyses were performed. First, an accident risk assessment was performed that takes into account the probabilities and consequences of a spectrum of accident severities using methodology developed by the U.S. Nuclear Regulatory Commission (Fischer et al. 1987). The accident risk assessment used route-specific information for accident rates and population densities. For the spectrum of accidents considered in the analysis, accident consequences in terms of collective dose to the population within 80 kilometers (50 miles) were multiplied by the accident probabilities to yield dose risk using the RADTRAN 4 computer code. Second, to represent the maximum reasonably foreseeable impacts to individuals and populations should an accident occur, radiological consequences were calculated for an accident of maximum reasonably foreseeable severity in each population zone. An accident is considered reasonably foreseeable if its probability of occurrence is greater than 1×10^{-7} per year. The accident consequence assessment for maximally exposed individuals and population groups was performed using the RISKIND computer code.

An important variable in the assessment of impacts from SNF transportation accidents is the type of SNF. A wide range of SNF types exists within the DOE complex with significant differences in radioactive material content, fuel material design, cladding design, reactor operating history, and storage (cooling time) history. These differences among SNF types translate into different radioactive material release characteristics under accident conditions. To account for the variation in SNF types, analyses were performed for the following representative SNF types: (a) naval reactor fuels, (b) Savannah River Production Reactor fuels, (c) Hanford N-Reactor fuels, (d) graphite fuels,

(e) special-case commercial reactor fuels, (f) university research/test reactor fuels, (g) DOE research/test reactor fuels, (h) foreign research reactor fuels, and (i) non-DOE research reactor fuels.

The impacts for specific alternatives were calculated in units of dose (person-rem) for each origin and destination pair associated with each representative SNF type. The impacts are further expressed as health risks in terms of latent cancer fatalities in exposed populations. The health risk conversion factors used were derived from International Commission on Radiological Protection Publication 60 (ICRP 1991).

I-5.1.1 Accident Rates

For calculating accident shipment-risk factors, state-level accident rates were taken from data provided in Saricks and Kvitek (1994) for rail and heavy combination trucks. For truck transportation, separate accident rates were used for rural, suburban, and urban population density zones in each state. One average accident rate was used for each state for rail transportation. For truck transport, accident fatality risks were based on state-level rates for interstate highways in urban and rural areas (Saricks and Kvitek 1994). Accident fatality risks for rail transportation were calculated using a nationwide average rate of 2.64×10^{-8} fatalities per rail-kilometer (Cashwell et al. 1986).

I-5.1.2 Accident Severity Categories and Conditional Probabilities

Accident severity categories for potential SNF transportation accidents are described in a U.S. Nuclear Regulatory Commission report commonly referred to as the Modal Study (Fischer et al. 1987). The Modal Study classification scheme for both truck and rail transportation is shown in Figure I-1. Severity is described as a function of the magnitudes of the mechanical forces (impact) and thermal forces (fire) to which a cask may be subjected during an accident. Because all accidents can be described in these terms, severity is independent of the specific accident sequence. In other words, any sequence of events that results in an accident in which a cask is subjected to forces within a certain range of values is assigned to the accident severity category associated with that range. The accident severity scheme is designed to take into account all reasonably foreseeable transportation accidents, including accidents with low probability but high consequences and those with high probability but low consequences.

The severity category matrix represents a set of scenarios defined by a combination of mechanical and thermal forces. A conditional probability is assigned in each category as shown in Figure I-2. For example, Category R(1,1) accidents are the least severe but most frequent, whereas Category R(4,5) accidents are very severe but very infrequent. To determine the expected frequency of each severity category, the conditional probability in each category was multiplied by the baseline accident rate. Each population density zone has a distinct baseline accident rate and distribution

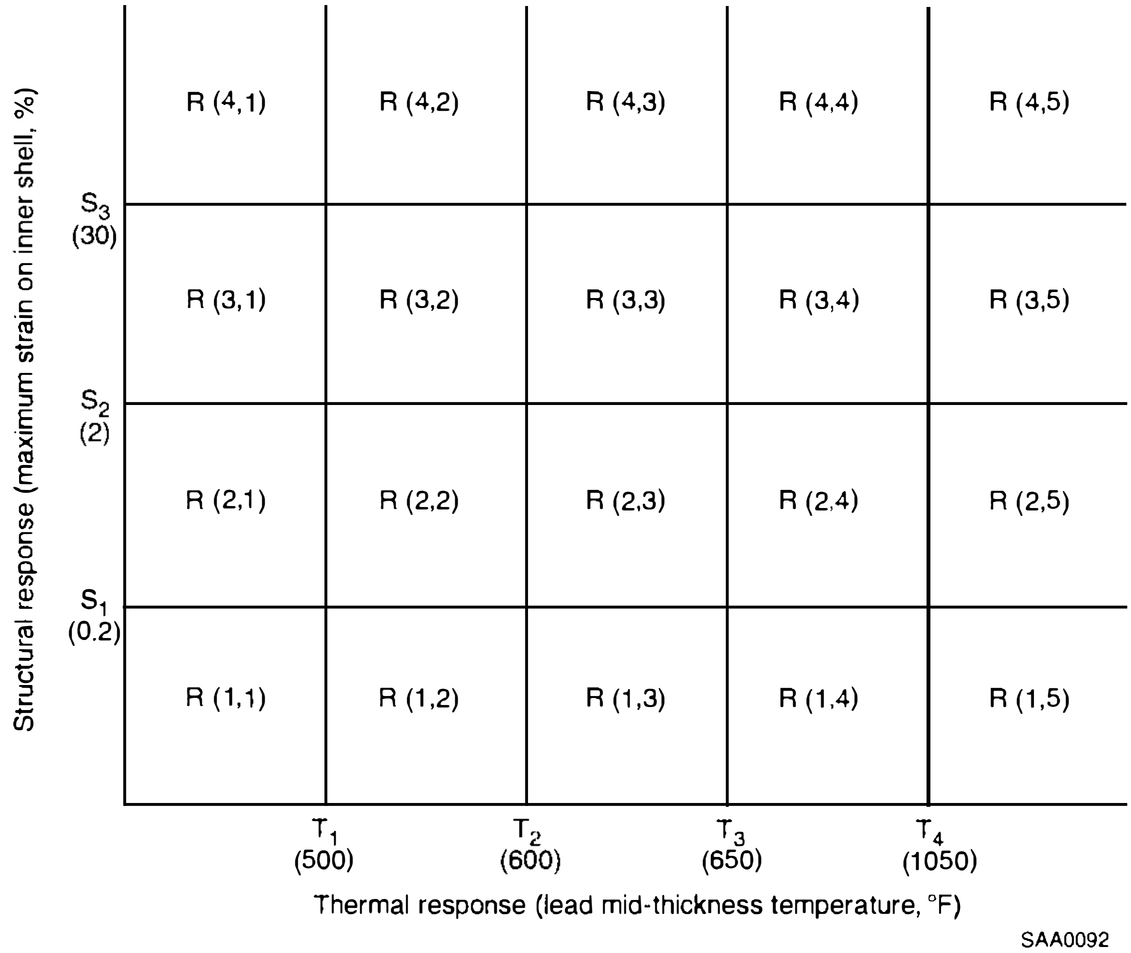

Figure I-1. Matrix of cask response regions for combined mechanical and thermal loads. (Source: Fischer et al. 1987)

Legend:

(P_t) = Probabilty of occurrence assuming a truck accident occurs
(P_r) = Probabilty of occurrence assuming a rail accident occurs

Structural response (maximum strain on inner shell, %) / Thermal response (lead mid-thickness temperature, °F)

	≤ T_1 (500)	T_1–T_2 (600)	T_2–T_3 (650)	T_3–T_4 (1050)	> T_4
> S_3 (30)	R (4,1) (P_t) 1.532×10^{-7} (P_r) 1.786×10^{-9}	R (4,2) 3.926×10^{-14} 3.290×10^{-13}	R (4,3) 1.495×10^{-14} 2.137×10^{-13}	R (4,4) 7.681×10^{-16} 1.644×10^{-13}	R (4,5) $<1 \times 10^{-16}$ 3.459×10^{-14}
S_2 (2) – S_3 (30)	R (3,1) (P_t) 1.7984×10^{-3} (P_r) 5.545×10^{-4}	R (3,2) 1.574×10^{-7} 1.021×10^{-7}	R (3,3) 2.034×10^{-7} 6.634×10^{-8}	R (3,4) 1.076×10^{-7} 5.162×10^{-8}	R (3,5) 4.873×10^{-8} 5.296×10^{-8}
S_1 (0.2) – S_2 (2)	R (2,1) (P_t) 3.8192×10^{-3} (P_r) 2.7204×10^{-3}	R (2,2) 2.330×10^{-7} 5.011×10^{-7}	R (2,3) 3.008×10^{-7} 3.255×10^{-7}	R (2,4) 1.592×10^{-7} 2.531×10^{-7}	R (2,5) 7.201×10^{-8} 1.075×10^{-8}
≤ S_1 (0.2)	R (1,1) (P_t) 0.994316 (P_r) 0.993962	R (1,2) 1.687×10^{-5} 1.2275×10^{-3}	R (1,3) 2.362×10^{-5} 7.9511×10^{-4}	R (1,4) 1.525×10^{-5} 6.140×10^{-4}	R (1,5) 9.570×10^{-6} 1.249×10^{-4}

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Figure I-2. Fraction of truck and rail accidents expected within each severity category, assuming an accident occurs. (Source: Fischer et al. 1987).

of accident severities related to differences in average vehicle velocity, traffic density, and other factors, including rural, suburban, or urban location.

For the accident risk assessment, accident risk was generically defined as the consequences of an accident multiplied by the probability of the occurrence of that accident, an approach consistent with the methodology suggested by the existing RADTRAN computer code. Accident unit-risk factors were calculated using the RADTRAN 4 computer code, then summed over the accident conditional probabilities and route characteristics for the origin and destination pairs to yield risk per shipment estimates. These accident risk factors take into account the entire spectrum of reasonably foreseeable transportation accidents, including low probability accidents that have high consequences and high probability accidents that have low consequences.

For the maximum reasonably foreseeable accident consequence assessment, the doses were assessed for populations and individuals assuming the most severe accident scenario with a probability greater than 1×10^{-7} per year. In terms of the radioactivity released to the environment, the most severe reasonably foreseeable accident is represented by eight accident severity categories [R(4,1) through R(4,5) and R(1,5) through R(3,5)]. Each of the eight most severe accident categories result in the same total release of radioactive material, but the conditional probabilities of occurrence vary. Therefore, the accident consequence assessment is based on a maximum reasonably foreseeable release of radioactivity with a conditional probability that is the sum of the conditional probabilities of the eight most severe accident categories. Accidents of this severity are extremely rare, occurring approximately once per 100,000 truck or 10,000 rail accidents involving a SNF shipment.

I-5.1.3 Atmospheric Conditions

Because it is impossible to predict the specific location of an offsite transportation accident, generic atmospheric conditions were selected for the risk and consequence assessments. For accident risk assessment, neutral weather conditions (Pasquill Stability Class D) were assumed. Neutral weather conditions are typified by moderate windspeeds, vertical mixing within the atmosphere, and good dispersion of atmospheric contaminants. Because neutral meteorological conditions compose the most frequently occurring atmospheric stability condition in the United States, these conditions are most likely to be present in the event of an accident involving a SNF shipment. On the basis of observations from National Weather Service surface meteorological stations at over 300 locations in the United States, on an annual average, neutral conditions (Pasquill Class C and D) occur 50 percent of the time, while stable (Pasquill Class E and F) and unstable (Pasquill Class A and B) conditions occur 33 percent and 17 percent of the time, respectively (Doty et al. 1976). The neutral category predominates in all seasons, but most frequently in the winter (nearly 60 percent of the observations). For the accident consequence assessment, doses were assessed under both neutral (Class D with 4 meters per second windspeed) and stable (Class F with 1 meter per second windspeed) atmospheric conditions. Stable weather conditions are typified by low windspeeds, very little vertical mixing within the atmosphere, and poor dispersion of atmospheric contaminants. Class F meteorology in combination with windspeeds of 1 meter per second generally occur no more than 5 percent of the time. Results calculated for neutral conditions represent the most likely consequences, and the results for stable conditions represent a worst-case weather situation.

I-5.1.4 Population Density Zones

Three population density zones (rural, suburban, and urban) were used for the offsite population risk assessment. These zones respectively correspond to mean population densities of 6, 719, and 3,861 persons per square kilometer. The three population density zones are based on an aggregation of the 12 population density zones provided in the HIGHWAY and INTERLINE output. For calculating, population density information was generated at the state level and used as RADTRAN input for the origin and destination pairs.

I-5.1.5 Exposure Pathways

Radiological doses were calculated for an individual located near the scene of the accident and for populations within 50 miles (80 kilometers) of the accident. Rural, suburban, and urban population densities were assessed. Dose calculations considered a variety of exposure pathways, including inhalation and direct exposure (cloudshine) from the passing cloud, ingestion from contaminated crops, direct exposure (groundshine) from radioactivity deposited on the ground, and inhalation of resuspended radioactive particles from the ground.

I-5.1.6 Health Risk Conversion Factors

The health risk conversion factors used to estimate expected latent cancer fatalities from radiological exposures were derived from International Commission on Radiological Protection Publication 60 (ICRP 1991): 5.0×10^{-4} and 4.0×10^{-4} latent fatal cancer cases per person-rem for members of the public and workers, respectively.

I-5.2 Spent Nuclear Fuel Characterization and Radioactive Release Characteristics

I-5.2.1 Characterization of Representative Spent Nuclear Fuel Types

Shipments of naval reactor SNF are addressed in Appendix D of Volume 1 of this EIS, with the exception of naval-type SNF that has been transferred from the U.S. Navy to the DOE and is currently in storage at the Idaho National Engineering Laboratory Idaho Chemical Processing Plant. Characterization data for naval-type SNF were derived from Appendix D of Volume 1 of this EIS.

Savannah River Site production reactor SNF was assumed to include both the spent driver fuel used to power the production reactors, as well as the quantities of irradiated plutonium target material currently in storage at the Savannah River Site. Spent driver fuel stored at the Savannah River Site includes fuel used in tritium and plutonium production. Analysis of these two fuel types showed that typical tritium production SNF contains a higher fission product and transuranic inventory than plutonium production SNF. Analysis of the characteristics of typical irradiated plutonium target material also showed that the radionuclide inventory would be bounded by the inventory in spent tritium production driver fuel. Therefore, for analysis purposes, both spent driver fuel and irradiated plutonium target material at the Savannah River Site was assumed to have the characteristics of spent tritium production driver fuel. Table I-20 shows the radionuclide inventory developed to represent Savannah River Site production reactor SNF based on published reports (WSRC 1991; WSRC 1990).

Characterization data for Hanford N-Reactor SNF were based on Mark IA fuel irradiated to an average burnup of 3,000 megawatt-days per metric ton uranium and assuming a 10-year cooling time since removal from the reactor. The 10-year cooling time is conservative because the Hanford N Reactor was last operated in 1987 and SNF of this type is expected to be at least 10 years old by the time shipments would begin. Table I-21 shows the radionuclide inventory used to represent Hanford N-Reactor SNF.

Most of the graphite SNF under the responsibility of the DOE is from the Fort St. Vrain reactor owned by Public Service of Colorado. Some Fort St. Vrain SNF is already in storage at the Idaho National Engineering Laboratory, but most SNF is still in storage at the Fort St. Vrain site awaiting transport to a DOE facility. In addition to the Fort St. Vrain SNF, smaller amounts of other graphite SNF are currently in storage at the Idaho National Engineering Laboratory. Characteristics for graphite SNF are, therefore, based on Fort St. Vrain SNF. Table I-22 shows the radionuclide inventory used to represent graphite reactor SNF based on six Fort St. Vrain fuel blocks irradiated to an average burnup of 70,000 megawatt-days per metric ton uranium and assuming a cooling time of 1,600 days (Block 1993). The 1,600-day (about 4.3 years) cooling time is conservative because the Fort St. Vrain reactor was shut down in August 1989, and shipments will not be made before June 1995.

SNF from various commercial reactors is currently in storage at various DOE sites, mostly at the Idaho National Engineering Laboratory. Special-case commercial SNF currently in storage at the Idaho National Engineering Laboratory includes core debris from the damaged Three Mile Island Unit 2 reactor. Commercial SNF includes both boiling water reactor and pressurized water reactor SNF. Pressurized water reactor SNF was chosen as most representative because it is most prevalent and typically contains the highest levels of radioactivity (Fischer et al. 1987). Table I-23 shows the radionuclide inventory used to represent commercial SNF based on one pressurized water reactor fuel assembly irradiated to an average burnup of 33,000 megawatt-days per metric ton uranium and assuming a cooling time of 10 years (Fischer et al. 1987). The 10-year cooling time is conservative because the majority of special-case commercial SNF currently in storage at DOE sites will be at least 10 years old by June 1995.

Table I-20. Radionuclide inventory for representative Savannah River Site production reactor spent nuclear fuel.[a]

Isotope	Inventory (curie)
H-3	1.21×10^{1}
Kr-85	2.62×10^{2}
Sr-90	3.21×10^{3}
Y-90	3.21×10^{3}
Ru-106	7.64×10^{0}
Rh-106	7.64×10^{0}
Cs-134	1.48×10^{2}
Cs-137	3.18×10^{3}
Ba-137m	3.01×10^{3}
Ce-144	1.51×10^{1}
Pr-144	1.51×10^{1}
Pm-147	1.07×10^{2}
Pu-238	6.84×10^{1}
Pu-239	7.69×10^{-1}
Pu-240	5.23×10^{-1}
Pu-241	9.52×10^{1}
Am-241	1.97×10^{0}

a. Inventory based on one fuel assembly from a tritium producing charge, 10 years cooling out of reactor.

Table I-21. Radionuclide inventory for representative Hanford N-Reactor spent nuclear fuel.[a]

Isotope	Inventory (curie per metric ton uranium)
H-3	3.09×10^{1}
Kr-85	5.89×10^{2}
Sr-90	6.80×10^{3}
Y-90	6.80×10^{3}
Ru-106	5.56×10^{1}
Sb-125	1.26×10^{2}
Cs-134	1.49×10^{2}
Cs-137	8.39×10^{3}
Ba-137m	7.94×10^{3}
Ce-144	3.24×10^{1}
Pm-147	2.24×10^{3}
Pu-238	5.06×10^{1}
Pu-239	1.10×10^{2}
Pu-240	5.97×10^{1}
Pu-241	4.47×10^{3}
Am-241	9.33×10^{1}

a. Inventory based on Mark IA N-Reactor fuel, 10 years cooling out of reactor, average burnup 3,000 megawatt-days per metric ton uranium.

Table I-22. Radionuclide inventory for representative graphite reactor spent nuclear fuel.[a]

Isotope	Inventory (curie)
Kr-85	2.35×10^3
Sr-90	1.57×10^4
Rh-106	5.94×10^2
Ru-106	5.94×10^2
Sb-125	3.36×10^2
Cs-134	7.45×10^3
Cs-137	1.65×10^4
Ce-144	3.77×10^3
Pr-144	3.77×10^3
Pm-147	6.32×10^3
Sm-151	5.4×10^1
Eu-154	9.48×10^2
Eu-155	1.38×10^2
U-232	1.8×10^1
U-233	2.4×10^1
Pu-238	4.20×10^2
Pu-241	3.06×10^2

a. Inventory based on six Fort St. Vrain fuel blocks, 1600 days cooling out of reactor, average burnup of 70,000 megawatt-days per metric ton uranium.

Table I-23. Radionuclide inventory for representative special-case commercial spent nuclear fuel.[a]

Isotope	Inventory (curie)
Co-60	6.28×10^{2}
Kr-85	2.23×10^{3}
Sr-90	2.75×10^{4}
Y-90	2.73×10^{4}
Ru-106	2.52×10^{2}
I-129	1.48×10^{-2}
Cs-134	4.85×10^{3}
Cs-137	3.85×10^{4}
Ba-137m	3.62×10^{4}
Ce-144	9.01×10^{1}
Pu-238	1.36×10^{3}
Pu-239	1.67×10^{2}
Pu-240	2.06×10^{2}
Pu-241	4.32×10^{4}
Am-241	9.66×10^{2}
Cm-244	6.90×10^{2}

a. Inventory based on one pressurized water reactor fuel assembly, 10 years cooling out of reactor, average burnup 33,000 megawatt-days per metric ton uranium.

Domestic university research and test reactors represent a variety of reactor types and fuel designs. High-enriched training, research, and isotope reactor (TRIGA) SNF was chosen as representative of university reactor SNF because it is one of the largest groups of university SNF to be transported and because it is a rod-type fuel that would be expected to have the highest release of fission products under severe accident conditions. The radionuclide inventory of high-enriched TRIGA fuel was calculated using the ORIGEN2 computer code (Croff 1980) assuming a 17-year reactor operating cycle based on operation of the Texas A&M University TRIGA reactor. To facilitate the modeling of accident consequences, the radionuclide inventory generated by the ORIGEN2 program was truncated to eliminate minor contributors to dose. The radionuclides eliminated accounted for less than 1 percent of the total dose. Additional details are available in Enyeart (1995). Table I-24 shows the radionuclide inventory representative of university research and test reactor SNF based on 19 TRIGA fuel rods irradiated to an average burnup of 20.2 percent and assuming a cooling time of 1 year.

DOE research and test reactors are also represented by a variety of reactor types and fuel designs. Experimental Breeder Reactor-II Mark-V SNF was chosen as representative of DOE research and test reactors because the reactor at the Idaho National Engineering Laboratory is one of the few DOE research and test reactors still operating. Mark-V fuel is the current generation of Experimental Breeder Reactor-II fuel types. The high plutonium content of Mark-V fuel increases the relative hazard of the radionuclide inventory compared to other DOE SNF types. The radionuclide inventory of the Mark-V fuel was calculated using the ORIGEN2 computer code assuming a typical Experimental Breeder Reactor-II operating cycle. To facilitate the modeling of accident consequences, the radionuclide inventory generated by the ORIGEN2 program was truncated to eliminate minor contributors to dose. The radionuclides eliminated accounted for less than 1 percent of the total dose. Additional details are available in Enyeart (1995). Table I-25 shows the radionuclide inventory representative of DOE research and test reactor SNF based on one Mark-V fuel assembly irradiated to a burnup of 7.88 percent and assuming a cooling time of 1 year.

Foreign research and test reactors use a number of different fuel designs. DOE has evaluated the characteristics of foreign research reactor SNF types in a separate EIS on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel. Based on this evaluation, a shipment of 40 TRIGA-type SNF elements was determined to result in the highest potential release of radioactivity in the event of an accident. To provide a bounding analysis for this EIS, foreign TRIGA-type SNF was selected as representative of all foreign research reactor SNF. To facilitate the modeling of accident consequences, the radionuclide inventory generated by the ORIGEN2 program was truncated to eliminate minor contributors to dose. The radionuclides eliminated accounted for less than 1 percent of the total dose. The radionuclide inventory of a single shipping cask, shown in Table I-26, is based on a reactor operating period of 3 years, with a burnup of 31 grams of uranium-235 per fuel element, followed by a cooling period of 1 year.

Table I-24. Radionuclide inventory for representative university research/test reactor spent nuclear fuel.[a]

Isotope	Inventory (curie)	Isotope	Inventory (curie)
H-3	3.25×10^{0}	Cs-137	9.72×10^{2}
Kr-85	8.60×10^{1}	Ba-137M	9.20×10^{2}
Sr-89	4.28×10^{1}	Ce-141	3.86×10^{0}
Sr-90	9.30×10^{2}	Ce-144	1.47×10^{3}
Y-90	9.30×10^{2}	Pr-144	1.47×10^{3}
Y-91	9.77×10^{1}	Pm-147	8.81×10^{2}
Zr-95	1.48×10^{2}	U-235	4.00×10^{-3}
Nb-95	3.20×10^{2}	U-236	5.50×10^{-3}
Ru-103	7.47×10^{0}	Pu-238	1.00×10^{0}
Rh-103m	6.74×10^{0}	Pu-239	1.57×10^{-1}
Ru-106	1.36×10^{2}	Pu-240	6.70×10^{-2}
Te-125m	4.11×10^{0}	Pu-241	5.88×10^{0}
Te-127	2.08×10^{0}	Am-241	4.57×10^{-2}
Te-127m	2.12×10^{0}	Cm-242	1.81×10^{-1}
Cs-134	1.10×10^{2}		

a. Inventory based on 19 TRIGA fuel rods (70 percent enrichment; 122 g/rod uranium-235 beginning-of-life), 1 year cooling out of reactor, 20.2 percent average burnup.

Table I-25. Radionuclide inventory for representative DOE research/test reactor spent nuclear fuel.[a]

Isotope	Inventory (curie per assembly)	Isotope	Inventory (curie per assembly)
H-3	7.98×10^0	Te-127	3.32×10^1
Mn-54	7.48×10^2	Te-129m	1.14×10^0
Fe-55	6.12×10^2	Cs-134	9.15×10^1
Co-58	1.25×10^2	Cs-137	1.04×10^3
Co-60	3.55×10^0	Ba-137m	9.80×10^2
Kr-85	9.75×10^1	Ce-141	1.49×10^1
Sr-89	1.45×10^2	Ce-144	7.76×10^3
Sr-90	7.23×10^2	Pr-144m	1.11×10^2
Y-90	7.23×10^2	Pr-144	7.76×10^3
Y-91	3.67×10^2	Pm-147	2.65×10^3
Zr-95	7.00×10^2	Sm-151	2.91×10^1
Nb-95	1.52×10^3	Eu-155	1.00×10^2
Ru-103	4.88×10^1	U-235	2.90×10^{-3}
Rh-103m	4.40×10^1	U-236	3.34×10^{-3}
Ru-106	3.65×10^3	Pu-238	1.48×10^0
Rh-106	3.65×10^3	Pu-239	4.05×10^1
Sn-123	2.48×10^1	Pu-240	3.61×10^1
Sb-125	1.21×10^2	Pu-241	1.39×10^3
Te-125m	2.96×10^1	Am-241	4.74×10^0
Te-127m	3.37×10^1		

a. Inventory based on EBR-II Mark-V fuel, 1 year cooling out of reactor, total burnup of 317 megawatt-days.

Table I-26. Radionuclide inventory for representative foreign research/test reactor spent nuclear fuel.[a]

Isotope	Inventory (curie)	Isotope	Inventory (curie)
H-3	1.31×10^{1}	Ce-141	6.97×10^{2}
Kr-85	3.63×10^{2}	Ce-144	2.55×10^{4}
Sr-89	2.75×10^{3}	Pr-144	2.55×10^{4}
Sr-90	3.16×10^{3}	Pm-147	7.02×10^{3}
Y-90	3.16×10^{3}	Pm-148m	4.68×10^{1}
Y-91	4.56×10^{3}	Eu-154	4.18×10^{1}
Zr-95	6.48×10^{3}	Eu-155	2.27×10^{1}
Nb-95	1.28×10^{4}	U-234	1.81×10^{-4}
Ru-103	8.44×10^{2}	U-235	7.91×10^{-3}
Rh-103m	8.44×10^{2}	U-238	6.51×10^{-3}
Ru-106	2.54×10^{3}	Pu-238	3.03×10^{0}
Rh-106m	2.54×10^{3}	Pu-239	5.50×10^{-1}
Sn-123	2.71×10^{1}	Pu-240	2.09×10^{0}
Sb-125	1.19×10^{2}	Pu-241	2.13×10^{2}
Te-125m	2.87×10^{1}	Am-241	4.07×10^{-1}
Te-127m	5.57×10^{1}	Am-242m	9.00×10^{-3}
Te-129m	2.31×10^{1}	Am-243	4.38×10^{-4}
Cs-134	1.16×10^{3}	Cm-244	7.14×10^{-3}
Cs-137	3.19×10^{3}	Cm-242	5.25×10^{0}

a. Inventory based on 40 foreign TRIGA fuel elements, 1 year cooling out of reactor, average burnup of 31 grams uranium-235 per fuel element.

Non-DOE research reactor types are generally similar to domestic university research and test reactors. Therefore, TRIGA reactor SNF was also chosen as representative of non-DOE research reactor SNF.

I-5.2.2 Radioactive Release Characteristics

Radiological consequences were calculated by assigning cask release fractions to each accident severity category for each chemically and physically distinct radioisotope. The release fraction is defined as the fraction of the radioactivity in the cask that could be released from the cask in a given severity of accident. Release fractions vary according to SNF type and the physical/chemical properties of the radioisotopes. Most solid radionuclides in SNF are nonvolatile and are, therefore, relatively nondispersible. Gaseous radionuclides, such as krypton-85, are relatively easy to release if the fuel cladding and cask are compromised.

Representative cask release fractions were developed for each of the representative SNF types. The U.S. Nuclear Regulatory Commission Modal Study developed release fractions for commercial pressurized water reactor SNF. The Modal Study release fractions, shown in Table I-27, are based on best engineering judgment and are conservative for most SNF types. For this analysis, the release fractions recommended in the Modal Study were applied only to commercial pressurized-water reactor SNF and TRIGA SNF, both of which are rod-type fuels. Because of the significant differences in fuel designs and the availability of more appropriate fuel-specific release characterization data, less conservative release fractions were applied to the other representative SNF types.

Release fractions for aluminum fuels (aluminum alloy fuel, aluminum cladding) were based on laboratory measurements of release fractions from aluminum fuels at high temperatures (Shibata et al. 1984) and the U.S. Nuclear Regulatory Commission Modal Study (Fischer et al. 1987). Because of the lower melting point of aluminum compared to metals used in other metallic fuels, the aluminum fuel release fractions are considered bounding for metallic fuels (that is, Savannah River Production Reactor, Hanford N-Reactor, and EBR-II Mark V SNF). Release fractions for the aluminum and other metallic fuel types are listed in Table I-28.

Release fractions for graphite fuels, specifically Fort St. Vrain SNF, were based on engineering analyses. Fort St. Vrain fuel is in the form of carbide particles, encased within a highly retentive four-layer ceramic coating. Stress analysis tests have shown that the fuel particles can withstand stresses well in excess of those that might be encountered in severe accidents. Thermal diffusion across the ceramic barrier under extreme temperature conditions is the only significant mechanism for release of fission products from intact Fort St. Vrain fuel. Fuel particles that have failed during reactor operation (less than 1 percent of the inventory) are vulnerable to vaporization and impact-induced releases of particulates, but volatile fission products would have been released within the extreme thermal environment of the operating reactor. Table I-29 summarizes the release fractions applied to Fort St. Vrain SNF, assuming 1 percent fuel failure during reactor operations.

Table I-27. Release fractions for transportation accidents involving special-case commercial, university, foreign, and non-DOE research reactor spent nuclear fuel types for the U.S. Nuclear Regulatory Commission Modal Study cask response regions.

	Release fraction[a]				
Cask response region	Inert gas	Iodine	Cesium	Ruthenium	Particulates
R(1,1)	0.0	0.0	0.0	0.0	0.0
R(1,2),R(1,3)	9.9×10^{-3}	7.5×10^{-5}	6.0×10^{-6}	8.1×10^{-7}	6.0×10^{-8}
R(2,1),R(2,2),R(2,3)	3.3×10^{-2}	2.5×10^{-4}	2.0×10^{-5}	2.7×10^{-6}	2.0×10^{-7}
R(1,4),R(2,4),R(3,4)	3.9×10^{-1}	4.3×10^{-3}	2.0×10^{-4}	4.8×10^{-5}	2.0×10^{-6}
R(3,1),R(3,2),R(3,3)	3.3×10^{-1}	2.5×10^{-3}	2.0×10^{-4}	2.7×10^{-5}	2.0×10^{-6}
R(1,5),R(2,5),R(3,5), R(4,5),R(4,1),R(4,2), R(4,3),R(4,4)	6.3×10^{-1}	4.3×10^{-2}	2.0×10^{-3}	4.8×10^{-4}	2.0×10^{-5}

a. U.S. Nuclear Regulatory Commission Modal Study (Fischer et al. 1987).

Table I-28. Release fractions for transportation accidents involving aluminum and metallic spent nuclear fuel types[a] for the U.S. Nuclear Regulatory Commission Modal Study cask response regions.

	Release fraction[b]				
Cask response region	Inert gas	Iodine	Cesium	Ruthenium	Particulates
R(1,1)	0.0	0.0	0.0	0.0	0.0
R(1,2),R(1,3)	9.9×10^{-3}	1.1×10^{-7}	3.0×10^{-8}	4.1×10^{-9}	3.0×10^{-10}
R(2,1),R(2,2),R(2,3)	3.3×10^{-2}	3.5×10^{-7}	1.0×10^{-7}	1.4×10^{-8}	1.0×10^{-9}
R(1,4),R(2,4),R(3,4)	3.9×10^{-1}	6.0×10^{-6}	1.0×10^{-6}	2.4×10^{-7}	1.0×10^{-8}
R(3,1),R(3,2),R(3,3)	3.3×10^{-1}	3.5×10^{-6}	1.0×10^{-6}	1.4×10^{-7}	1.0×10^{-8}
R(1,5),R(2,5),R(3,5), R(4,5),R(4,1),R(4,2), R(4,3),R(4,4)	6.3×10^{-1}	6.0×10^{-5}	1.0×10^{-5}	2.4×10^{-6}	1.0×10^{-7}

a. These release fractions are applicable to the following SNF types:
1. N Reactor
2. Savannah River Site production reactor
3. DOE research/test reactor

b. Derived from Shibata et al. (1984) and U.S. Nuclear Regulatory Commission Modal Study (Fischer et al. 1987).

Table I-29. Release fractions for transportation accidents involving graphite spent nuclear fuel for the U.S. Nuclear Regulatory Commission Modal Study cask response regions.

	Release fraction					
Cask response region	Inert gas[a]	Strontium, cerium[b]	Antimony[c]	Cesium[b]	Ruthenium, rhodium[c]	Particulates[d]
R(1,1)	0.0	0.0	0.0	0.0	0.0	0.0
R(1,2),R(1,3),R(1,4), R(2,1),R(2,2),R(2,3), R(2,4),R(3,1),R(3,2), R(3,3),R(3,4),R(4,1), R(4,2),R(4,3),R(4,4)	5.3×10^{-3}	3.7×10^{-7}	1.0×10^{-6}	2.4×10^{-7}	7.3×10^{-8}	1.0×10^{-9}
R(1,5),R(2,5),R(3,5), R(4,5)	1.2×10^{-2}	5.0×10^{-6}	1.0×10^{-6}	9.1×10^{-6}	7.3×10^{-8}	1.0×10^{-9}

a. Thermally induced, from NUREG/CR-0722, Table 40, all fuel (Lorenz et al. 1980).

b. Empirical data from the Fort St. Vrain Final Safety Analysis Report, Rev. 8, Table A.3-1 (PSC no date).

c. Thermally induced semivolatiles from incore failed fuel; 1 percent fuel failure, 100 percent respirable; release fraction from Lorenz et al. (1980).

d. Impact induced nonvolatiles, 1 percent incore failed fuel, 5 percent respirable, release fraction of 2×10^{-6} from Wilmot (1981).

I-5.3 Results of Calculations

I-5.3.1 Impacts from the No Action Alternative

There are no offsite shipments of DOE, university, foreign, or non-DOE research reactor SNF under this alternative. Consequently, there are no transportation accident impacts. The limited number of naval fuel shipments made under the No Action alternative are covered in Appendix D of Volume 1 of this EIS.

I-5.3.2 Impacts from the Decentralization Alternative

The SNF shipments included under this alternative are those of domestic university, foreign, and non-DOE research reactor SNF to the Idaho National Engineering Laboratory and Savannah River Site. Naval fuel shipments made under different options of the Decentralization alternative are covered in Appendix D of Volume 1 of this EIS. Shipments are expected to be made by truck, but the impact analysis also assessed transportation by rail. The same shipping cask was assumed to be used for both truck and rail shipments, and a single shipping cask was assumed for each shipment.

The cumulative accident risk for transportation by truck was calculated to be 0.0009 latent cancer fatality and 0.15 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0003 latent cancer fatality and 0.21 traffic fatality. Table I-30 summarizes the transportation accident risks for the Decentralization alternative.

As shown in Table I-31, the maximum reasonably foreseeable transportation accident has a probability of occurrence of about 1.6×10^{-7} per year for a suburban population zone. Under normal (neutral) weather conditions, the total population dose is estimated to be about 14 person-rem, which would be expected to result in less than one latent cancer fatality in the exposed population. For comparison, the same population would be expected to experience about 100,000 latent fatal cancers from other causes. The probability of this accident occurring in an urban population zone, or occurring under stable weather conditions in any population zone, is less than 1×10^{-7} per year.

I-5.3.3 Impacts from the 1992/1993 Planning Basis Alternative

This alternative includes the transport of five types of SNF. It assumes that the Fort St. Vrain SNF currently in storage in Colorado is transported to the Idaho National Engineering Laboratory. Likewise, special-case commercial SNF currently stored at West Valley is transported to the Idaho National Engineering Laboratory. DOE research and test reactor SNF is transported to either the Idaho National Engineering Laboratory or Savannah River Site, with most going to the

Table I-30. SNF transportation accident risks for the Decentralization alternative (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities[a]	Traffic fatalities[b]
Truck	1.7	0.0009	0.15
Rail	0.57	0.0003	0.21

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-31. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Decentralization alternative (1995 to 2035).

Alternative: Decentralization
Maximum reasonably foreseeable accident: University research reactor SNF shipment by rail
Population zone: Suburban[a]
Maximum reasonably foreseeable accident probability: 1.6×10^{-7} per year with neutral meteorology, less than 1×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	14 person-rem	(e)	0.032 rem	(e)
Latent cancer fatalities[d]	Rail	0.007	(e)	1.6×10^{-5}	(e)

a. The maximum reasonably foreseeable accident occurs in a suburban population zone. The probability of the accident occurring in an urban population zone is less than 1×10^{-7} per year. In a rural population zone, the dose would be approximately 9 percent of the suburban population dose.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of latent fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

e. Consequences not developed for accidents with probabilities less than 1×10^{-7} per year.

Idaho National Engineering Laboratory. Shipments of university, foreign, and non-DOE research reactor SNF are split between the Idaho National Engineering Laboratory and the Savannah River Site. Shipments could be by truck or rail, so the analysis addresses the two extremes of all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.0009 latent cancer fatality and 0.19 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0003 latent cancer fatality and 0.22 traffic fatality. Table I-32 summarizes the transportation accident risks for the 1992/1993 Planning Basis alternative.

The maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The accident has a probability of occurrence of about 2.0×10^{-7} per year for a suburban population zone. Under normal (neutral) weather conditions, the total population dose is estimated to be about 13,000 person-rem (average dose of 26 millirem per person), which could result in an estimated seven latent fatal cancers in the exposed population. For comparison, the same population would be expected to experience about 100,000 latent fatal cancers from other causes. The probability of this accident occurring in an urban population zone, or occurring under stable weather conditions in any population zone, is less than 1×10^{-7} per year. Table I-33 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

1.5.3.4 Impacts from the Regionalization Alternative

This alternative includes Regionalization 4A (by fuel type) and Regionalization 4B (by geography). Under Regionalization by Fuel Type, the same SNF types are transported as in the 1992/1993 Planning Basis alternative with differences occurring in the destinations of some SNF based on fuel type. DOE research and test reactor SNF is transported to either the Idaho National Engineering Laboratory or the Savannah River Site, with most SNF going to the Idaho National Engineering Laboratory. Graphite-type and special-case commercial SNF is transported to the Idaho National Engineering Laboratory. As with the 1992/1993 Planning Basis alternative, shipments could be by truck or rail, and the analysis evaluates impacts assuming either of two extremes: all shipments by truck or all shipments by rail.

Under Regionalization by Fuel Type, the cumulative accident risk for transportation by truck was calculated to be 0.0010 latent cancer fatality and 0.26 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0003 latent

Table I-32. SNF transportation accident risks for the 1992/1993 Planning Basis alternative (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities[a]	Traffic fatalities[b]
Truck	1.9	0.0009	0.19
Rail	0.61	0.0003	0.22

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-33. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the 1992/1993 Planning Basis alternative (1995 to 2035).

Alternative: 1992/1993 Planning Basis
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban[a]
Maximum reasonably foreseeable accident probability: 2.0×10^{-7} per year with neutral meteorology, less than 1.0×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	(e)	54 rem	(e)
Latent cancer fatalities[d]	Rail	7	(e)	0.027	(e)

a. The maximum reasonably foreseeable accident occurs in a suburban population zone. The probability of the accident occurring in an urban population zone is less than 1×10^{-7} per year. In a rural population zone, the dose would be approximately 3 percent of the suburban population dose.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

e. Consequences not developed for accidents with probabilities less than 1×10^{-7} per year.

cancer fatality and 0.25 traffic fatality. Table I-34 summarizes the transportation accident risk for the Regionalization by Fuel Type.

As in the 1992/1993 Planning Basis alternative, the maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The accident has a probability of occurrence of about 2.8×10^{-7} per year for a suburban population zone. The consequences under normal (neutral) weather conditions are the same as those described under the 1992/1993 Planning Basis alternative. Table I-35 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

The maximum reasonably foreseeable accident under stable weather conditions has a probability less than 1×10^{-7} per year for all population zones except rural. A total population dose of 3,500 person-rem was estimated for the rural population zone (average dose of 2 rem per person), which could result in an estimated two latent fatal cancers in the exposed population. For comparison, the same population would be expected to experience about 350 latent fatal cancers from other causes.

The Regionalization by Geography alternative contains six separate alternatives, and the transportation impacts of each option have been analyzed for comparison. Under this alternative, the same SNF types are transported as under the 1992/1993 Planning Basis alternative with differences occurring in the destinations of the SNF based on geographical considerations. Non-Navy SNF originating from western United States locations or points of entry would be transported to the Idaho National Engineering Laboratory, Hanford Site, or the Nevada Test Site. Non-Navy SNF originating from eastern United States locations or points of entry would be transported to the Savannah River Site or the Oak Ridge Reservation. Navy SNF would not be split on an east-west basis because the Navy would operate a facility for examining naval SNF at only one of tbe DOE sites.

Cumulative accident risks for transportation by truck range from 0.0009 latent cancer fatality and 0.21 traffic fatality for Regionalization at the Idaho National Engineering Laboratory and the Savannah River Site, to 0.0011 latent cancer fatality and 0.39 traffic fatality for Regionalization at the Nevada Test Site and the Oak Ridge Reservation. Cumulative accident risks for transportation by rail range from 0.0002 latent cancer fatality and 0.21 traffic fatality for Regionalization at the Idaho National Engineering Laboratory and the Oak Ridge Reservation to 0.0003 latent cancer fatality and 0.30 traffic fatality for Regionalization at the Nevada Test Site and the Savannah River Site.

As in Regionalization by Fuel Type, the maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The consequences of the maximum reasonably foreseeable accident are the same for each of the six Regionalization by Geography alternatives. The maximum reasonably foreseeable accident under neutral weather conditions occurs in a suburban population zone because the accident probability for an urban

Table I-34. SNF transportation accident risks for Regionalization by Fuel Type (1995-2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities[a]	Traffic fatalities[b]
Truck	2.0	0.0010	0.26
Rail	0.65	0.0003	0.25

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-35. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under Regionalization by Fuel Type (1995 to 2035).

Alternative: Regionalization by Fuel Type
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 2.8×10^{-7} per year with neutral meteorology; 1.1×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

population zone is less than 1×10^{-7} per year. The total population dose is estimated to be about 13,000 person-rem (average dose of 26 millirem per person), which could result in an estimated seven latent fatal cancers in the exposed population. For comparison, the same population would be expected to experience about 100,000 latent fatal cancers from other causes.

The probability of the maximum reasonably foreseeable transportation accident varies slightly among the six Regionalization by Geography alternatives. The maximum reasonably foreseeable accident in a suburban population zone has an estimated probability of occurrence ranging from about 2.7×10^{-7} per year for Regionalization at the Hanford Site and Savannah River Site, to about 3.7×10^{-7} per year for Regionalization at the Nevada Test Site and Savannah River Site. The maximum reasonably foreseeable accident in a rural population zone has an estimated probability of occurrence ranging from about 1.5×10^{-7} per year for Regionalization at the Hanford Site and Savannah River Site, to about 3.3×10^{-7} per year for Regionalization at the Nevada Test Site and Oak Ridge Reservation.

Tables I-36 through I-47 summarize the doses and health effects from the accident risk assessment and the maximum reasonably foreseeable consequence assessment for each of the Regionalization by Geography alternatives.

I-5.3.5 Impacts from the Centralization Alternatives

The impacts from centralization at the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and the Nevada Test Site are presented in this section.

I-5.3.5.1 Centralization at the Hanford Site. Under this alternative, SNF currently stored at other DOE sites, Fort St. Vrain, university, foreign, and non-DOE research reactors is eventually transported to the Hanford Site. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.0050 latent cancer fatality and 0.57 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0013 latent cancer fatality and 0.52 traffic fatality. Table I-48 summarizes the transportation accident risks for the Centralization at the Hanford Site alternative.

As in the 1992/1993 Planning Basis and Regionalization alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The accident has a probability of occurrence of about 5.1×10^{-7} per year under neutral (normal) weather conditions and 3.6×10^{-7} per year under stable (worst-case) weather conditions. The consequences are the same as those described under the Regionalization by Geography alternative. Table I-49

Table I-36. SNF transportation accident risks for Regionalization hy Geography (Idaho National Engineering Laboratory and Savannah River Site) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities[a]	Traffic fatalities[b]
Truck	1.7	0.0009	0.21
Rail	0.59	0.0003	0.22

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-37. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under Regionalization by Geography (Idaho National Engineering Laboratory and Savannah River Site) (1995 to 2035).

Alternative: Regionalization by Geography (INEL & SRS)
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 3.0×10^{-7} per year with neutral meteorology, 1.9×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-38. SNF transportation accident risks for Regionalization by Geography (Idaho National Engineering Laboratory and Oak Ridge Reservation) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities[a]	Traffic fatalities[b]
Truck	1.8	0.0009	0.22
Rail	0.40	0.0002	0.21

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-39. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under Regionalization by Geography (Idaho National Engineering Laboratory and Oak Ridge Reservation) (1995 to 2035).

Alternative: Regionalization by Geography (INEL & ORR)
Maximum reasonably foreseeable accident: Special-case commercial SNP shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 3.0×10^{-7} per year with neutral meteorology, 2.0×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-40. SNF transportation accident risks for Regionalization by Geography (Hanford Site and Savannah River Site) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities[a]	Traffic fatalities[b]
Truck	1.8	0.0009	0.24
Rail	0.62	0.0003	0.22

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-41. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under Regionalization by Geography (Hanford Site and Savannah River Site) (1995 to 2035).

Alternative: Regionalization by Geography (HS & SRS)
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 2.7×10^{-7} per year with neutral meteorology, 1.5×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-42. SNF transportation accident risks for Regionalization by Geography (Hanford Site and Oak Ridge Reservation) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities[a]	Traffic fatalities[b]
Truck	1.9	0.0009	0.24
Rail	0.43	0.0002	0.21

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-43. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under Regionalization by Geography (Hanford Site and Oak Ridge Reservation) (1995 to 2035).

Alternative: Regionalization by Geography (HS & ORR)
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 2.7×10^{-7} per year with neutral meteorology, 1.5×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-44. SNF transportation accident risks for Regionalization by Geography (Nevada Test Site and Savannah River Site) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities[a]	Traffic fatalities[b]
Truck	2.0	0.0010	0.38
Rail	0.61	0.0003	0.30

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-45. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under Regionalization by Geography (Nevada Test Site and Savannah River Site) (1995 to 2035).

Alternative: Regionalization by Geography (NTS & SRS)
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 3.7×10^{-7} per year with neutral meteorology, 3.3×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-46. SNF transportation accident risks for Regionalization by Geography (Nevada Test Site and Oak Ridge Reservation) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities[a]	Traffic fatalities[b]
Truck	2.1	0.0011	0.39
Rail	0.42	0.0002	0.30

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-47. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under Regionalization by Geography (Nevada Test Site and Oak Ridge Reservation) (1995 to 2035).

Alternative: Regionalization by Geography (NTS & ORR)
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 3.6×10^{-7} per year with neutral meteorology, 3.3×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-48. SNF transportation accident risks for the Centralization at the Hanford Site alternative (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities[a]	Traffic fatalities[b]
Truck	9.9	0.0050	0.57
Rail	2.5	0.0013	0.52

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-49. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Hanford Site alternative (1995 to 2035).

Alternative: Centralization at the Hanford Site
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and Rural (stable)[a]
Maximum reasonably foreseeable accident probability: 5.1×10^{-7} per year with neutral meteorology, 3.6×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

I-5.3.5.2 Centralization at the Idaho National Engineering Laboratory. Under this alternative, all SNF currently stored at other DOE sites, Fort St. Vrain, and university, foreign, and non-DOE research reactors is eventually transported to the Idaho National Engineering Laboratory. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.0048 latent cancer fatality and 0.49 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0012 latent cancer fatality and 0.44 traffic fatality. Table I-50 summarizes the transportation accident risks for the Centralization at the Idaho National Engineering Laboratory alternative.

As in the 1992/1993 Planning Basis and Regionalization 4A and 4B alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The accident has a probability of occurring of about 4.7×10^{-7} per year under neutral (normal) weather conditions and about 3.3×10^{-7} per year under stable (worst-case) weather conditions. The consequences are the same as those described under Regionalization by Geography alternative. Table I-51 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

I-5.3.5.3 Centralization at Savannah River Site. Under this alternative, SNF currently stored at other DOE sites, Fort St. Vrain, university, foreign, and non-DOE research reactors is eventually transported to the Savannah River Site. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.0016 latent cancer fatality and 0.84 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0004 latent cancer fatality and 0.49 traffic fatality. Table I-52 summarizes the transportation accident risks for the Centralization at Savannah River Site alternative.

As in the 1992/1993 Planning Basis and Regionalization alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The maximum reasonably foreseeable accident under neutral (normal) weather conditions occurs in an urban population zone and has a probability of occurrence of about 1.7×10^{-7} per year. A total population dose of 72,000 person-rem was estimated (average dose of 27 millirem per person), which

Table I-50. SNF transportation accident risks for the Centralization at the Idaho National Engineering Laboratory alternative (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent cancer fatalities[a]	Traffic fatalities[b]
Truck	9.5	0.0048	0.49
Rail	2.4	0.0012	0.44

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-51. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Idaho National Engineering Laboratory alternative (1995 to 2035).

Alternative: Centralization at the Idaho National Engineering Laboratory
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 4.7×10^{-7} per year with neutral meteorology, 3.3×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer facilities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less than 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

could result in an estimated 36 latent cancer fatalities. For comparison, the same population would be expected to experience about 540,000 latent cancer fatalities from other causes.

The maximum reasonably foreseeable accident under stable (worst-case) weather conditions occurs in a suburban population zone and has a probability of occurring of about 1.2×10^{-7} per year. A total population dose of 110,000 person-rem was estimated (average dose of 0.53 rem per person), which could result in an estimated 55 latent cancer fatalities. For comparison, the same population would be expected to experience about 42,000 latent cancer fatalities from other causes.

Table I-53 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

I-5.3.5.4 Centralization at Oak Ridge Reservation. Under this alternative, SNF currently stored at other DOE sites, Fort St. Vrain, university, foreign, and non-DOE research reactors is eventually transported to the Oak Ridge Reservation. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.0014 latent cancer fatality and 0.78 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0003 latent cancer fatality and 0.43 traffic fatality. Table I-54 summarizes the transportation accident risks for the Centralization at Oak Ridge Reservation alternative.

As in the 1992/1993 Planning Basis and Regionalization alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The maximum reasonably foreseeable accident under neutral (normal) weather conditions occurs in an urban population zone and has a probability of occurring of about 1.1×10^{-7} per year. The accident consequences are the same as those described for the urban zone accident under the Centralization at Savannah River Site alternative.

The maximum reasonably foreseeable accident under stable (worst-case) weather conditions occurs in a rural population zone and has a probability of occurring of about 5.7×10^{-7} per year. The accident consequences are the same as those described for the rural zone accident under the Regionalization by Geography alternative.

Table 1-55 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

Table I-52. SNF transportation accident risks for the Centralization at the Savannah River Site alternative (1995 to 2035).

Transport mode	Dose Risk (person-rem)	Latent cancer fatalities[a]	Traffic fatalities[b]
Truck	3.1	0.0016	0.84
Rail	0.80	0.0004	0.49

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-53. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Savannah River Site alternative (1995 to 2035).

Alternative: Centralization at the Savannah River Site
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Urban (neutral) and Suburban (stable)[a]
Maximum reasonably foreseeable accident probability: 1.7×10^{-7} per year with neutral meteorology, 1.2×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	72,000 person-rem	110,000 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	36	55	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in an urban population zone under neutral weather conditions. The probability of the accident in an urban zone under stable weather conditions is less than 1×10^{-7} per year. The maximum reasonably foreseeable accident for stable weather conditions occurs in a suburban population zone.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-54. SNF transportation accident risks for the Centralization at the Oak Ridge Reservation alternative (1995 to 2035).

Transport mode	Dose Risk (person-rem)	Latent cancer fatalities[a]	Traffic fatalities[b]
Truck	2.8	0.0014	0.78
Rail	0.52	0.0003	0.43

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-55. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Oak Ridge Reservation alternative (1995 to 2035).

Alternative: Centralization at the Oak Ridge Reservation
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Urban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 1.1×10^{-7} per year with neutral meteorology, 5.7×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	72,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	36	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in an urban population zone under neutral weather conditions. The accident probability under stable weather conditions is less than 1×10^{-7} per year, except in a rural population zone.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

I-5.3.5.5 Centralization at Nevada Test Site. Under this alternative, SNF currently stored at other DOE sites, Fort St. Vrain, university, foreign, and non-DOE research reactors is eventually transported to the Nevada Test Site. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.0050 latent cancer fatality and 0.72 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.0012 latent cancer fatality and 0.58 traffic fatality. Table I-56 summarizes the transportation accident risks for the Centralization at Nevada Test Site alternative.

As in the 1992/1993 Planning Basis and Regionalization alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special-case commercial SNF. The accident has a probability of occurring of about 1.0×10^{-7} per year under neutral (normal) weather conditions in a suburban population zone and about 5.0×10^{-7} per year under stable (worst-case) weather conditions in a rural population zone. The consequences are the same as those described under the Regionalization by Geography alternative. Table I-57 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

I-5.3.6 Impacts of Using Alternate Points of Entry for Foreign Research Reactor Spent Nuclear Fuel Shipments

For transportation accident risks (radiological and vehicle-related), shipments from Jacksonville, Florida, to the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site would yield lower impacts than shipments from Charleston, South Carolina, Galveston, Texas, Hampton Roads, Virginia, Savannah, Georgia, and the Military Ocean Terminal, Sunny Point, North Carolina, to these same sites. Shipments from Wilmington, North Carolina, to the Savannah River Site and Oak Ridge Reservation would also yield lower impacts than shipments from Charleston, South Carolina, Galveston, Texas, Hampton Roads, Virginia, Savannah, Georgia, and the Military Ocean Terminal Sunny Point, North Carolina, to these same sites. Shipments from Wilmington, North Carolina, to the Hanford Site, Idaho National Engineering Laboratory, and Nevada Test Site would yield slightly higher impacts (about 6 percent) than shipments from Charleston, South Carolina, Galveston, Texas, Hampton Roads, Virginia, Savannah, Georgia, and the Military Ocean Terminal, Sunny Point, North Carolina, to these same sites.

Table I-56. SNF transportation accident risks for the Centralization at the Nevada Test Site alternative (1995 to 2035).

Transport mode	Dose Risk (person-rem)	Latent cancer fatalities[a]	Nonradiological fatalities[b]
Truck	10.0	0.0050	0.72
Rail	2.4	0.0012	0.58

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-57. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Nevada Test Site alternative (1995 to 2035).

Alternative: Centralization at the Nevada Test Site
Maximum reasonably foreseeable accident: Special-case commercial SNF shipment by rail
Population zone: Urban (neutral) and Rural (stable)[a]
Maximum reasonably foreseeable accident probability: 1.0×10^{-7} per year with neutral meteorology, 5.0×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	72,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	36	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in an urban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

I-6 POTENTIAL MITIGATION MEASURES

The possible impacts from transportation associated with the alternatives could be mitigated in a number of different ways. For example, the routes used for truck shipments could be chosen using U.S. Department of Transportation routing guidelines. These guidelines are designed to reduce the radiological impacts associated with transportation. The guidelines consider as primary factors (a) the radiation exposure from incident-free transport, (b) the risk to general population from an accidental release of radioactive material, and (c) the economic risk from an accidental release of radioactive material. The guidelines consider as secondary factors (a) emergency response effectiveness, (b) evacuation capabilities, (c) location of special facilities such as schools or hospitals, and (d) traffic fatalities and injuries unrelated to the radioactive nature of the cargo.

Impact mitigation is also provided through the use of approved shipping containers. For shipments containing large amounts of radioactivity, such as SNF, Type B containers will be used. These containers are designed to withstand normal transport conditions and hypothetical accident conditions.

If an accident did occur, Federal, state, local, and Tribal authorities are trained in emergency response. For example, the Shoshone-Bannock Tribes, the State of Idaho, Bingham County, Bingham Memorial Hospital, Bannock Regional Medical Center, Pocatello Regional Medical Center, Idaho Power Company, Intermountain Gas Company, and the U.S. Department of Energy participated in a comprehensive, cooperative Transportation Accident Exercise held in Idaho in 1992 (TRANSAX '92).

The U.S. Environmental Protection Agency has developed protective action guides (EPA 1991) and protective actions that are designed to limit doses in the event of a nuclear incident. Use of these guides and actions also mitigates the impacts of transportation accidents involving radioactive material.

I-7 SPENT NUCLEAR FUEL TRANSPORTATION BY BARGE

As an alternative to truck or rail transport of SNF, barge transport of 71 SNF shipments from Brookbaven National Laboratory, located on Long Island, New York, to the Savannah River Site was evaluated. This section summarizes the impacts from transporting the 71 shipments from Brookhaven National Laboratory to the Savannah River Site.

I-7.1 Transportation Routes

Several routing options were evaluated for the barge shipments from Brookhaven National Laboratory to the Savannah River Site:

- Truck transport from Brookhaven National Laboratory to the Shoreham, New York, dock or Port Jefferson, New York. Shoreham and Port Jefferson are both located on Long Island near Brookbaven National Laboratory.

- Barge transport from Shoreham or Port Jefferson, New York, to Hampton Roads, Virginia; the Military Ocean Terminal, Sunny Point, North Carolina; Charleston, South Carolina; Savannah, Georgia; or directly to the Savannah River Site.

- Truck transport from Hampton Roads, Virginia; the Military Ocean Terminal, Sunny Point, North Carolina; Charleston, South Carolina; or Savannah, Georgia to the Savannah River Site.

The HIGHWAY computer code (Johnson et al. 1993a) was used to estimate the truck routes and the INTERLINE computer code (Johnson et al. 1993b) was used to estimate the barge routes. The truck and barge routes are summarized in Pippen (1995).

I-7.2 Incident-Free Transportation

Incident-free transportation assessments were conducted for barge shipments from Brookhaven National Laboratory to the Savannah River Site and included transport by truck, transport by barge, and intermodal transfers (e.g., truck to barge and barge to truck transfers). The methods and data used to estimate the radiological and nonradiological impacts of these shipments are discussed in Pippen (1995).

For barge shipments using the Shoreham, New York, dock as a point of departure from Long Island, the cumulative number of total fatalities (radiological plus nonradiological fatalities) ranged from 0.0048 to 0.0092. The lower number of fatalities was estimated when the barge shipments were made directly to the Savannah River Site. The larger number of fatalities was estimated when the barge shipments were made from Brookhaven National Laboratory to Shoreham, New York, to Hampton Roads, Virginia, to the Savannah River Site.

For barge shipments using Port Jefferson, New York, as a point of departure from Long Island, the cumulative number of total fatalities (radiological plus nonradiological fatalities) ranged from 0.0052 to 0.0093. The lower number of fatalities was estimated when the barge shipments were made directly to the Savannah River Site. The larger number of fatalities was estimated when the barge shipments were made from Brookhaven National Laboratory to Port Jefferson to Hampton Roads, Virginia, to the Savannah River Site.

I-7.3 Transportation Accidents

Transportation accident assessments were conducted for barge shipments from Brookhaven National Laboratory to the Savannah River Site. These assessments included evaluations of accident risks (both radiological risks and traffic fatalities) and accident consequences. The methods and data used to estimate the accident risks and consequences of these shipments are discussed in Pippen (1995).

For barge shipments using the Shoreham, New York, dock as a point of departure from Long Island, the cumulative accident risk (radiological plus nonradiological fatalities) ranged from 0.0011 to 0.0019. The lower number of fatalities was estimated when the barge shipments were made directly to the Savannah River Site. The larger number of fatalities was estimated when the barge shipments were made from Brookhaven National Laboratory to Shoreham, New York, to Hampton Roads, Virginia, to the Savannah River Site.

For barge shipments using Port Jefferson, New York, as a point of departure from Long Island, the cumulative accident risk (radiological plus nonradiological fatalities) ranged from 0.00087 to 0.0018. The lower number of fatalities was estimated when the barge shipments were made directly to the Savannah River Site. The larger number of fatalities was estimated when the barge shipments were made from Brookhaven National Laboratory to Shoreham, New York, to Hampton Roads, Virginia, to the Savannah River Site.

The consequences of the maximum reasonably foreseeable accident for barge shipments were less than the consequences of the maximum reasonably foreseeable accident for truck shipments, as discussed in Section I-5. This was because the barge routes are further from populations than truck routes.

I-8 TRANSPORTATION IMPACTS OF FOREIGN PROCESSING OF SPENT NUCLEAR FUEL CURRENTLY LOCATED AT THE HANFORD SITE

This section summarizes the transportation impacts of processing the Hanford Site N-Reactor SNF at a foreign processing facility. The detailed assessment of this transportation option, including a description of the foreign processing option and the methods and assumptions used in the analysis, is contained in Volume 1, Appendix A, Attachment B of this EIS.

I-8.1 Radiological Dose to Workers

This subsection describes expected radiological consequences to workers during transportation of N-Reactor SNF currently stored at the Hanford Site. The transportation analysis included shipment from the Hanford Site to representative West and East Coast points of entry (Portland, Oregon; Seattle, Washington; and Norfolk, Virginia) followed by overseas transport to a representative commercial processing facility in the United Kingdom. Overland shipment by barge, truck, or rail was considered as appropriate for each point of entry.

I-8.1.1 Worker Dose from Shipment Preparation Activities at the Hanford Site

Packaging of the K Basin fuel for overseas shipment was estimated to result in worker doses of approximately 140 person-rem (5.5×10^{-2} latent cancer fatalities) over a period of approximately 2 years. However, if stabilization of the fuel before transport were necessary, an additional 180 person-rem might be accumulated by onsite workers over a 4-year period, resulting in 7.0×10^{-2} latent cancer fatalities. Consequences of fuel-handling accidents of the K basins are addressed in Volume 1, Appendix A.

1.8.1.2 Worker Doses from Transportation

Collective worker impacts from incident-free transportation were estimated to range from 1.3×10^{-3} latent cancer fatalities for barge transportation between the Hanford Site and the point of entry at Portland, Oregon, to 4.3×10^{-2} latent cancer fatalities for the option of transport by truck between the Hanford Site and the point of entry at Norfolk, Virginia. These impacts account for transport of SNF leaving the Hanford Site as well as the return transport of high-level waste, plutonium oxide, and uranium oxide.

Radiological consequences to workers from activities at the point of entry for transport of SNF to the United Kingdom were evaluated based on commercial experience during the last 9 months of 1994. The consequences for loading and unloading 408 casks during shipment from the United States to the United Kingdom were estimated to be approximately 1.2 person-rem to all workers over the expected 5-year campaign. An additional two fuel-handling activities per cask at the Hanford Site and at the United Kingdom process facility would approximately double that estimate, resulting in a collective dose of 2.4 person-rem and a potential for 9.8×10^{-4} latent cancer fatalities for all shipments. The maximum dose to an individual worker, assuming that worker was involved in handling all 408 casks at one point in the shipping sequence, would be approximately 0.4 rem over 5 years.

The consequences to a nearby worker were evaluated for accidents at, or on the approach to, the representative points of entry considered in the overland transportation analysis. In addition, the point of entry at Newark, New Jersey, was included in this part of the analysis because of its large surrounding population (it is adjacent to New York City) whereas the other points of entry are located in smaller population centers. The consequences of the maximum reasonably foreseeable accident (frequency $> 1 \times 10^{-7}$ per year) to a worker at a distance of 100 meters (328 feet) ranged from 1.7 rem (6.8×10^{-4} latent cancer fatalities) at Seattle/Tacoma, Washington, to 2.1 rem (8.4×10^{-4} latent cancer fatalities) at Portland, Oregon, or Norfolk, Virginia. The corresponding total risks from accidents of all severity categories for 17 SNF shipments were 8.0×10^{-9} latent cancer fatalities at Seattle/Tacoma to 1.0×10^{-8} latent cancer fatalities at Norfolk or Portland.

Radiological consequences were estimated for workers as a result of normal transport operations and accidents during overseas shipments of SNF from the Hanford Site to the United Kingdom. The primary impact of routine (incident-free) marine transport of SNF would be potential radiological exposure to crew members of the ships used to carry the casks. While at sea, the crew dose would be limited to those individuals who may enter the ship's hold during transit and receive external radiation in the vicinity of the packaged fuel. The consequences to crew members would depend on the duration of the voyage and the time spent inspecting each cask. Assuming surface dose rates at the regulatory limit, the collective dose to the inspection crew from all SNF shipments could range from 2.4 to 12 person-rem, depending on the routing. Return shipments of high-level waste, uranium, and plutonium would result in lower doses to the crew. All doses to individual crew members would be within administrative control and regulatory limits for radiation workers. Actual commercial experience indicates that worker consequences could be much lower than these bounding estimates.

The consequences of accidents during ocean transit would likely be similar to those of point of entry workers who are near the scene of an accident. Individuals in the immediate vicinity of the impact would probably not survive an accident severe enough to release radioactive materials from a SNF shipping cask. Effects on the ocean environment would not be expected to be discernable because of dispersion during an airborne release.

The frequency of accidents on the open ocean was estimated to be 4.6×10^{-5} for an average duration voyage of approximately 20 days to transport SNF from foreign research reactors to the

United States. The frequency of accidents for overseas shipment of SNF and process materials via ships built for this purpose would likely be within a factor of 2 or 3 of this estimate.

I-8.2 Consequences to Members of the Public

This subsection describes expected consequences to the public from activities required to transport N-Reactor SNF to the United Kingdom.

I-8.2.1 Public Impacts from Shipment Preparation Activities at the Hanford Site

Activities at the Hanford Site before and during preparation for shipment of N-Reactor SNF would result in generally small consequences to the public, as discussed in Volume 1, Appendix A, of this EIS. Removal and packaging of SNF at the K Basins was estimated to result in offsite consequences comparable to those observed during initial segregation of the fuel, or less than 3×10^{-7} rem (1.5×10^{-10} probability of latent cancer fatalities) to the maximally exposed offsite individual. The risk from accidents involving handling of N-Reactor fuel at the K Basins is presented in Volume 1, Appendix A, of this EIS.

I-8.2.2 Public Impacts from Transportation Activities

Members of the public exposed to radiation during transportation include persons on the highway, railroad, or waterway with the shipment; persons residing near these transport links; and persons at intermediate stops along the route (such as refueling stops and stops at rail classification yards).

Public impacts from incident-free transportation include radiological impacts from direct radiation as well as nonradiological impacts from vehicle emissions. Radiological impacts from incident-free transportation were estimated to range from 2.1×10^{-4} latent cancer fatalities for barge transportation between the Hanford Site and the point of entry at Portland, Oregon, to 1.3×10^{-1} latent cancer fatalities for the option of transport by truck between the Hanford Site and the point of entry at Norfolk, Virginia. Nonradiological impacts from incident-free transportation were estimated to range from 1.2×10^{-3} latent cancer fatalities for the option of truck transport from the Hanford Site to the point of entry at Seattle/Tacoma, Washington, to 1.6×10^{-2} latent cancer fatalities for the option of truck transport from the Hanford Site to the point of entry at Norfolk, Virginia.

Public impacts from potential transportation accidents include radiological risks from radioactive materials that could be released to the environment as well as nonradiological risks associated with traffic accidents (i.e., vehicle collisions). Cumulative radiological transportation accident risks range from 1.8×10^{-6} latent cancer fatalities for the option of rail transport between the Hanford Site and the point of entry at Seattle/Tacoma, Washington, to 4.2×10^{-5} latent cancer fatalities for either truck or rail transport between the Hanford Site and the point of entry at Norfolk, Virginia. Traffic accident risks range from 8.9 $\times$ 10^{-3} fatalities for the option of truck transport between the Hanford Site and the point of entry at Seattle/Tacoma, Washington, to 1.3 $\times$ 10^{-1} fatalities for the option of truck transport between the Hanford Site and the point of entry at Norfolk, Virginia.

The maximum reasonably foreseeable transportation accident involves a return shipment of high-level waste transported by rail from the point of entry at Seattle/Tacoma, Washington, to the Hanford Site. If this accident were to occur in an urban population zone, it could result in an estimated one latent cancer fatality within the affected population. The probability of this accident is about 1.3 $\times$ 10^{-7} per year.

Normal port activities during transport of N-Reactor SNF are not expected to have any consequences for members of the public other than point of entry workers. The consequences to the public from accidents during point of entry transit were estimated using the same assumptions as for worker consequences. The highest risk to the public from point of entry activities was estimated to result from accidents at the dock. Under stable atmospheric dispersion conditions, the maximum risk to the public was estimated to be 8.4 $\times$ 10^{-5} latent cancer fatalities. The maximum foreseeable accident resulted in an estimated 380 latent cancer fatalities in the population within 80 kilometers (50 miles) of Newark, New Jersey. The estimated frequency of this accident was 2.2 $\times$ 10^{-7} for 17 overseas shipments of SNF.

There is not expected to be any dose to members of the public or marine life resulting from incident-free ocean transport of N-Reactor SNF to the United Kingdom. The effects of losing a cask at sea are estimated to be comparable to those evaluated for transporting foreign research reactor SNF to the United States based on similar shipping inventories of long-lived radionuclides per cask. The maximum dose to an individual for a cask lost in coastal waters was expected to be 11 millirem per year if the cask was left in place until all its contents dispersed. The corresponding consequences to marine biota were 0.24 millirad per year for fish, 0.32 millirad per year for crustaceans, and 13 millirad per year for mollusks. The consequences resulting from loss of a cask in the deep ocean would be many orders of magnitude lower than the estimates for coastal waters.

I-9 HISTORICAL SPENT NUCLEAR FUEL TRANSPORTATION ACCIDENTS

Transportation incidents for 1949 through 1970 were surveyed using summary reports prepared by the U.S. Atomic Energy Agency (AEC 1957, Patterson and DeFatta 1962, Patterson and Mehn 1963, AEC 1966, McCluggage 1971). In these summary reports, incidents are classified into six classes based on the extent of radioactive material release (Patterson and DeFatta 1962) and accidents and incidents are not differentiated. For 1949 through 1970, there were 14 incidents involving irradiated fuel elements. No packages approximating a Type B shipping cask were breached as a result of these incidents (McCluggage 1971). Two representative incidents are summarized below.

On November 15, 1960, a tractor-trailer carrying 7 steel-jacketed lead casks containing 25 irradiated fuel elements was involved in an accident with a station wagon. The station wagon was completely demolished and the driver killed. The tractor was badly damaged and the driver suffered a broken hand and abrasions. The irradiated fuel elements were undisturbed. This incident was classified as a Class I radiation release, which means that no radioactive material was released and there was no loss of integrity to the package.

In another case (June 2-6, 1960), leakage of contaminated cooling water from a rail shipment consisting of irradiated fuel elements and some ruptured elements in aluminum cans resulted in contamination of three railroad yards. This incident was classified as a Class IV radiation release, which means that radioactive material was released to the ground or trafficway with no runoff or aerial dispersion. There were no injuries associated with this incident.

Spent nuclear fuel transportation accidents for 1971 through 1993 were surveyed based on data in the Radioactive Materials Incident Report database. This database contains information on radioactive materials transportation incidents and accidents from the U.S. Department of Transportation, U.S. Nuclear Regulatory Commission, U.S. Department of Energy, state radiation control offices, and media coverage of radioactive materials transportation incidents and accidents (Cashwell and McClure 1992). The Radioactive Materials Incident Report database contains information on transportation accidents, handling accidents, and reported incidents; this discussion is limited to transportation accidents involving SNF.

Between 1971 and 1993, there were seven transportation accidents involving SNF. Three of these accidents involved rail shipments, and four of these accidents involved truck shipments. These accidents were summarized in Cashwell and McClure (1992). Only one of these accidents resulted in more than minor damage to the SNF cask. On December 8, 1971, a truck transporting a SNF element in a Type B shipping cask on U.S. Highway 25 in Tennessee swerved to avoid a head-on collision with another vehicle and was forced off the road. The driver of the truck was killed by the impact and the SNF cask was thrown into a ditch. The DOE Radiological Assistance Team from Oak

Ridge, Tennessee, arrived and surveys indicated that the structural integrity of the cask was intact and there was no release of contents.

I-10 CUMULATIVE IMPACTS OF TRANSPORTATION

I-10.1 Radiological Impacts

The cumulative impacts of the transportation of SNF consist of impacts from (a) historical shipments of SNF to the Hanford Site, Savannah River Site, Idaho National Engineering Laboratory, Oak Ridge Reservation, and the Nevada Test Site; (b) the alternatives evaluated in this EIS; (c) other reasonably foreseeable actions that include transportation of radioactive material; and (d) general radioactive materials transportation that is not related to a particular action. The discussion of cumulative transportation impacts concentrates on the cumulative impacts of offsite transportation, because offsite transportation yields potential doses to a greater portion of the general population than does onsite transportation. The collective dose to the general population and workers is the measure used to quantify cumulative transportation impacts. This measure of impact was chosen because it can be directly related to latent cancer fatalities using a cancer risk coefficient and because of the difficulty in identifying a maximally exposed individual for shipments throughout the United States spanning the period 1943 through 2035 (93 years).

Collective doses from historical shipments of SNF to the Hanford Site, Savannah River Site, Oak Ridge Reservation, and the Nevada Test Site were summarized in Jones and Maheras (1994a, 1994b, 1994c, 1994d). Data for these shipments were available for 1971 through 1993 and were linearly extrapolated back to the start of operations at each site because data before 1971 were not available. For the Hanford Site and Oak Ridge Reservation, the start of operations was 1943; for the Savannah River Site, the start of operations was 1953; and for the Nevada Test Site, the start of operations was 1951. The results of these analyses are summarized in Table I-58.

The historical shipments of SNF to the Idaho National Engineering Laboratory consisted of shipments of naval SNF and test specimens from 1957 through 1995 (see Attachment A to Appendix D of Volume 1 of this EIS). Extrapolation of naval shipments was not necessary because a detailed records search accounted for all shipments. Historical SNF also consisted of shipments of other DOE SNF to the Idaho National Engineering Laboratory besides naval shipments, such as research reactor SNF and special-case commercial SNF (Maheras 1994). Data for these shipments were available for 1973 through 1993 and were linearly extrapolated back to 1953, the start of operations at the Idaho Chemical Processing Plant, because data for 1953 through 1972 were not available. The results of these analyses are also summarized in Table I-58.

There are considerable uncertainties in these historical estimates of collective dose. For example, the population densities and transportation routes used in the dose assessments were based on census data for 1990 and the United States highway and rail system as it existed in 1993.

Table I-58. Cumulative transportation-related radiological collective doses and latent cancer fatalities (1943 to 2035).

Category	Collective occupational dose (person-rem)	Collective general population dose (person-rem)
Historical spent nuclear fuel		
Hanford Site (1943 to 1993)	52	27
Savannah River Site (1953 to 1993)	50	29
Idaho National Engineering Laboratory (1953 to 1993)		
DOE spent nuclear fuel	56	30
Naval spent nuclear fuel	62	1.6
Oak Ridge Reservation (1943 to 1993)	35	18
Nevada Test Site[a] (1951 to 1993)	1.4	0.70
Spent nuclear fuel shipments for Alternatives 1-5		
Naval[b]	1.5 to 15	0.34 to 12
DOE truck (100%)[c] (1995 to 2035)	0.0 to 1,000	0.0 to 2,300
DOE train (100%)[c] (1995 to 2035)	0.0 to 130	0.0 to 170
Reasonably foreseeable actions		
Geologic repository[c,d]		
Truck (100%)	8,600	48,000
Train (100%)	750	740
Waste Isolation Pilot Plant[e]		
Test phase (100% truck)	110	48
Disposal phase		
Truck (100%)	1,800	1,500
Train (maximum)[f]	68	940
Submarine reactor compartment disposal[g]	–	0.053
Return of cesium-137 isotope capsules[h]	0.42	5.7
Uranium billets[i]	0.50	0.014
General transportation		
1943 to 1982	220,000	170,000
1983 to 2035	89,000	98,000

Table I-58. (continued).

Category	Collective occupational dose (person-rem)	Collective general population dose (person-rem)
Summary		
Historical	200	110
Spent nuclear fuel shipments for Alternatives 1-5		
Truck	1.5 to 1,000	0.34 to 2,400
Train	1.5 to 150	0.34 to 190
Reasonably foreseeable actions		
Truck	11,000	50,000
Train	820	1700
General transportation (1943 to 2035)	310,000	270,000
Total collective dose	320,000	320,000
Total latent cancer fatalities	130	160

a. Shipments from Turkey Point Power Plant in Florida to the Engine Maintenance, Assembly, and Disassembly Facility at the Nevada Test Site.

b. Naval SNF and test specimen shipments based on a combination of truck and rail transport.

c. Shipments based on 100 percent transport by truck or 100 percent transport by rail.

d. Reference: DOE (1986)

e. Reference: DOE (1990)

f. The maximum rail case is based on rail transport where rail access is available and truck transport where rail access is not available.

g. Reference: USN (1984)

h. Reference: DOE (1994).

i. Reference: DOE (1992).

Using census data for 1990 overestimates historical collective doses because the United States population has continuously increased over the time covered in these assessments. Basing collective dose estimates on the United States highway and rail system as it existed in 1993 may slightly underestimate doses for shipments that occurred in the 1940s, 1950s, and 1960s, because a larger portion of the transport routes would have been on non-interstate highways where the population may have been slightly closer to the road. Data were not available that correlated transportation routes and population densities for the 1940s, 1950s, 1960s, and 1970s; therefore, it was necessary to use more recent data to make dose estimates. By the 1970s, the structure of the interstate highway system was largely fixed and most shipments would have been made on interstates.

Shipment data were linearly extrapolated for years when data were unavailable, which also results in uncertainty. However, this technique was validated by linearly extrapolating the data in SAIC (1991) for 1973 through 1989 to estimate the number of shipments that took place during the time period 1964 through 1972 (also contained in SAIC 1991). The 1973 through 1989 time period corresponded to the time period when data were available for the Idaho Chemical Processing Plant. The data in SAIC (1991) could not be used directly because only shipment counts are presented for 1964 through 1982 and no origins or destinations were listed for years before 1983. Based on the data in SAIC (1991), linearly extrapolating the data for 1973 through 1989 overestimates the shipments for 1964 through 1972 by 20 percent when compared to the actual shipment counts for 1964 through 1972.

Collective doses for SNF shipments associated with Alternatives 1 through 5 were summarized previously in this appendix and in Appendix D of Volume 1 of this EIS (for naval spent nuclear fuel). For truck shipments, the collective dose to workers ranged from 1.5 person-rem (the No Action alternative) to 1,000 person-rem (Centralization at Savannah River), or 0.00060 to 0.40 latent cancer fatalities. Collective dose to the general population ranged from 0.34 person-rem (the No Action alternative) to 2,400 person-rem (Centralization at Savannah River), or 0.00017 to 1.2 latent cancer fatalities. These doses and latent cancer fatalities include shipments of naval SNF and test specimens.

For train shipments, the collective dose to workers ranged from 1.5 person-rem (the No Action Alternative) to 150 person-rem (Centralization at Nevada Test Site), or 0.00060 to 0.060 latent cancer fatalities. Collective dose to the general population ranged from 0.34 person-rem (the No Action Alternative) to 190 person-rem (Centralization at Savannah River), or 0.00017 to 0.095 latent cancer fatalities. These doses and latent cancer fatalities include shipments of naval SNF and test specimens.

Transportation impacts may also result from reasonably foreseeable projects. Two major proposed projects that involve extensive transportation of radioactive material are: (a) shipments of SNF and defense high-level waste to a geologic repository, and (b) shipments of transuranic waste to the Waste Isolation Pilot Plant, located in Carlsbad, New Mexico. DOE is presently determining the suitability of Yucca Mountain, Nevada, as a site for a geologic repository for commercial SNF and defense high-level waste; therefore, the geologic repository was assumed to be located in Yucca Mountain, Nevada, for the transportation cumulative impacts analysis.

Based on the transportation dose assessments presented in DOE (1986), the worker collective dose for truck shipments to a repository was 8,600 person-rem or 3.4 latent cancer fatalities. The collective dose to the general population from truck shipments to a repository was 48,000 person-rem or 24 latent cancer fatalities. The worker collective dose for train shipments to a repository was 750 person-rem or 0.30 latent cancer fatalities. The collective dose to the general population from train shipments to a repository was 740 person-rem or 0.37 latent cancer fatalities.

Based on the transportation dose assessments presented in DOE (1990), the worker collective dose from truck shipments to the Waste Isolation Pilot Plant was 1,900 person-rem or 0.76 latent cancer fatalities. The collective dose to the general population from truck shipments to the Waste Isolation Pilot Plant was 1,500 person-rem or 0.75 latent cancer fatalities. The worker collective dose from train shipments to the Waste Isolation Pilot Plant was 180 person-rem or 0.072 latent cancer fatalities. The collective dose to the general population from train shipments to the Waste Isolation Pilot Plant was 990 person-rem or 0.50 latent cancer fatalities. These collective doses include the 5-year Test Phase and the 20-year Disposal Phase.

There are three other reasonably foreseeable projects that involve limited transportation of radioactive material: (a) 100 shipments of submarine reactor compartments from the Puget Sound Naval Shipyard to the Hanford Site for burial, (b) return of cesium-137 isotope capsules to the Hanford Site, and (c) transport of uranium billets from the Hanford Site to the United Kingdom. The transport of submarine reactor compartments is an ongoing activity that is not yet completed; therefore, it was categorized as a reasonably foreseeable action. The doses for these actions are presented in Table I-61.

There are also general transportation activities that take place that are unrelated to the alternatives evaluated in this EIS or to reasonably foreseeable actions. Examples of these activities are shipments of radiopharmaceuticals to nuclear medicine laboratories and shipments of commercial low-level radioactive waste to commercial disposal facilities. The U.S. Nuclear Regulatory Commission evaluated these types of shipments based on a survey of radioactive materials transportation published in 1975 (NRC 1977). Categories of radioactive material evaluated in NRC (1977) included: (a) limited quantity shipments, (b) medical, (c) industrial, (d) fuel cycle, and (e) waste.

The U.S. Nuclear Regulatory Commission estimated that the annual collective worker dose for these shipments was 5,600 person-rem or 2.2 latent cancer fatalities. The annual collective general population dose for these shipments was estimated to be 4,200 person-rem or 2.1 latent cancer fatalities. Because comprehensive transportation doses were not available, these collective dose estimates were used to estimate transportation collective doses for 1943 through 1982 (40 years). These dose estimates included SNF and radioactive waste shipments and truck and rail shipments.

Based on the transportation dose assessments in NRC (1977), the cumulative transportation collective doses for 1943 through 1982 were 220,000 person-rem for workers and 170,000 person-rem for the general population. These collective doses correspond to 88 latent cancer fatalities for workers and 85 latent cancer fatalities for the general population.

In 1983, another survey of radioactive materials transportation in the United States was conducted (Javitz et al. 1985). This survey included U.S. Nuclear Regulatory Commission and Agreement State licensees and the U.S. Department of Energy. Both SNF and radioactive waste shipments were included in the survey. Weiner et al. (1991a, b) used the survey by Javitz et al. (1985) to estimate collective doses from general transportation. The transportation dose assessments in Weiner et al. (1991a, b) were used to estimate transportation doses for 1983 through 2035 (53 years). The interval 1995 through 2035 corresponds to the interval of time associated with the spent nuclear fuel management activities evaluated in this EIS.

Weiner et al. (1991a) evaluated eight categories of radioactive material shipments by truck: (a) industrial, (b) radiography, (c) medical, (d) fuel cycle, (e) research and development, (f) unknown, (g) waste, and (h) other. Based on a median external exposure rate, an annual collective worker dose of 1,400 person-rem and an annual collective general population dose of 1,400 person-rem were estimated. These collective doses correspond to 0.56 and 0.70 latent cancer fatalities per year for workers and the general population, respectively. Over the 53-year time period from 1983 through 2035, the collective worker and general population doses would be 74,000 person-rem or 30 and 37 latent cancer fatalities for workers and the general population, respectively.

Weiner et al. (1991b) also evaluated six categories of radioactive material shipments by plane: (a) industrial, (h) radiography, (c) medical, (d) research and development, (e) unknown, and (f) waste. Based on a median external exposure rate, an annual collective worker dose of 290 person-rem and an annual collective general population dose of 450 person-rem were estimated. These collective doses correspond to 0.12 and 0.23 latent cancer fatalities per year for workers and the general population, respectively. Over the 53-year time period from 1983 through 2035, the collective worker dose would be 15,000 person-rem and the general population collective dose would be 24,000 person-rem or 6.0 and 12 latent cancer fatalities for workers and the general population, respectively.

Like the historical transportation dose assessments, the estimates of collective doses because of general transportation also exhibit considerable uncertainty. For example, data for 1975 were applied to general transportation activities from 1943 through 1982. This approach probably overestimates doses because the amount of radioactive material that was transported in the 1950s and

1960s was less than the amount transported in the 1970s. For example, in 1968, the shipping rate for radioactive material packages was estimated to be 300,000 packages per year (Patterson 1968); in 1975 this rate was estimated to be 2,000,000 packages per year (NRC 1977). However, because comprehensive data that would enable a more realistic transportation dose assessment are not available, the dose estimates developed by the U.S. Nuclear Regulatory Commission were used.

The total worker and general population collective doses are summarized in Table I-58. Total collective worker doses from all types of shipments (historical, the alternatives, reasonably foreseeable actions, and general transportation) were estimated to be 320,000 person-rem (130 latent cancer fatalities), for the period of time 1943 through 2035 (93 years). Total general population collective doses were also estimated to be 320,000 person-rem (160 latent cancer fatalities). The majority of the collective dose for workers and the general population was because of general transportation of radioactive material. The total number of latent cancer fatalities over the time period 1943 through 2035 was estimated to be 290. Over this same period of time (93 years), approximately 28,000,000 people would die from cancer, based on 300,000 latent cancer fatalities per year (NRC 1977). It should be noted that the estimated number of transportation-related latent cancer fatalities would be indistinguishable from other latent cancer fatalities, and the transportation-related latent cancer fatalities are 0.0010 percent of the total number of latent cancer fatalities.

I-10.2 Vehicular Accident Impacts

Fatalities involving the transport of radioactive materials were surveyed for 1971 through 1993 using the Radioactive Material Incident Report database. For 1971 through 1993, 21 vehicular accidents involving 36 fatalities occurred. These fatalities resulted from vehicular accidents and were not associated with the radioactive nature of the cargo. No radiological fatalities because of transportation accidents have ever occurred in the United States. During the same period of time, over 1,000,000 persons were killed in vehicular accidents in the United States.

For Alternatives 1 through 5, 0.047 to 1.4 vehicular accident fatalities are estimated to occur. During the 40-year time period from 1995 through 2035, approximately 1,600,000 people would be killed in vehicular accidents in the United States.

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CONTENTS

FIGURES

TABLES

Appendix J
Spent Nuclear Fuel Management

This appendix describes a range of technologies potentially available for management of spent nuclear fuel (SNF) and the status of each technology. The identified technologies support the SNF programmatic objective to define a management path and proceed toward ultimate disposition of all U.S. Department of Energy (DOE) SNF. Included are technologies for fuel preparation, storage (stabilization) or, where appropriate, direct interim storage. The stabilization and direct storage technologies may also be applicable to ultimate disposition in some instances. The stabilization technologies selected for discussion range from the minimal to the extensive stabilization processing technologies that could be applied to prepare the SNF for extended interim storage or ultimate disposition. In addition, programmatic and institutional factors, which are considerations in the selection of technology options for application, are discussed. Also presented is a brief description of the types of DOE SNF, particularly as their characteristics apply to the technology options.

J-1 BACKGROUND

During the last 40 years, DOE and its predecessor agencies have generated, transported, received, stored, and reprocessed SNF at facilities in the nationwide DOE complex. This SNF was generated from various sources, including DOE production reactors; the Naval Nuclear Propulsion Program reactors; DOE, university, and other research and test reactors; special-case commercial power reactors; and foreign research reactors. Production reactors were constructed and operated at the Hanford and Savannah River Sites to provide special nuclear material and other radioactive isotopes for the DOE's defense programs. These production reactors are no longer operated. Naval Nuclear Propulsion Program reactors and some test and research reactors are still operating. DOE has reprocessed SNF at the Idaho National Engineering Laboratory, Hanford Site, and Savannah River Site to recover fissile materials (uranium-235 and plutonium-239) and other valuable radionuclides.

More than 100,000 metric tons of heavy metal (MTHM) of SNF was produced by DOE and its predecessor agencies since 1943. In the past, most of the SNF was chemically processed to recover the fissile materials, largely uranium-235 and plutonium-239, either for the national defense programs or reactor research and development.

With the end of the Cold War, DOE and the U.S. Department of Defense reevaluated the scale of their weapons production, nuclear propulsion, and research missions. Because of the lack of need for additional fissile materials, DOE decided in 1992 to phase out reprocessing for the recovery of fissile materials. Approximately 2,700 MTHM of SNF remains that has not been processed. Additionally, approximately 100 MTHM of DOE SNF is expected to be generated in the next 40 years. This DOE SNF, which is in a wide range of enrichments and physical conditions, is stored at various locations in the United States and overseas. This material requires management until a decision regarding its ultimate disposition is reached.

Most of the existing fuel is currently stored in 10- to 40-year-old water pools (designed for temporary storage of SNF until it could be reprocessed) at several locations at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. Smaller quantities are stored at approximately 60 locations nationwide, including 55 non-DOE United States research reactor facilities. The vulnerabilities associated with the storage of SNF are identified in a recent DOE report to the Secretary of Energy entitled, *Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and Other Reactor Irradiated Nuclear Materials and Their Environment, Safety, and Health Vulnerabilities* (DOE 1993). A DOE plan of action (Phases I, II, and III) to address these vulnerabilities has been issued (DOE 1994a, b, c).

J-2 SPENT NUCLEAR FUEL

Individual fuel elements and assemblies in nuclear reactors are constructed in many configurations, but tbey generally consist of tbe fuel matrix, cladding, and structural hardware. The fuel assemblies and structural hardware constitute tbe reactor core. Section 1.1.1 of Volume 1 of tbis EIS presents a summary description of SNF.

The fuel matrix contains tbe fissile material (typically uranium as a metal, metal alloy, or an oxide). For water-cooled reactors, tbe matrix form is typically plates or cylindrical pellets. Typically, for gas-cooled reactors, tbe matrix is particles, which are an oxide or carbide composite of the fuel material encapsulated by a ceramic coating.

Cladding materials surrounding the fuel matrix serve two principal functions: (a) protection of the fuel matrix from corrosion by the fluid that removes heat from the reactor core, and (b) containment of radioactive fission products generated within the fuel during reactor operation. The degree and rate of cladding corrosion varies with reactor design.

The structural hardware serves both to support the fuel assemblies and to maintain a fixed geometry for the fissile materials in the reactor core. For example, structural materials fix the location of the fuel elements relative to one another in a fuel assembly and also fix the location of the fuel assemblies relative to one anotber in the reactor core. Structural hardware also provides mechanical support for the assemblies and the core, as well as providing defined paths for cooling tbe core. These functions are essential to control the nuclear reactions in the reactor core and ensure that adequate cooling is provided to all heat-generating regions of the reactor core.

The characteristics of tbe fuel elements in a reactor are tailored to the purpose of the reactor system. Two examples, important to SNF management, are discussed below. One example is for fuel with high-integrity cladding and the other is for fuel with lesser cladding integrity. Integrity refers to the corrosion resistance of the fuel to the reactor coolant and/or to its corrosion resistance in the environment in which it is stored.

- High-Integrity Fuels Used in Naval Reactors and Nuclear Power Plants. Naval fuels use highly enriched uranium, while nuclear power plant fuels generally use low-enriched uranium. These types of reactors use water for cooling the fuel assemblies. The reactors are operated at high coolant temperatures and pressures. The design objectives associated with commercial fuel and these reactor types are to maximize power output and minimize time spent refueling. For naval reactors, other design objectives are also critical: ability to withstand battleshock, ability to preclude release of any fission products because operating personnel must live and work in close proximity to the reactor, and ability to change reactor power levels quickly so the ship can alter speed when needed. As a result, the cladding materials are selected to be very corrosion resistant at high temperatures (a zirconium alloy is used). Long-term fuel element integrity is emphasized. From the standpoint of SNF management, such fuel element designs are well-suited for direct storage of the SNF (either wet or dry) without additional stabilization. Aggressive (concentrated) chemical and/or mechanical means are required to remove cladding if fuel processing is considered as an option for stabilization.

- Savannah River Production Reactor Fuels (and targets). The Savannah River Site production reactors also used water for cooling fuel assemblies. However, the reactors were operated at relatively low temperatures and essentially at atmospheric pressure. The design of these production reactor cores was optimized for production of special nuclear materials and other valuable radioactive isotopes. Fuel irradiation times were generally on the order of a few months. Fuel element cooling times prior to reprocessing were relatively short because the fuel elements were designed for special nuclear materials production and recovery. A high degree of corrosion resistance for the cladding was not part of the design. Aluminum cladding was selected so that the fuel elements could be dissolved for processing by less highly concentrated chemical solutions than for fuel with higher integrity cladding. Therefore, this fuel type is not as suitable for long-term storage (either wet or dry) as are the higher integrity fuels.

The DOE SNF represents a broad spectrum of fuel element designs, both for the fuel matrix material and the cladding. To provide perspective, the characteristics of the principal types of DOE SNF are briefly discussed below. Inventories for the various types (current and projected), in units of MTHM, are summarized in Table J-1, along with a qualitative statement regarding fuel element enrichment and cladding integrity.

J-2.1 Category 1—Naval Fuel

This SNF type includes the fuel from the Naval Nuclear Propulsion Program, including fuel from submarines, surface vessels, and prototype reactors. Naval fuel is highly enriched and is clad with a zirconium alloy. This fuel design is structurally strong (able to withstand battleshock loads well in excess of 50 times the force of gravity), the cladding is highly corrosion-resistant (no release of fission products), and the fuel is designed to operate for more than 20 years.

J-2.2 Category 2—Aluminum-Clad Production Reactor Fuel

The principal source of DOE aluminum-clad SNF was target and driver fuel from the Savannah River Site defense production reactors. The driver fuel is highly enriched aluminum-uranium alloy clad with aluminum. Most of the targets are depleted uranium metal (containing less uranium-235 than natural uranium), also clad with aluminum. Corrosion resistance of the cladding

Table J-1. Spent nuclear fuel inventories and corrosion resistance.[a]

SNF category	Reactor type	Existing inventory (MTHM)	Projected new SNF inventory for the next 40 years (MTHM)	Total projected inventory (MTHM)	Cladding corrosion resistance	Enrichment
1	Naval reactors	10	55	65	High	High
2	Production reactors, with aluminum-clad fuel; also aluminum-clad fuel from research and development reactors	190	25	210	Medium	High and low
3	Production reactors, zirconium-alloy-clad fuel	2100	0	2100	Medium to low	Low
4	High-temperature gas-cooled reactor fuel	28	0	28	High	High
5	Commercial research and development fuel	160	0	160	Variable	Variable
6a	Experimental, stainless-steel-clad fuel	83	14	97	Variable	Variable
6b	Experimental zirconium-alloy-clad fuel	78	0.42	78	Medium	Variable
6c	Miscellaneous fuel	0.42	1.3	1.7	Variable	Variable

a. Numbers may not sum due to rounding.

is moderate. Aluminum cladding is susceptible to corrosion when stored in water pools with poor water quality. Also, this category is used for SNF from the Advanced Test Reactor at the Idaho National Engineering Laboratory, some domestic and foreign research reactors SNF, and some production reactor fuel at the Hanford Site. With proper water quality, this fuel has been stored for more than 20 years without cladding corrosion problems.

Some of the fuel and targets have been in storage in water pools (with poor water quality) since 1989. Fuel is showing signs of corrosion, and targets are heavily corroded.

J-2.3 Category 3—Zirconium-Clad Production Reactor Fuel

All fuel in this category is from the Hanford Site N Reactor. It consists of a low-enriched uranium alloy fuel matrix, clad with a zirconium alloy. The fuel irradiation times were such that relatively large concentrations of fissile plutonium were produced.

Some of the N-Reactor's SNF has been in storage for over 20 years and a large number of fuel elements have holes in the cladding (breached), which permits corrosion of the fuel matrix. One result is contamination of the water in the storage pools at the Hanford Site. With respect to fuel with breached cladding, it is known that the irradiated metallic uranium can undergo reactions with water to produce uranium hydrides. The hydrided, irradiated uranium can be pyrophoric (subject to spontaneous burning) if it is permitted to dry out and is exposed to air (ITAT 1994). The potential pyrophoric nature of the fuel is an important consideration as management strategies for this fuel (including stabilization and transportation) are evaluated.

J-2.4 Category 4—High-Temperature Gas-Cooled Graphite Reactor Fuel

Graphite-matrix fuel was primarily used in two gas-cooled, commercial reactors: Fort St. Vrain and Peach Bottom. This type of fuel consists of small pellets of highly enriched uranium-carbide fuel surrounded by layers of pyrolytic carbon and protective layers of other carbide compounds that serve as the primary cladding. The pellets are dispersed in much larger graphite structures that provide neutron moderation and secondary containment. The fuel has high corrosion resistance when stored dry. However, the fuel is not amenable to wet storage.

J-2.5 Category 5—Commercial Reactor Research and Development Fuel

DOE has participated in numerous commercial reactor and SNF safety investigations. These activities have resulted in accumulations by DOE of SNF elements from a number of commercial reactors. Typically, this SNF consists of zirconium-alloy-clad, low-enriched uranium oxide fuels. Many of these elements were examined in DOE analytical facilities; others were used in test reactors to study fuel behavior in simulated accidents. The damaged core from the Three Mile Island-Unit 2 reactor was investigated extensively by DOE, under cooperative research and development agreements, at several DOE sites. This damaged fuel is also included in this category.

J-2.6 Category 6—Test and Experimental Reactor Fuels

This is a category of fuels of broad description. The fuels range from low to high enrichment and encompass metal, metal alloy, and oxide fuel matrices. The fuel can be divided into three categories.

J-2.6.1 Category 6a—Stainless-Steel-Clad Fuels from Experimental Reactors

Uranium enrichments are generally high in fuels from these reactors, but low-enrichment fuels are included as well. Fuel matrices consist of uranium-zirconium hydride, uranium dioxide, plutonium oxide, plutonium alloy, uranium carbide, uranium metal, and uranium alloys. The principal sources of fuel in this category are the Experimental Breeder Reactor-II and Zero Power Physics Reactor at the Idaho National Engineering Laboratory, Hanford Fast Flux Test Facility, and the blanket assemblies from the FERMI reactor.

J-2.6.2 Category 6b—Zirconium-Alloy-Clad Spent Nuclear Fuel from Experimental Reactors

Typically, fuel in this category has a uranium dioxide fuel matrix, but there is uranium-molybdenum alloy fuel also in this inventory. Enrichment can be either high or low. Most of this SNF originated at the Shippingport Power Reactor where the light water breeder reactor concept was tested. Some thorium and uranium-233 fuels are found in this category.

J-2.6.3 Category 6c—Miscellaneous Fuel

Fuel in this miscellaneous category is derived mainly from the Molten Salt Reactor Experiment at the Oak Ridge Reservation. That fuel is now stored in the salt storage tanks beneath the reactor.

J-3 SPENT NUCLEAR FUEL INTERIM MANAGEMENT OPTIONS

In 1992, the Secretary of Energy directed the DOE to develop an integrated long-term SNF management program. The program is assessing DOE's current SNF inventory and SNF storage facilities, integrating DOE's many existing SNF activities into one program, developing an integrated decisionmaking and policy basis for SNF operations, and ensuring that all issues associated with SNF are resolved safely and cost effectively.

Until ultimate disposition is determined, it is not possible to define the SNF characteristics suitable for ultimate disposition. Pending selection of an ultimate disposition, SNF must be maintained in safe storage. Solutions to the storage questions may require changes in management strategies for these fuels, including such options as the construction of new facilities and stabilization of certain fuels.

Technologies for SNF management are required to ensure safe, environmentally sound, and economic management until ultimate disposition is implemented. There are a number of technology options available for accomplishing these objectives. Key design factors to be considered include the fuel design, structural integrity of the fuel, degree of corrosion of the cladding, fuel enrichment, and the chemical stability of the cladding and the fuel matrix. The principal technology option categories for storage are outlined in a general way on a flow chart (Figure J-1).

The options for SNF management include direct storage (high-integrity fuels) or SNF stabilization in preparation for continued storage. Technologies included under SNF stabilization are containerization, processing without separation of fissile materials, and processing in which there is separation of the fissile material. The status of technologies for each of the approaches are discussed in Section J-4. Related institutional factors associated with implementing the various management approaches are discussed in Section J-5.

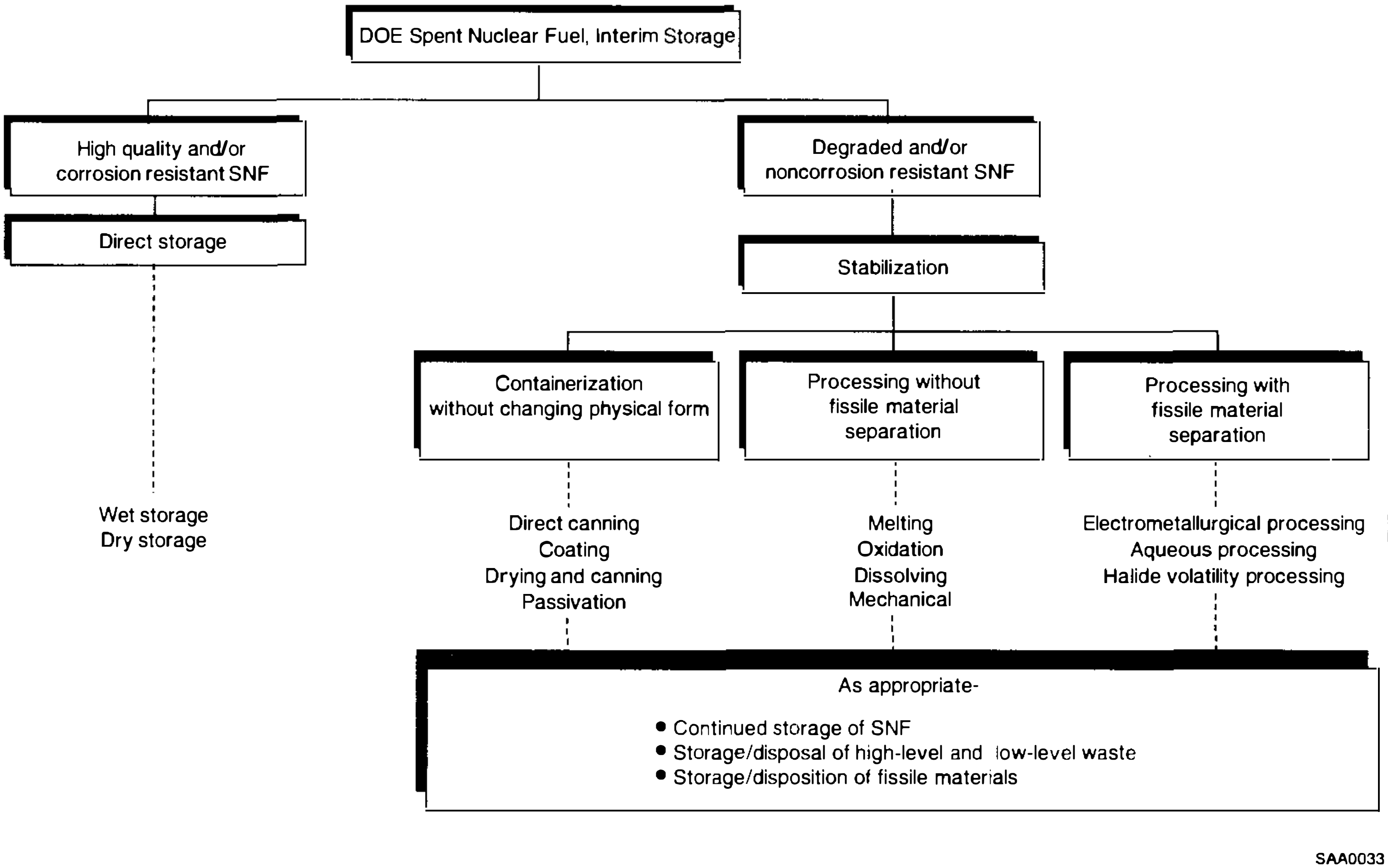

Figure J-1. Technology options for preparing spent nuclear fuel for interim storage.

J-4 SUMMARY OF TECHNOLOGIES FOR SPENT NUCLEAR FUEL MANAGEMENT

In 1992, DOE had proposed to engage in research and development activities for technology development and demonstration required to ensure that SNF could be appropriately prepared for disposition in a geologic repository. Any such repository is not expected to be available until after the year 2010. Therefore, DOE has changed its focus in this effort to better define the SNF research and development program. The DOE is utilizing a system approach (a logical, structured approach to assure effective actions) to technology development for preparing SNF for safe interim storage and ultimate disposition in a geologic repository.

Figure J-1 summarizes the technology options available for preparing SNF for interim storage. Indicated under each of the four general categories on the figure is a range of representative technology options. This section describes technology options listed on Figure J-1 and discusses the following:

- The option (describes what it involves)
- Applicable fuel types
- Maturity (demonstrated technology, early stages, or developmental)
- Status of commercial and foreign applications/development that may be applicable to DOE SNF management
- References that contain more detail on the technology.

When evaluating SNF management options, criticality control is an important factor, particularly for SNF with enriched uranium fuel.

Criticality considerations apply for both direct storage and stabilization. The storage system must meet applicable requirements governing nuclear criticality, which specify that the system be designed to ensure that a nuclear criticality is not possible unless at least two independent (concurrent or sequential) changes occur in the systems essential to the control of nuclear criticality.

Also important in selecting management options for SNF are the characteristics of the fuel type and the physical condition of the fuel. For specific types of fuel, characterization may be necessary to determine the extent of stabilization required and/or the most suitable stabilization process to transition the particular SNF into interim storage.

J-4.1 Direct Storage

Direct storage means storing SNF in essentially the same physical form in which it is removed from the reactor (that is, little or limited stabilization of the fuel elements). Fuel that has high-integrity cladding is amenable to direct storage provided criticality issues can be adequately addressed for the planned storage interval (IAEA 1988). Specific examples are naval SNF and SNF removed from most types of commercial nuclear electric generating stations (both in the United States and foreign countries).

If a reactor that has operated at high power has fuel removed soon after shutdown (within weeks), the level of heat generation associated with fission product decay may be sufficient to damage and possibly melt the fuel if the fuel assembly is not cooled adequately. In addition, radiation levels are high from decaying fission products and radionuclides in the irradiated structural materials. Thus, both effective cooling and effective shielding of the stored SNF are essential. Common practice is to place the SNF in a water pool, for at least a period of time, following removal from the reactor. The level of heat generation and radioactive decay associated with SNF decreases with time after removal from the reactor. With the passage of time, it is possible and may be desirable to transfer SNF from a wet to a dry storage mode because, in general, the costs and potential environmental safety and health vulnerabilities associated with dry storage are less than those associated with wet storage (Lopez 1994, Taylor and Shikashio 1993). The status of wet and dry storage technologies is discussed in the following two subsections.

J-4.1.1 Wet Storage

Water pools (or water pits) are part of the design of nearly all nuclear reactor facilities. They are used to provide a storage location for SNF when it is removed from the reactor. The pools usually are designed to store the inventory of fuel removed from a reactor for a number of years. Pool depth is sufficient to provide shielding for personnel working in the region of the water pool. The water pool system normally includes a subsystem for water chemistry control with a purpose of maintaining the conditions of the water in the pool so cladding corrosion is minimized, water in the pool is clean enough that the SNF can be viewed underwater during fuel movement and fuel removal operations, and chloride content is controlled to maintain pool liner integrity. The water pools usually are of concrete construction and lined with stainless steel so as to minimize the potential accumulation of radioactivity on or under the surface of the concrete pool walls.

Wet storage systems generally have more heat removal capability than dry storage systems because heat transfer to liquids is more efficient than to gases, such as air or nitrogen.

Design, construction, and operation of water pools for SNF storage is a mature technology option for DOE and for commercial nuclear power plants (Takáts 1994). Wet storage system design modifications usually center around re-racking the fuel in a pool to permit more fuel to be stored in a given pool. Fuel element spacing in rack designs is carefully analyzed to ensure that there is an adequate margin relative to criticality prevention for existing or contemplated SNF to be stored in the racks in the water pool.

J-4.1.2 Dry Storage Systems

In a dry storage system, cooling is provided by heat transfer to the inner wall of the storage system with eventual heat rejection to the air surrounding the storage system. Dry storage systems are mature technologies that are being applied for DOE SNF and for SNF at United States commercial and foreign nuclear electric generating systems (Schneider et al. 1992).

Dry storage system options generally are of three types: (a) stand-alone modular casks, (b) modular vault arrays, and (c) multiple-unit vault storage systems. Hot cells are also employed but are not generally considered cost efficient for storing significant quantities of SNF. Multiple examples of each of these three types have been built and are storing SNF at the present time in DOE, commercial, and foreign applications.

- **Stand-Alone Modular Casks**. A number of large stand-alone casks are available in the DOE system and in commercial applications. The casks are top- or end-loading, made from a variety of materials, and have been developed primarily in North America and Europe (Monthey and Bergsman 1994). Some cask designs are licensed for offsite transport of SNF and others are used principally for onsite fuel movement.

  There are also a variety of smaller stand-alone casks that are designed primarily for onsite transportation and storage of specific irradiated fuels and other materials. The safety basis documentation for these casks can be found in accompanying safety analysis reports (for example, Saito 1992).

- **Modular Vault Arrays**. A second type of dry storage system uses a basic concrete housing with an arrangement of openings in the concrete. Canisters containing fuel are placed in the openings. The concrete housing provides supplementary shielding and prohibits unauthorized access to the SNF. Depending on the design, fuel can be stored either vertically or horizontally in canisters.

- **Multiple-Unit Vault Storage Systems**. Multiple-unit vault systems tend to be large facilities that contain cask unloading stations, fuel handling cells, ventilation systems, and office space (Carter 1994). In the main storage area array, fuel assemblies or fuel assemblies in canisters are stored vertically in floor wells topped with shielded plugs. Insertion or removal of a canister containing the fueled component is accomplished using a shielded, floor-supported machine or a wall-mounted, unshielded bridge crane.

J-4.2 Containerization

Some SNF has deteriorated because of past storage conditions, fuel damage during operation or destructive tests, or use of cladding materials that are quite susceptible to deterioration if placed in prolonged wet storage without adequate protection. To provide adequate protection for the public, environment, and facility workers, containerization technologies have been employed to (a) add additional containment to the SNF, (b) provide a passivating environment for the spent fuel (a passivating environment is one where corrosion is minimized), or (c) place the spent fuel into an inert atmosphere to retard or eliminate the fuel-element deterioration process. These technologies are described below.

J-4.2.1 Canning

Canning is the technology whereby the SNF is placed into an engineered metal canister, which then is usually sealed. This technology (commonly called overpacking) is usually done in a water pool. Overpacking is used as a temporary corrective action if the SNF is releasing fission products. Further refinements include blowing the water out of the overpack canister while it is still underwater and then evacuating the canister (vacuum) to evaporate the remaining water. An inert gas, such as helium or nitrogen, can also be added. Another refinement to this technology involves adding a chemical for passivation to the water inside the canister to retard the corrosion of the SNF by the water. This approach has been attempted at the K-West Basin at the Hanford Site; however, its effectiveness is unknown because the fuel has not been inspected since it was canned. Small vents in the lid of the can, which allow release of gases generated by radiolysis or corrosion, have also been used.

Canning can also be carried out in a shielded, dry cell having remote-handling capabilities. The SNF is brought into the remote cell and dried, either by normal drip-drying or employing heating ovens to expedite the drying process. The SNF can be visually inspected in the remote cell and then placed into a metal canister that is welded closed. Inert gas can be added; high quality inspection of the closed canister is also possible.

This technology has been used extensively throughout DOE and foreign countries for research fuels. The commercial industry has not done a significant amount of direct canning because the commercial nuclear fuels have been designed for high integrity and so rarely require an overpack.

J-4.2.2 Passivation

The passivation approach is applicable to SNF that may contain regions that could undergo adverse chemical reactions if exposed to air or moisture during dry storage. Passivation increases the stability of the fuel by reducing its reaction rate with air or other oxidants. Consequently, if the fuel were inadvertently exposed to air during dry storage, the heat generated would be less than the minimum heat dissipation rate, thus minimizing the chances of a fuel fire or rapid adverse chemical reactions. This process potentially could be used to stabilize metallic fuel with damaged cladding, such as Hanford Site N-Reactor fuel.

Passivation could also include preparatory steps such as SNF cleaning, drying, and heating in a controlled environment to remove any bound water or to potentially remove or oxidize uranium hydride. A typical process first involves fuel cleaning. When cleaning is completed, a flow of dry inert gas is introduced around the fuel, which is maintained at the predetermined elevated temperature. A small concentration of oxidant is introduced into the flowing inert gas. Reactive regions of the fuel matrix react with the small amount of oxidant at the elevated temperature to oxidize them and make them nonreactive. When process instrumentation indicates that the reaction rate between the oxidant and the fuel (in the controlled environment) is sufficiently low, the fuel is cooled down and appropriately packaged. The fuel packaging must restrain the fuel from excessive movement to prevent the formation or exposure of new highly reactive fuel regions.

A passivation process has been used on metallic fuel in a laboratory setting by the British, who considered it to be a potentially viable method to transition their SNF from wet to dry storage. Passivation is being investigated for use on N-Reactor fuel at the Hanford Site.

J-4.2.3 Coating

Coating is a technology whereby the SNF is placed into a metal container, dried to remove any water, and then heated to the casting temperature for particular materials such as lead, copper, or an epoxy. The fuel element is covered with the molten material. The intent is to provide monolithic containment around the fuel element to ensure that the SNF will not release any fission products, nor encounter an atmosphere that causes the fuel to degenerate further. To date, this technology has been investigated primarily as an approach for preparing SNF for disposal. Pressing copper around SNF at high pressures has been studied by the Swedish government.

J-4.3 Processing

For over 40 years, DOE has employed aqueous reprocessing. The purpose for reprocessing was to separate plutonium and residual uranium materials in the SNF from the radioactive fission products and structural material, including fuel element cladding.

Some of the SNF that is currently in storage at the Savannah River Site, Hanford Site, and Idaho National Engineering Laboratory shows signs of degraded cladding. Aqueous processing may be a way of preventing safety and environmental problems with fuels that have questionable cladding integrity (DOE 1994a). From the standpoint of SNF stabilization, processing is a technology for which DOE facilities exist and where there are still capable technical and facility operating personnel to staff and support facility operations. By removing part of the SNF inventory from the present wet storage environments, processing affords an additional level of stability for the inventory of stored SNF.

Processing of SNF with separation of fissile materials has a long history of operations. The technology is mature and well understood. The primary process used for fissile materials separation for DOE SNF, commercial fuels, and foreign separations processing has been the PUREX (Plutonium URanium EXtraction) process or variations of this process. Facilities for PUREX-type processing have been built in the United States, a number of European countries, Russia, and Japan. In the United States, all of the recently operating facilities are owned and operated by DOE. With the end of the cold war, DOE and the U.S. Department of Defense reevaluated the need for additional fissile materials and decided in 1992 to phase out processing for recovery of fissile materials. DOE's processing facilities at the Hanford Site and Idaho National Engineering Laboratory are now shut down. One processing facility at the Savannah River Site has recently been restarted to stabilize aqueous solutions of uranium.

While chemical separation is the only technology currently available, there are other technologies that could accomplish fuel processing. The following technologies are intended to provide representative examples of technologies that could be employed for various types of SNF subject to the appropriate National Environmental Policy Act documentation. All technologies are not applicable to all types of fuel.

Several processes have been proposed and studied to stabilize SNF that do not involve separation of uranium and/or plutonium from the other highly radioactive contaminants. These processes involve changing the SNF physical and chemical form to make the volume smaller, material less reactive, or the material more homogeneous. Materials to assist in preventing nuclear criticality (nuclear poison) may also be introduced into the process. Because none of these methods remove fissile material, the possibility of a nuclear criticality exists for DOE SNF with a fuel matrix of highly enriched uranium-235, unless the uranium-235 is diluted with uranium-238 or a nuclear poison is added to assist in preventing nuclear criticality.

J-4.3.1 Oxidation

An oxidation process can be used for two purposes. It can be used to (a) separate the fuel from the cladding, minimize the volume of material to be stored, or prepare the fuel matrix to be more easily dissolved, or (b) convert fuel matrix or graphite fuel elements into a stable oxide form.

The decladding options include

- AIROX—Holes are drilled into the fuel matrix. Uranium dioxide (UO_2) is oxidized to U_3O_8 by injecting oxygen gas at 400°C (750°F). There is an increase in fuel matrix volume of about 70 percent. The uranium then is reduced back to UO_2 using hydrogen gas. The process is repeated several times until the cladding breaks apart. This process is in the developmental stages.

- RAHYD—Holes are drilled into the fuel matrix. Uranium metal is reduced with hydrogen gas at 225°C (435°F) to produce uranium trihydride. There is about a 70 percent volume increase. The fuel matrix is then converted back to uranium metal by heating to 780°C (1400°F). The process is repeated several times until the cladding breaks apart. This process is in the developmental stages.

- CARBOX—Holes are drilled into the fuel matrix. Oxygen is injected into uranium carbide fuel at 400 to 700°C (750 to 1300°F) to form U_3O_8. There is about an 85 percent volume increase. This process is in the developmental stages.

After the fuel is declad, the fuel matrix material can be consolidated and packaged for storage.

Development work was performed on decladding technologies in the late 1950s and early 1960s in connection with dry SNF reprocessing research at Atomics International.

The fuel elements can also be oxidized to convert the cladding and/or the fuel matrix into oxide form. One example is the burning of the graphite and metal fuels. The oxidized fuel and any ash would contain the uranium, plutonium, and most of the fission products, which then would be consolidated and packaged for storage. Technology for burning graphite fuels is well developed and has been used at the Idaho National Engineering Laboratory (WINCO 1992).

J-4.3.2 Chemical Dissolution

The fuel is dissolved chemically by a highly concentrated acid or base solution. If necessary, a nuclear poison can be added to assist in criticality control. Separation of the fissile material from the fission products and cladding material does not occur. The resultant product is converted into an SNF interim storage form, such as a glass, oxide, or ceramic, with improved characteristics relative to criticality control. This process applies to all DOE fuel types except graphite fuel. The dissolution technology is well developed (Long 1978) and has been used throughout the DOE complex and in several foreign countries.

J-4.3.3 Mechanical

Several mechanical processes, such as shredding, chopping, grinding, and disassembly, have been proposed to change the configuration of the fuel. The resultant product can be mixed with other material, such as glass formers or depleted uranium, for safe interim storage. All DOE fuel can be treated by this method. Choppers have been used at several DOE facilities, and shredders have been evaluated at the Idaho National Engineering Laboratory for graphite fuel (WINCO 1992).

J-4.3.4 Aqueous Processing

The primary aqueous extraction processing approach used is called PUREX. Aqueous processing consists of chemically dissolving the fuel in an acid, adjusting the solution pH for stability and uranium extraction, and contacting (mixing) the acid solution with an organic phase, such as kerosene or n-dodecane, usually with tributyl phosphate added (Long 1978, Benedict 1981). The organic compound forms a complex with the uranyl ion that is extracted into the organic phase, thus separating the uranium from other dissolved constituents of the fuel. Depending on the fuel type, the entire fuel element may be dissolved, or the cladding can be breached by chopping the element to enable the acid to leach the fuel matrix. For the chop-leach approach, there remains undissolved cladding hulls. The acid solutions used in the process are tailored to the fuel type. By adjusting the valence of plutonium, it can be separated from the uranium and/or fission products by a series of water-solution-to-organic-phase extraction steps. The PUREX process is applicable to almost all fuel types, if there is a suitable fuel matrix dissolution (headend) process. A process variation called TRUEX, developed at Argonne National Laboratory, can be used to recover the transuranic elements other than uranium or plutonium.

Aqueous processing of SNF utilizing the basic PUREX separation approach is a mature technology and is used world-wide (Leigh 1992). The United States has used PUREX aqueous processing for separating fissile materials from irradiated defense fuels since the 1950s at the Savannah River Site, Hanford Site, and Idaho National Engineering Laboratory. The West Valley Plant in New York, constructed for fissile material extraction from commercial light water reactor fuels, used a PUREX-type process. The United Kingdom, France, Russia, and Japan use large-scale aqueous PUREX processing to recover fissile materials from spent fuels.

J-4.3.5 Electrometallurgical Processing

Electrometallurgical processing employs rapid anhydrous (or water-free) chemical reactions at high temperature for the extraction of metal from mixtures or concentrates and for refining metallic elements and compounds. The process is based on passing an electrical current through fused salts. It involves three steps. First, a basket of chopped fuel is made anodic with respect to the electrorefiner crucible, which promotes rapid dissolution of the fuel into the electrolyte salts. These salts float on a pool of liquid cadmium metal. Second, a metallic cathode is introduced into the salts and much of the uranium is deposited on the metallic cathode (which is removed for uranium recovery). Third, a liquid cadmium cathode is then used to collect the remaining uranium, plutonium, and fission products. Zirconium and noble metals remain in the molten electrorefiner cadmium pool. Most fission products remain in the electrolyte salts. Cadmium in the liquid cadmium cathode can be distilled, leaving the fissile materials and uranium/plutonium for further disposition, as appropriate. The process is being developed at Argonne National Laboratory-West and being demonstrated on a near-commercial pilot-plant scale in the Fuel Cycle Facility at the Idaho National Engineering Laboratory using sodium-bonded metallic fuel. In principle, other metallic fuel can be processed electrometallurgically. This developmental process is unique to DOE with no foreign or commercial counterparts at the present time.

J-4.3.6 Halide Volatility

A dry chloride volatility process is being developed for separation of the nonradioactive bulk cladding material (e.g., zirconium), fissile uranium, and other fissile or nonfissile transuranic products in SNF. This process is in the conceptual stage (Christian 1994). The process involves complete volatilization of a SNF element. Fuel is exposed to chlorine gas at high temperature [greater than 1200°C (2200°F)]. All of the fuel constituents form volatile chlorides. The chloride compounds are separated by scrubbing the gases through a molten zinc chloride bath to remove the fission products and transuranic radionuclides. The fission products and transuranic radionuclides are recovered by evaporating away the zinc chloride. The remaining chloride gases are fractionally condensed to separate and recover nonradioactive constituents, uranium, iodine, and krypton. The process produces a single waste form (e.g., glass) for ultimate disposition. A significant reduction in volume can be achieved. The process can be applied to fuels with almost any of the existing claddings (such as zirconium alloys, aluminum, and stainless steel).

J-4.4 Capabilities of Existing Facilities for Processing Each of the Fuel Types

The current DOE SNF inventory was characterized into six categories as discussed previously in Section J-2 and Table J-1. Table J-2 summarizes the locations for each category of SNF as well as the processing capabilities that might be brought to bear on them. The information in the tables is expanded on below.

Table J-2. Capabilities of existing facilities for processing each type of spent nuclear fuel (SNF).

SNF category	Description	Source	Conditioning and stabilization needs for interim storage	Processing technology status	Existing applicable facilities
1	Metallic fuel with zirconium-alloy cladding	Naval fuel	Excellent condition; minimal stabilization required	Proven on a production scale	Existing Idaho National Engineering Laboratory facilities using second generation dissolution facilities (fluorinel dissolution process cell) and extraction via CPP-601 facility
2	Highly enriched metallic fuel with aluminum clad	Fuel from the Savannah River Site production reactors; Idaho National Engineering Laboratory Advanced Test Reactor driver fuel; some domestic and foreign research reactor fuels	Condition varies; stabilization is a near-term issue; fuel in wet storage will degrade further during interim period; long-term dry storage has unresolved questions	Proven on a production scale	Existing Savannah River Site facilities for Savannah River fuel; other research and development SNF can be processed at either the Savannah River Site or Idaho National Engineering Laboratory
3	Low enrichment, metallic fuel with zircaloy-clad	Hanford Site N-Reactor fuel	Poor condition and degrading; about half of the SNF has breached cladding with fuel leaching; stabilization is a near-term issue	Proven on a production scale	Existing Savannah River Site or Idaho National Engineering Laboratory facilities with new chop-leach head-end; certain foreign facilities exist that have the capability to process N-Reactor SNF
4	Uranium carbide in graphite matrix within a graphite structure UO_2 fuel with zirconium	Gas-cooled commercial reactors at Fort St. Vrain and Peachbottom	Excellent condition; minimal stabilization necessary	Proven on a production scale for ROVER SNF; proven on a prototype scale for other graphite fuels	Idaho National Engineering Laboratory or Savannah River Site facilities could be used with a new head-end facility
5	Zircaloy-clad rods typically with low-enrichment UO_2 pellets	DOE tests of commercial reactor fuel; damaged Three-Mile Island core debris	Condition excellent with the exception of Three-Mile Island core debris; minimal stabilization necessary	Proven on a production scale	Existing Idaho National Engineering Laboratory or Savannah River Site facilities perhaps with new head-end facility

Table J-2. (continued).

SNF category	Description	Source	Conditioning and stabilization needs for interim storage	Processing technology status	Existing applicable facilities
6a	Various stainless-steel clad fuels with either high or low enrichment	Idaho National Engineering Laboratory and Hanford Site test reactors	Various and sometimes unknown fuel condition. Degradation of some fuels expected because of long storage times	Proven on a production scale for steel-clad high-enriched uranium SNF; prototype demonstrations are needed for other types	Existing Idaho National Engineering Laboratory or Savannah River Site facilities with new or modified head-end
6b	Zircaloy-clad UO_2 or U-Mo alloy of high or low enrichment	Shippingport power reactor and various experiment reactors	Various and sometimes unknown fuel condition; degradation of some fuels expected because of long storage times	Proven for some fuel types; others may require further work	Existing Idaho National Engineering Laboratory or Savannah River Site facilities with an upgraded dissolution facility
6c	Liquid uranium-235 in a salt solution, no cladding	Molten salt reactor experiment at Oak Ridge National Laboratory	Unknown; corrosive nature of fuel raises questions regarding present conditions; evidence of corrosion of storage container exists; stabilization will be required	Processing technology not yet identified	None at present

J-5 SPENT NUCLEAR FUEL INSTITUTIONAL CONSIDERATIONS

This section, in a general way, summarizes potential impacts of institutional considerations on SNF management. The institutional factors include availability of an infrastructure of personnel with knowledge and training in SNF management; facility capacity for SNF operations; and availability of equipment, facilities, railheads, and roadways for transport of SNF. These factors are important considerations in evaluating and selecting technology options for SNF management.

J-5.1 Availability of Technical Personnel Trained in Spent Nuclear Fuel Management

The management of SNF requires personnel qualified and experienced in a number of appropriate skill areas and operations. The skill areas include proficiency in the design, fabrication, and use of special tooling; specific training in safety and radiation protection; specific understanding of criticality controls; an understanding of SNF and SNF handling and shipping operations; and emergency preparedness capabilities. Most operations involving SNF must be performed remotely in hot cells.

The disciplines specific to SNF management include mechanical and structural engineering, construction engineering, radiation protection, nuclear safety, industrial safety, chemistry, and nuclear physics.

J-5.2 Availability of Facilities for Spent Nuclear Fuel Management Operations

Important facilities factors to be considered in SNF management include availability and adequacy of existing facilities for storing and stabilizing of SNF and the design requirements for new facilities. Important factors when evaluating existing facilities include fuel type to be handled, fuel integrity, type of storage (for example, wet or dry), stabilization requirements, capacity and condition of dry storage facilities, and any conditioning or processing that could be required for ultimate disposition.

J-5.3 Transport of Spent Nuclear Fuel

Important factors relating to transport of SNF include fuel reactivity or stability, availability of shielded casks, availability of cask-handling cranes with adequate capacity, status of licenses and permits for a particular site, availability of transport equipment and loading and unloading facilities, availability of qualified roadways and/or railheads, and vehicle tracking and communications capabilities.

J-5.4 Safeguards and Security

The management of SNF typically requires rigorous safeguards and security controls to protect the fissile material within the SNF from diversion. In addition, protection of personnel, the public, and environment must be maintained. These requirements result in specific safeguards and security criteria that include access control to areas where SNF is handled, stored, and processed and the maintenance of controlled databases to account for fuels and their inventory of fissile materials.

J-5.5 Current Federal and State Agreements

DOE has entered into agreements with state governments that apply to SNF sites. The DOE agreement with the State of New York provides that the SNF will be removed from the West Valley Site to another DOE site. An agreement among the DOE, Navy, and State of Idaho regarding the Idaho National Engineering Laboratory provides for removal of SNF from underwater storage in the north and middle basins of Building CPP-603 by the end of 1996 and from the south basin of this facility by the end of 2000. There is also an agreement among the DOE, U.S. Environmental Protection Agency, and State of Washington regarding the Hanford Site that requires the removal of SNF and pool sludge from the Building 105-K basins.

J-5.6 Maintaining Flexibility Until Ultimate Disposition is Available

Some stabilization technologies for storage may be undesirable if they could potentially make a later conversion to an acceptable form for ultimate disposition very difficult. For example, SNF stabilized for interim storage could be precluded from ultimate disposition by certain possible acceptance criteria.

J-6 REFERENCES

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Appendix K
Environmental Consequences Data

This appendix presents data that were used to discuss environmental consequences and to generate the graphics used in comparing environmental consequences among alternatives (in Chapter 3) and among alternatives and sites (in Chapter 5). These data are taken from Volume 1 Appendices A through F and converted as required to different units or time periods. To understand the technical basis and context for each of the reported data elements, refer to the appropriate site appendix:

Hanford Site	Appendix A
Idaho National Engineering Laboratory	Appendix B
Savannah River Site	Appendix C
Naval Nuclear Propulsion Program	Appendix D
Other Generator/Storage Locations	Appendix E
Nevada Test Site and Oak Ridge Reservation	Appendix F

The appendix contains (a) a key to alternatives, (b) a summary of data by alternative, and (c) a summary of data by alternative and site. The key to alternatives defines the site combinations represented by the subalternatives and options and relates these to the columns in Tables K-1 and K-2. The summary of data by alternative in Table K-1 presents the summed (or maximum) impacts across all sites involved in that alternative, subalternative, and option. The summary of data by alternative and site in Table K-2 presents data for each site that is affected by that alternative, subalternative, and option. Those sites not affected by a particular option are not shown.

Ten categories of data, numbered in the first column of the attached tables, were used to develop the discussions and graphs in Chapter 5 and are summarized by discipline below.

1. Land Use—The value presented is an estimate of the amount of additional acreage that would be disturbed if a particular alternative was implemented. Minimum and maximum values were provided for options within each alternative where available. The maximum percent of the total site area that would be dedicated to spent nuclear fuel (SNF) management activities was also calculated. Land use impacts are discussed in Section 5.2.1 of Volume 1. A detailed discussion on land use is provided in Appendices A through F.

2. Employment Related to SNF Management—The values presented are the projected 10-year average changes in site employment related to proposed SNF management activities for the period from 1995 to 2005. Minimum and maximum values were calculated where data were available. Baseline site employment refers to the sitewide employment at June 1995, inclusive of those employed in SNF management activities. The maximum percent of baseline site employment represents the maximum incremental change in sitewide employment that might

occur because of the proposed SNF management activities. SNF-related employment is discussed by alternative in Section 5.1, Chapter 5, Volume 1. A detailed analysis of socioeconomic impacts is provided in Appendices A through F.

3. Population Collective Dose—The radiation dose that would be received by the population within 80 kilometers (50 miles) of each site per year from normal operations. It is derived from data in the site appendices and represents the dose for the maximum option within each alternative. Because of the differences in methods used to generate the data, the estimated SNF management doses are sometimes higher than total site doses. The SNF management doses were developed by modeling releases from existing and proposed facilities, and sitewide doses were determined by a combination of modeling of existing facilities and monitoring data. The monitoring data are more accurate, while the modeling approach overestimates expected dose, making the expected dose higher than would probably be realized. Population collective doses are described by alternative in Section 5.1, Chapter 5, Volume 1.

4. Maximally Exposed Individual (MEI)—The MEI is a hypothetical person located downwind at the site boundary closest to the facilities that might have radiation releases. The MEI doses are calculated by modeling releases from existing and proposed facilities from normal operations. Data on the MEI doses can be found in Appendices A through F and represent the dose for the maximum option within each alternative.

5. Worker Dose—The dose that would be received by workers at facilities, based on expected radiation levels at those facilities for normal operations. Sitewide worker doses are based on historical monitoring of workers. These values are not particularly useful in comparing among sites or alternatives as worker doses are controlled by limiting worker involvement in activities that could result in exposures to radiation. Both individual doses and collective doses to workers are taken from Appendices A through F.

6. Water Use—The values represent an estimate of the change in annual consumption of water (in millions of gallons) that may result from the proposed SNF management activities for a given alternative. Minimum and maximum values are provided where available. The baseline water use is the annual water consumption for a site for all operations. The maximum percent of baseline site water represents the annual maximum incremental change in water use that would occur because of the proposed SNF management activities. Water impacts are discussed in Section 5.2.6, Chapter 5, Volume 1. A detailed discussion of water use and related consequences is provided in Appendices A through F.

7. Electricity Use—The values represent an estimate of the change in annual power consumption (in megawatt-hours per year) that would result from the proposed SNF management activities for a given alternative. Minimum and maximum values are provided where available. The baseline site electricity use is the annual power consumption for a site for all operations. The

maximum percent of site electricity use represents the annual maximum incremental change in power consumption that would occur because of the proposed SNF management activities. Electricity use is discussed by alternative in Section 5.1, Chapter 5, Volume 1. A detailed discussion of electricity use is provided in Appendices A through F.

8. Sewage—The values represent an estimate of the change in annual rate of wastewater generation (in millions of gallons) that would result from the proposed SNF management activities for a given alternative. Minimum and maximum values are provided where available. The baseline site sewage value represents the annual volume of wastewater generated from total site operations. The maximum percent of baseline site sewage represents the annual maximum incremental change in wastewater generation that would occur because of the proposed SNF management activities. Wastewater generation is discussed in Section 5.2.9 of Volume 1. A detailed discussion of wastewater generation is provided in Appendices A through F.

9. Waste Volume Estimates (high-level, transuranic, mixed, and low-level waste)—The annual generation rate of these waste types (in cubic meters per year) from the proposed SNF management activities is provided. These values represent 10-year cumulative generation rates divided by ten. Minimum and maximum values are provided where available. The waste volumes are discussed by alternative in Section 5.1 of Volume 1. A detailed discussion of the waste-generating activities at each site is provided in Appendices A through F.

10. Facility Accidents—For accidents, the individual and collective dose values in the tables represent the consequences for the accident having the highest radiological risk (dose times frequency, not necessarily the highest dose) to the public or to workers. The accidents selected for reporting are not necessarily the same for workers and the general population. In each category, the accident with the highest risk was selected, which may be different for workers and the general population. Doses and risks in Table K-2 are the maximum values from each alternative in Table K-1. Accident analyses reported in this summary are based on SNF management-related activities only and are found in the site appendices. Doses from accidents are described by alternative in Section 5.1 of Volume 1. The Savannah River Site did not quantify the worker dose for the maximum risk accident because the safety analysis reports from which accident information was extracted were prepared before the issuance of DOE Order 5480.23 (DOE 1992). Before 1992, applicable DOE orders did not require the inclusion of worker doses in safety analysis reports. Appendix C to Volume 1 of this EIS provides a co-located worker dose rather than a worker dose for the maximum risk accident.

11. Transportation—For incident-free transportation, the values in Table K-2 represent the total annual average fatalities from shipments of SNF for each alternative. Total fatalities are the sum of radiation-related latent cancer fatalities for transportation workers and the general population, plus nonradiological fatalities from vehicular emissions. These data are an

risks, two sets of data are presented in Table K-2 for each alternative. The estimated risks of cancer fatalities represent the radiological risk from transportation accidents. The estimated risk of traffic fatalities represent the nonradiological risk from traffic accidents. Both quantities are on an annual average basis. These data are an aggregate of the data presented in Appendices D and I.

The data in Table K-1 have been rounded to two significant figures, the greatest number of significant figures that can be justified with this analysis. Zero values indicate no impact for that parameter. In the summary table by alternatives, however, missing site data are treated as zeroes, so the impacts for given alternatives can be understated. Missing data are indicated by blanks. Missing values exist only where impacts are expected to be very small or trivial, so the magnitude of underestimation is probably also small.

Table K-1 shows the magnitude of differences between alternatives is very low. To understand observed differences between alternatives, Chapter 5 of this EIS should be consulted. Differences between sites within an alternative require examination of the site-specific appendices for the reasons noted above.

Key to Alternatives and Sites

No Action: Very limited SNF shipments, limited upgrades to facilities, limited stabilization.

Decentralization: Non-DOE sites (except Navy) transport to DOE sites, some upgrades to facilities, stabilization.

- Option A: No examination of naval SNF
- Option B: Limited examination of naval SNF at Puget Sound Naval Shipyard
- Option C: Full examination of naval SNF at Idaho National Engineering Laboratory; SNF returned to Navy sites for storage

1992/1993 Planning Basis: New SNF transported to Idaho National Engineering Laboratory or Savannah River Site, facility upgrades and expansion, stabilization.

Regionalization: SNF transported to regional sites, facility upgrades and expansion, stabilization.

- 4A: SNF to Idaho National Engineering Laboratory or Savannah River Site depending on fuel type
- 4B: SNF to Western or Eastern Regional Site depending on geography

Option	Western Regional Site	Eastern Regional Site	Expended Core Facility location
1E	Hanford Site	Savannah River Site	Savannah River Site
1W	Hanford Site	Savannah River Site	Hanford Site
2W	Idaho National Engineering Laboratory	Savannah River Site	Idaho National Engineering Laboratory
3E	Nevada Test Site	Savannah River Site	Savannah River Site
3W	Nevada Test Site	Savannah River Site	Nevada Test Site
4E	Hanford Site	Oak Ridge Reservation	Oak Ridge Reservation
4W	Hanford Site	Oak Ridge Reservation	Hanford Site
5W	Idaho National Engineering Laboratory	Oak Ridge Reservation	Idaho National Engineering Laboratory
6E	Nevada Test Site	Oak Ridge Reservation	Oak Ridge Reservation
6W	Nevada Test Site	Oak Ridge Reservation	Nevada Test Site

Centralization: SNF transported to central site, facility upgrades and expansion, stabilization.

- Option A: Hanford Site is the central site
- Option B: Idaho National Engineering Laboratory is the central site
- Option C: Savannah River Site is the central site
- Option D: Oak Ridge Reservation is the central site
- Option E: Nevada Test Site is the central site

Hanford	Hanford Site
INEL	Idaho National Engineering Laboratory
SRS	Savannah River Site
ORR	Oak Ridge Reservation
NTS	Nevada Test Site
Navy	Navy shipyards and prototype locations
Other	Small DOE, other government, and university research reactor sites

Table K-1. Summary of impacts by alternatives and by site.[a]

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		No-Action	No-Action	No-Action	No-Action	No-Action	No-Action	No-Action
Subalternative								
Option	Units							
Land for new facilities, minimum	Acres	0	1	0			16	0
Land for new facilities, maximum	Acres	0	1	0			16	1
Site area	Acres	358,400	570,914	198,000			6,055	48.770
Percent of site area, maximum		0.00	0.00	0.00			0.26	0.00
SNF-related employment, minimum	Person-years per year	0	-236	50			8	0
SNF-related employment, maximum	Person-years per year	0	-236	50			8	0
Baseline site employment	Person-years per year	18,700	8,620	15,800			30,050	27,820
Percent of baseline site employment, minimum		0.00	-2.74	0.32			0.03	0.00
Percent of baseline site employment, maximum		0.00	-2.74	0.32			0.03	0.00
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	1.3E-5	5.0E-5	2.3E-9			2.1E-5	
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	2.0E-4	4.0E-5	4.4E-3			3.0E-5	1.1E-2
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.3E-9	2.0E-9	4.0E-14			1.5E-6	
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	1.0E-8	2.8E-8	6.5E-8			1.1E-8	2.2E-6
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	1.6E-4	1.0E-5	4.0E-5			2.3E-6	
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	7.3E-6	6.2E-5	8.8E-5			2.2E-8	
Water use, SNF management, minimum	Million gallons per year	0.0	-3.0	9.3			0.0	
Water use, SNF management, maximum	Million gallons per year	0.0	-3.0	9.3			0.0	
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,700			9,859	
Maximum percent of baseline site water use		0.00	-0.17	0.04			0.00	
Electricity use, SNF management, minimum	Megawatt-hours per year	0	-9,929	1,400			0	
Electricity use, SNF management, maximum	Megawatt-hours per year	0	-9,820	1,400			0	
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000			411,067	
Percent of site electricity use, minimum		0.00	-4.77	0.21			0.00	
Percent of site electricity use, maximum		0.00	-4.72	0.21			0.00	
Sewage, SNF management, minimum	Million gallons per year	1.1	0.0	9.3			0.0	
Sewage, SNF management, maximum	Million gallons per year	1.1	0.0	9.3			0.0	
Baseline site sewage	Million gallons per year	55	143	182			0	
Percent of baseline site sewage, maximum		1.90	0.00	5.09			0	

Table K-1. (continued).

Alternative		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		No-Action	No-Action	No-Action	No-Action	No-Action	No-Action	No-Action
Subalternative								
Option	Units							
High level waste, SNF management, minimum	Cubic meters per year	0	0	0			0	
High level waste, SNF management, maximum	Cubic meters per year	0	0	0			0	
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	17			0	
Transuranic waste, SNF management, maximum	Cubic meters per year	0	0	17			0	
Mixed waste, SNF management, minimum	Cubic meters per year	1	0	0			0	
Mixed waste, SNF management, maximum	Cubic meters per year	1	0	0			0	
Low level waste, SNF management, minimum	Cubic meters per year	150	0	400			0	
Low level waste, SNF management, maximum	Cubic meters per year	150	0	400			0	
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	1	0	17			0	
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	1	0	17			0	
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	3.7E+1	7.0E+0	8.5E-3			2.6E+1	
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	3.7E-3	7.0E-5	1.4E-3			2.6E-4	
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	1.4E-3	3.9E-5	(b)			7.4E-2	
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	1.4E-7	4.0E-8	(b)			7.4E-7	

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization
Subalternative								
Option	Units	A	A	A	A	A	A	A
Land for new facilities, minimum	Acres	11	1	0			16	
Land for new facilities, maximum	Acres	18	1	10			16	
Site area	Acres	358,400	570,914	198,000			6,055	
Percent of site area, maximum		0.01	0.00	0.01				
SNF-related employment, minimum	Person-years per year	80	-236	200			6	
SNF-related employment, maximum	Person-years per year	638	-236	215			272	
Baseline site employment	Person-years per year	18,700	8,620	15,800			30,050	
Percent of baseline site employment, minimum		0.43	-2.74	1.27			0.03	
Percent of baseline site employment, maximum		3.41	-2.74	1.36			0.91	
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	5.0E-5	8.0E-3			1.4E-4	
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	2.0E-4	4.0E-5	4.4E-3			3.0E-5	
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	2.0E-9	2.0E-7			1.5E-6	
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	1.0E-8	2.8E-8	6.5E-8			1.1E-8	
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.0E-5	6.0E-5			2.3E-6	
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	7.3E-6	6.2E-5	8.8E-5			2.2E-8	
Water use, SNF management, minimum	Million gallons per year	0.5	-3.0	14.5			0.0	
Water use, SNF management, maximum	Million gallons per year	39.6	-3.0	95.0			0.0	
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,700			9,859	
Maximum percent of baseline site water use		1.00	-0.17	0.40			0.00	
Electricity use, SNF management, minimum	Megawatt-hours per year	100	-9,929	19,400			0	
Electricity use, SNF management, maximum	Megawatt-hours per year	127,000	-9,820	56,400			0	
Baseline site electricity use	Megawatt-hours per year	340,000	206,000	660,000			411,067	
Percent of site electricity use, minimum		0.03	-4.77	2.94			0.00	
Percent of site electricity use, maximum		37.35	-4.72	8.55			0.00	
Sewage, SNF management, minimum	Million gallons per year	1.1	0.0	12.8			0.0	
Sewage, SNF management, maximum	Million gallons per year	3.2	0.0	13.3			0.0	
Baseline site sewage	Million gallons per year	55	143	182			0	
Percent of baseline site sewage, maximum		5.71	0.00	7.31				

Table K-1. (continued).

Alternative		Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization
		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Subalternative								
Option	Units	A	A	A	A	A	A	A
High level waste, SNF management, minimum	Cubic meters per year	0	0	0			0	
High level waste, SNF management, maximum	Cubic meters per year	23	0	2			0	
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	18			0	
Transuranic waste, SNF management, maximum	Cubic meters per year	20	0	19			0	
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0			0	
Mixed waste, SNF management, maximum	Cubic meters per year	1	0	0			0	
Low level waste, SNF management, minimum	Cubic meters per year	94	0	400			0	
Low level waste, SNF management, maximum	Cubic meters per year	220	0	800			0	
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0	0	18			0	
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	0	21			0	
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	8.5E-3			2.6E+1	
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	4.9E-4	7.0E-5	3.0E-3			2.6E-4	
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.9E-5	(b)			7.4E-2	
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	5.6E-7	4.0E-8	(b)			7.4E-7	

Table K-1. (continued).

Alternative / Subalternative / Option	Units	Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization
Subalternative								
Option	Units	B	B	B	B	B	B	B
Land for new facilities, minimum	Acres	11	1	0			16	
Land for new facilities, maximum	Acres	18	1	10			16	
Site area	Acres	358,400	570,914	198,000			6,055	
Percent of site area, maximum		0.01	0.00	0.01				
SNF-related employment, minimum	Person-years per year	80	-236	200			73	
SNF-related employment, maximum	Person-years per year	638	-236	215			337	
Baseline site employment	Person-years per year	18,700	8,620	15,800			30,050	
Percent of baseline site employment, minimum		0.43	-2.74	1.27			0.24	
Percent of baseline site employment, maximum		3.41	-2.74	1.36			1.12	
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	5.0E-5	8.0E-3			1.4E-4	
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	2.0E-4	4.0E-5	4.4E-3			3.0E-5	
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	2.0E-9	2.0E-7			1.5E-6	
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	1.0E-8	2.8E-8	6.5E-8			1.1E-8	
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.0E-5	6.0E-5			2.3E-6	
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	7.3E-6	6.2E-5	8.8E-5			2.2E-8	
Water use, SNF management, minimum	Million gallons per year	0.5	-3.0	14.5			0.0	
Water use, SNF management, maximum	Million gallons per year	39.6	-3.0	95.0			0.0	
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,700			9,859	
Maximum percent of baseline site water use		1.00	-0.17	0.40			0.00	
Electricity use, SNF management, minimum	Megawatt-hours per year	100	-9,929	19,400			0	
Electricity use, SNF management, maximum	Megawatt-hours per year	127,000	-9,820	56,400			0	
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000			411,067	
Percent of site electricity use, minimum		0.03	-4.77	2.94			0.00	
Percent of site electricity use, maximum		37.35	-4.72	8.55			0.00	
Sewage, SNF management, minimum	Million gallons per year	1.1	0.0	12.8			0.0	
Sewage, SNF management, maximum	Million gallons per year	3.2	0.0	13.3			0.0	
Baseline site sewage	Million gallons per year	55	143	182			0	
Percent of baseline site sewage, maximum		5.71	0.00	7.31				

Table K-1. (continued).

Alternative		Hanford	INEL	SRS	ORR	NTS	Naval	Other
		Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization
Subalternative								
Option	Units	B	B	B	B	B	B	B
High level waste, SNF management, minimum	Cubic meters per year	0	0	0			0	
High level waste, SNF management, maximum	Cubic meters per year	23	0	2			0	
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	18			0	
Transuranic waste, SNF management, maximum	Cubic meters per year	20	0	19			0	
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0			0	
Mixed waste, SNF management, maximum	Cubic meters per year	1	0	0			0	
Low level waste, SNF management, minimum	Cubic meters per year	94	0	400			0	
Low level waste, SNF management, maximum	Cubic meters per year	220	0	800			0	
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0	0	18			0	
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	0	21			0	
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	8.5E-3			2.6E+1	
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	4.9E-4	7.0E-5	3.0E-3			2.6E-4	
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.9E-5	(b)			7.4E-2	
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	5.6E-7	4.0E-8	(b)			7.4E-7	

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Decentrali-zation	Decentrali-zation	Decentrali-zation	Decentrali-zation	Decentrali-zation	Decentrali-zation	Decentrali-zation
Subalternative								
Option	Units	C	C	C	C	C	C	C
Land for new facilities, minimum	Acres	11	1	0			16	
Land for new facilities, maximum	Acres	18	1	10			16	
Site area	Acres	358,400	570,914	198,000				
Percent of site area, maximum		0.01	0.00	0.01				
SNF-related employment, minimum	Person-years per year	80	20	200			8	
SNF-related employment, maximum	Person-years per year	638	20	215			272	
Baseline site employment	Person-years per year	18,700	8,620	15,800			30,050	
Percent of baseline site employment, minimum		0.43	0.23	1.27			0.03	
Percent of baseline site employment, maximum		3.41	0.23	1.36			0.91	
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	5.1E-5	8.0E-3			1.4E-4	
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	2.0E-4	4.0E-5	4.4E-3			3.0E-5	
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	2.1E-9	2.0E-7			1.5E-6	
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	1.0E-8	2.8E-8	6.5E-8			1.1E-8	
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.0E-5	6.0E-5			2.3E-6	
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	7.3E-6	6.2E-5	8.8E-5			2.2E-8	
Water use, SNF management, minimum	Million gallons per year	0.5	0.0	14.5			0.0	
Water use, SNF management, maximum	Million gallons per year	39.6	0.0	95.0			0.0	
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,700			9,859	
Maximum percent of baseline site water use		1.00	0.00	0.40			0.00	
Electricity use, SNF management, minimum	Megawatt-hours per year	100	71	19,400			0	
Electricity use, SNF management, maximum	Megawatt-hours per year	127,000	180	56,400			0	
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000			411,067	
Percent of site electricity use, minimum		0.03	0.03	2.94			0.00	
Percent of site electricity use, maximum		37.35	0.09	8.55			0.00	
Sewage, SNF management, minimum	Million gallons per year	1.1	0.0	12.8			0.0	
Sewage, SNF management, maximum	Million gallons per year	3.2	0.0	13.3			0.0	
Baseline site sewage	Million gallons per year	55	143	182			0	
Percent of baseline site sewage, maximum		5.71	0.00	7.31				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization
Subalternative								
Option	Units	C	C	C	C	C	C	C
High level waste, SNF management, minimum	Cubic meters per year	0	0	0			0	
High level waste, SNF management, maximum	Cubic meters per year	23	0	2			0	
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	18			0	
Transuranic waste, SNF management, maximum	Cubic meters per year	20	0	19			0	
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0			0	
Mixed waste, SNF management, maximum	Cubic meters per year	1	0	0			0	
Low level waste, SNF management, minimum	Cubic meters per year	94	425	400			0	
Low level waste, SNF management, maximum	Cubic meters per year	220	425	600			0	
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0	0	18			0	
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	0	21			0	
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	8.5E-3			2.6E+1	
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	4.9E-4	7.0E-5	3.0E-3			2.6E-4	
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.2E-3	(b)			7.4E-2	
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	5.6E-7	7.2E-8	(b)			7.4E-7	

Table K-1. (continued).

Alternative / Subalternative / Option	Units	Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Planning Basis	Planning Basis	Planning Basis	Planning Basis	Planning Basis	Planning Basis	Planning Basis
Subalternative								
Option	Units							
Land for new facilities, minimum	Acres	11	19	0				
Land for new facilities, maximum	Acres	18	19	10				
Site area	Acres	358,400	570,914	198,000				
Percent of site area, maximum		0.01	0.00	0.01				
SNF-related employment, minimum	Person-years per year	80	220	200				
SNF-related employment, maximum	Person-years per year	638	220	235				
Baseline site employment	Person-years per year	18,700	8,620	15,800				
Percent of baseline site employment, minimum		0.43	2.55	1.27				
Percent of baseline site employment, maximum		3.41	2.55	1.49				
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	8.3E-4	1.0E-4	8.0E-3				
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	2.0E-4	4.0E-5	4.4E-3				
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	4.0E-9	2.0E-7				
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	1.0E-8	2.8E-8	6.5E-8				
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.0E-5	6.0E-5				
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	7.3E-6	6.2E-5	8.8E-5				
Water use, SNF management, minimum	Million gallons per year	0.5	0.0	14.5				
Water use, SNF management, maximum	Million gallons per year	39.6	0.6	95.0				
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,700				
Maximum percent of baseline site water use		1.00	0.03	0.40				
Electricity use, SNF management, minimum	Megawatt-hours per year	100	150	19,400				
Electricity use, SNF management, maximum	Megawatt-hours per year	127,000	2,200	56,400				
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000				
Percent of site electricity use, minimum		0.03	0.07	2.94				
Percent of site electricity use, maximum		37.35	1.06	8.55				
Sewage, SNF management, minimum	Million gallons per year	1.1	0.0	12.8				
Sewage, SNF management, maximum	Million gallons per year	3.2	0.4	13.3				
Baseline site sewage	Million gallons per year	55	143	182				
Percent of baseline site sewage, maximum		5.71	0.30	7.31				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Planning Basis	Planning Basis	Planning Basis	Planning Basis	Planning Basis	Planning Basis	Planning Basis
Subalternative								
Option	Units							
High level waste, SNF management, minimum	Cubic meters per year	0	0	0				
High level waste, SNF management, maximum	Cubic meters per year	23	6	2				
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	18				
Transuranic waste, SNF management, maximum	Cubic meters per year	20	36	19				
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0				
Mixed waste, SNF management, maximum	Cubic meters per year	1	1	0				
Low level waste, SNF management, minimum	Cubic meters per year	94	625	400				
Low level waste, SNF management, maximum	Cubic meters per year	220	1,035	750				
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0	0	18				
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	43	21				
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	8.5E-3				
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	4.9E-4	7.0E-5	3.4E-3				
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.2E-3	(b)				
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	5.6E-7	7.2E-8	(b)				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		A	A	A	A	A	A	A
Option	Units							
Land for new facilities, minimum	Acres	6	19	0				
Land for new facilities, maximum	Acres	18	19	10				
Site area	Acres	358,400	570,914	198,000				
Percent of site area, maximum		0.01	0.00	0.01				
SNF-related employment, minimum	Person-years per year	62	220	200				
SNF-related employment, maximum	Person-years per year	468	220	235				
Baseline site employment	Person-years per year	18,700	8,620	15,800				
Percent of baseline site employment, minimum		0.33	2.55	1.27				
Percent of baseline site employment, maximum		2.50	2.55	1.49				
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	1.0E-4	9.0E-3				
Estimated maximum latent cancer fetalitles in 80-km population, site operations	Latent cancer fatalities per year	2.0E-4	4.0E-5	4.4E-3				
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	4.0E-9	2.0E-7				
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	1.0E-8	2.8E-8	8.5E-8				
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.0E-5	6.0E-5				
Maximum probability of latent cancer fatality in worker, site operations	Latant cancer fatalities per year	7.3E-6	6.2E-5	8.8E-5				
Water use, SNF management, minimum	Million gallons per year	0.5	0.0	14.5				
Water use, SNF management, maximum	Million gallons per year	39.6	0.6	94.2				
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,700				
Maximum percent of baseline site water use		1.00	0.03	0.40				
Electricity use, SNF management, minimum	Megawatt-hours per year	100	150	24,400				
Electricity use, SNF management, maximum	Megawatt-hours per year	127,000	2,200	67,400				
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000				
Percent of site electricity use, minimum		0.03	0.07	3.70				
Percent of site electricity use, maximum		37.35	1.06	10.21				
Sewage, SNF management, minimum	Million gallons per year	1.1	0.0	12.6				
Sewage, SNF management, maximum	Million gallons per year	3.2	0.4	13.4				
Baseline site sewage	Million gallons per year	55	143	182				
Percent of baseline site sewage, maximum		5.71	0.28	7.36				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		A	A	A	A	A	A	A
Option	Units							
High level waste, SNF management, minimum	Cubic meters per year	0	0	0				
High level waste, SNF management, maximum	Cubic meters per year	23	6	2				
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	17				
Transuranic waste, SNF management, maximum	Cubic meters per year	20	36	18				
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0				
Mixed waste, SNF management, maximum	Cubic meters per year	1	1	0				
Low level waste, SNF management, minimum	Cubic meters per year	94	625	400				
Low level waste, SNF management, maximum	Cubic meters per year	220	1,035	790				
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0	0	17				
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	43	20				
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	8.5E-3				
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	4.9E-4	7.0E-5	3.7E-3				
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.2E-3	(b)				
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	5.6E-7	7.2E-8	(b)				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		B	B	B	B	B	B	B
Option	Units	1W,4W	2W,5W	1E,2E,3E	4E,5E,6E	3W,6W	N/A	N/A
Land for new facilities, minimum	Acres	66	31	35	120	120		
Land for new facilities, maximum	Acres	98	31	70	120	120		
Site area	Acres	358,400	570,914	198,000	34,667	864,000		
Percent of site area, maximum		0.03	0.01	0.04	0.35	0.01		
SNF-related employment, minimum	Person-years per year	734	220	797	1,118	1,118		
SNF-related employment, maximum	Person-years per year	1,366	220	852	1,118	1,118		
Baseline site employment	Person-years per year	18,700	8,620	15,800	17,082	8,563		
Percent of baseline site employment, minimum		3.92	2.55	5.04	6.54	13.05		
Percent of baseline site employment, maximum		7.30	2.55	5.39	6.54	13.05		
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	2.0E-4	9.0E-3	2.6E-3	4.1E-5		
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	2.0E-4	4.0E-5	4.4E-3	2.7E-2	2.6E-6		
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	2.0E-8	2.0E-7	3.1E-6	5.9E-8		
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	1.0E-8	2.8E-8	6.5E-8	9.2E-6	5.5E-9		
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.0E-5	7.0E-5	1.8E-5	1.6E-5		
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	7.3E-6	8.2E-5	8.8E-5	1.1E-6	2.0E-6		
Water use, SNF management, minimum	Million gallons per year	5.7	0.6	17.0	6.1	6.1		
Water use, SNF management, maximum	Million gallons per year	44.5	13.0	96.7	6.1	6.1		
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,700	6,680	1,120		
Maximum percent of baseline site water use		1.12	0.76	0.41	0.09	0.54		
Electricity use, SNF management, minimum	Megawatt-hours per year	10,100	2,100	34,400	33,000	33,000		
Electricity use, SNF management, maximum	Megawatt-hours per year	137,000	11,000	66,400	33,000	33,000		
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000	1,000,000	183,100		
Percent of site electricity use, minimum		2.97	1.01	5.21	3.30	18.02		
Percent of site electricity use, maximum		40.29	5.29	10.06	3.30	18.02		
Sewage, SNF management, minimum	Million gallons per year	1.8	0.1	12.8	3.6	3.6		
Sewage, SNF management, maximum	Million gallons per year	5.3	1.2	13.4	3.6	3.6		
Baseline site sewage	Million gallons per year	55	143	182	200	0		
Percent of baseline site sewage, maximum		952	0.83	7.36	1.80			

Table K-1. (continued).

	Units	Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		B	B	B	B	B	B	B
Option		1W,4W	2W,5W	1E,2E,3E	4E,5E,6E	3W,6W	N/A	N/A
High level waste, SNF management, minimum	Cubic meters per year	0	0	0	0	0		
High level waste, SNF management, maximum	Cubic meters per year	23	160	2	0	0		
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	17	16	16		
Transuranic waste, SNF management, maximum	Cubic meters per year	20	36	18	16	16		
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0	0	0		
Mixed waste, SNF management, maximum	Cubic meters per year	1	1	0	0	0		
Low level waste, SNF management, minimum	Cubic meters per year	520	795	625	628	628		
Low level waste, SNF management, maximum	Cubic meters per year	645	1,035	1,215	628	628		
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0	0	17	16	16		
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	197	20	16	16		
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	4.8E+0	8.4E+0	1.8E-1		
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	5.7E-4	7.0E-5	3.5E-3	3.4E-3	1.1E-4		
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.7E-2	3.2E-3	(b)	1.3E-1	1.3E-1		
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	6.9E-7	7.2E-8	(b)	3.2E-7	2.4E-7		

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionali-zation	Regionali-zation	Regionali-zation	Regionali-zation	Regionali-zation	Regionali-zation	Regionali-zation
Subalternative		B	B	B	B	B	B	B
Option	Units	1E,4E	N/A	1W,2W,3W	4W,5W,6W	3E,6E	N/A	N/A
Land for new facilities, minimum	Acres	36		35	90	90		
Land for new facilities, maximum	Acres	68		40	90	90		
Site area	Acres	358,400		198,000	34,667	864,000		
Percent of site area, maximum		0.02		0.02	0.26	0.01		
SNF-related employment, minimum	Person-years per year	172		235	556	556		
SNF-related employment, maximum	Person-years per year	804		290	556	556		
Baseline site employment	Person-years per year	18,700		15,800	17,082	8,563		
Percent of baseline site employment, minimum		0.92		1.49	3.25	6.49		
Percent of baseline site employment, maximum		4.30		1.84	3.25	6.49		
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4		9.0E-3	2.5E-3	4.1E-5		
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	2.0E-4		4.4E-3	2.7E-2	2.6E-6		
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8		2.0E-7	3.1E-6	5.9E-8		
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	1.0E-8		6.5E-8	9.2E-6	5.5E-9		
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4		7.0E-5	1.6E-5	1.6E-5		
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	7.3E-6		8.8E-5	1.1E-6	2.0E-6		
Water use, SNF management, minimum	Million gallons per year	3.2		14.5	3.6	3.6		
Water use, SNF management, maximum	Million gallons per year	42.0		94.2	3.6	3.6		
Baseline water use, site operations	Million gallons per year	3,963		23,700	6,680	1,120		
Maximum percent of baseline site water use		1.06		0.40	0.05	0.32		
Electricity use, SNF management, minimum	Megawatt-hours per year	100		24,400	23,000	23,000		
Electricity use, SNF management, maximum	Megawatt-hours per year	127,000		56,400	23,000	23,000		
Baseline site electricity use	Megawatt-hours per year	340,000		660,000	1,000,000	183,100		
Percent of site electricity use, minimum		0.03		3.70	2.30	12.56		
Percent of site electricity use, maximum		37.35		8.55	2.30	12.56		
Sewage, SNF management, minimum	Million gallons per year	1.8		12.8	3.6	3.6		
Sewage, SNF management, maximum	Million gallons per year	5.3		13.4	3.6	3.6		
Baseline site sewage	Million gallons per year	55		182	200	0		
Percent of baseline site sewage, maximum		9.52		7.36	1.80			

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		B	B	B	B	B	B	B
Option	Units	1E,4E	N/A	1W,2W,3W	4W,5W,6W	3E,6E	N/A	N/A
High level waste, SNF management, minimum	Cubic meters per year	0		0	0	0		
High level waste, SNF management, maximum	Cubic meters per year	23		2	0	0		
Transuranic waste, SNF management, minimum	Cubic meters per year	0		17	16	16		
Transuranic waste, SNF management, maximum	Cubic meters per year	20		18	16	16		
Mixed waste, SNF management, minimum	Cubic meters per year	0		0	0	0		
Mixed waste, SNF management, maximum	Cubic meters per year	1		0	0	0		
Low level wa te, SNF management, minimum	Cubic meters per year	95		400	203	203		
Low level waste, SNF management, maximum	Cubic meters per year	220		790	203	203		
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0		17	16	16		
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44		20	16	16		
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1		8.5E-3	2.1E-2	8.6E-4		
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	5.7E-4		3.5E-3	3.4E-3	1.1E-4		
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2		(b)	1.9E-3	1.9E-3		
Estimated maximum risk of worker latent cancer fatalities from maxim risk accident	Latent cancer fatalities per year	6.6E-7		(b)	1.9E-7	1.9E-7		

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		B	B	B	B	B	B	B
Option	Units	2,3,5,8	1,3,4,6	4,5,6	1,2,3	1,2,4,5	N/A	N/A
Land for new facilities, minimum	Acres	6	1	0				
Land for new facilities, maximum	Acres	12	1	0				
Site area	Acres	358,400	570,914	198,000				
Percent of site area, maximum		0.00	0.00	0.00				
SNF-related employment, minimum	Person-years per year	391	-226	90				
SNF-related employment, maximum	Person-years per year	585	-226	90				
Baseline site employment	Person-years per year	18,700	8,620	15,800				
Percent of baseline site employment, minimum		2.09	-2.62	0.57				
Percent of baseline site employment, maximum		3.13	-2.62	0.57				
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	4.0E-5	2.3E-9				
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	2.0E-4	4.0E-5	4.4E-3				
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	2.0E-9	4.0E-14				
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	1.0E-8	2.8E-8	6.5E-8				
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.0E-5	4.0E-5				
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	7.3E-6	6.2E-5	8.8E-5				
Water use, SNF management, minimum	Million gallons per year	19.8	-3.0	10.9				
Water use, SNF management, maximum	Million gallons per year	39.6	-2.9	10.9				
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,700				
Maximum percent of baseline site water use		1.00	-0.17	0.05				
Electricity use, SNF management, minimum	Megawatt-hours per year	0	-9,990	11,400				
Electricity use, SNF management, maximum	Megawatt-hours per year	20,000	-8,000	11,400				
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000				
Percent of site electricity use, minimum		0.00	-4.80	1.73				
Percent of site electricity use, maximum		5.88	-3.85	1.73				
Sewage, SNF management, minimum	Million gallons per year	2.1	0.0	10.0				
Sewage, SNF management, maximum	Million gallons per year	2.6	0.1	10.0				
Baseline site sewage	Million gallons per year	55	143	182				
Percent of baseline site sewage, maximum		4.76	0.09	5.49				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		B	B	B	B	B	B	B
Option	Units	2,3,5,6	1,3,4,6	4,5,6	1,2,3	1,2,4,5	N/A	N/A
High level waste, SNF management, minimum	Cubic meters per year	6	0	0				
High level waste, SNF management, maximum	Cubic meters per year	23	3	0				
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	5				
Transuranic waste, SNF management, maximum	Cubic meters per year	20	32	5				
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0				
Mixed waste, SNF management, maximum	Cubic meters per year	1	1	0				
Low level waste, SNF management, minimum	Cubic meters per year	110	0	400				
Low level waste, SNF management, maximum	Cubic meters per year	220	130	400				
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	6	0	5				
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	36	5				
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	8.5E-3				
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	4.1E-4	7.0E-5	1.4E-3				
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.9E-5	(b)				
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	4.7E-7	4.0E-8	(b)				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Centralization	Centralization	Centralization	Centralization	Centralization	Centralization	Centralization
Subalternative								
Option	Units	A	B	C	D	E	N/A	N/A
Land for new facilities, minimum	Acres	116	31	70	120	120		
Land for new facilities, maximum	Acres	123	31	130	120	120		
Site area	Acres	358,400	570,914	198,000	34,867	864,000		
Percent of site area, maximum		0.03	0.01	0.07	0.35	0.01		
SNF-related employment, minimum	Person-years per year	848	220	1,602	1,118	1,118		
SNF-related employment, maximum	Person-years per year	1,464	220	1,672	1,118	1,118		
Baseline site employment	Person-years per year	18,700	8,620	15,800	17,082	8,563		
Percent of baseline site employment, minimum		4.53	2.55	10.14	6.54	13.05		
Percent of baseline site employment, maximum		7.83	2.55	10.58	6.54	13.05		
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	2.0E-4	9.0E-3	2.6E-3	4.1E-5		
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	2.0E-4	4.0E-5	4.4E-3	2.7E-2	2.6E-6		
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	2.0E-8	2.0E-7	3.1E-6	5.9E-8		
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	1.0E-8	2.8E-8	6.5E-8	9.2E-6	5.5E-9		
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.0E-5	6.0E-4	1.6E-5	1.6E-5		
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	7.3E-6	6.2E-5	8.8E-5	1.1E-6	2.0E-6		
Water use, SNF management, minimum	Million gallons per year	6.5	0.6	22.0	6.1	6.1		
Water use, SNF management, maximum	Million gallons per year	44.5	13.0	102.5	6.1	6.1		
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,700	6,680	1,120		
Maximum percent of baseline site water use		1.12	0.76	0.43	0.09	0.54		
Electricity use, SNF management, minimum	Megawatt-hours per year	10,100	2,100	54,400	33,000	33,000		
Electricity use, SNF management, maximum	Megawatt-hours per year	137,000	11,000	120,400	33,000	33,000		
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000	1,000,000	183,100		
Percent of site electricity use, minimum		2.97	1.01	8.24	3.30	18.02		
Percent of site electricity use, maximum		40.29	5.29	18.24	3.30	18.02		
Sewage, SNF management, minimum	Million gallons per year	1.8	0.1	17.9	3.6	3.6		
Sewage, SNF management, maximum	Million gallons per year	5.3	1.2	18.4	3.6	3.6		
Baseline site sewage	Million gallons per year	55	143	182	200	0		
Percent of baseline site sewage, maximum		9.52	0.83	10.11	1.80			

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Centralization	Centralization	Centralization	Centralization	Centralization	Centralization	Centralization
Subalternative								
Option	Units	A	B	C	D	E	N/A	N/A
High level waste, SNF management, minimum	Cubic meters per year	0	0	0	0	0		
High level waste, SNF management, maximum	Cubic meters per year	23	160	2	0	0		
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	16	16	16		
Transuranic waste, SNF management, maximum	Cubic meters per year	20	36	20	16	16		
Mixed waste, SNF management, minimum	Cubic meters per year	1	0	0	0	0		
Mixed waste, SNF management, maximum	Cubic meters per year	1	1	0	0	0		
Low level waste, SNF management, minimum	Cubic meters per year	585	795	825	628	628		
Low level waste, SNF management, maximum	Cubic meters per year	715	1,035	1,225	628	628		
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	1	0	16	16	16		
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	197	22	16	16		
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	4.8E+0	8.4E+0	1.8E-1		
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	8.5E-4	7.0E-5	7.2E-3	3.4E-3	1.1E-4		
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.7E-2	3.2E-3	(b)	1.3E-1	1.3E-1		
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	7.9E-7	7.2E-8	(b)	3.2E-7	2.4E-7		

Table K-1. (continued).

Alternative		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Centralization	Centralization	Centralization	Centralization	Centralization	Centralization	Centralization
Subalternative								
Option	Units	B,C,D,E	A,C,D,E	A,B,D,E	A,B,C,E	A,B,C,D	N/A	N/A
Land for new facilities, minimum	Acres	8	1	0				
Land for new facilities, maximum	Acres	12	1	0				
Site area	Acres	358,400	570,914	198,000				
Percent of site area, maximum		0.00	0.00	0.00				
SNF-related employment, minimum	Person-years per year	391	-228	90				
SNF-related employment, maximum	Person-years per year	585	-226	90				
Baseline site employment	Person-years per year	18,700	8,620	15,800				
Percent of baseline site employment, minimum		2.09	-2.62	0.57				
Percent of baseline site employment, maximum		3.13	-2.62	0.57				
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	4.0E-5	2.3E-9				
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	2.0E-4	4.0E-5	4.4E-3				
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	2.0E-9	4.0E-14				
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	1.0E-8	2.8E-8	6.5E-8				
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.0E-5	4.0E-5				
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	7.3E-6	6.2E-5	8.8E-5				
Water use, SNF management, minimum	Million gallons per year	19.8	-3.0	10.9				
Water use, SNF management, maximum	Million gallons per year	39.6	-2.9	10.9				
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,700				
Maximum percent of baseline site water use		1.00	-0.17	0.05				
Electricity use, SNF management, minimum	Megawatt-hours per year	0	-9,990	11,400				
Electricity use, SNF management, maximum	Megawatt-hours per year	20,000	-8,000	11,400				
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000				
Percent of site electricity use, minimum		0.00	-4.80	1.73				
Percent of site electricity use, maximum		5.88	-3.85	1.73				
Sewage, SNF management, minimum	Million gallons per year	2.1	0.0	10.0				
Sewage, SNF management, maximum	Million gallons per year	2.6	0.1	10.0				
Baseline site sewage	Million gallons per year	55	143	182				
Percent of baseline site sewage, maximum		4.76	0.09	5.49				

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Centralization	Centralization	Centralization	Centralization	Centralization	Centralization	Centralization
Subalternative								
Option	Units	B,C,D,E	A,C,D,E	A,B,D,E	A,B,C,E	A,B,C,D	N/A	N/A
High level waste, SNF management, minimum	Cubic meters per year	6	0	0				
High level waste, SNF management, maximum	Cubic meters per year	23	3	0				
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	5				
Transuranic waste, SNF management, maximum	Cubicmeters per year	20	32	5				
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0				
Mixed waste, SNF management, maximum	Cubic meters per year	1	1	0				
Low level waste, SNF management, minimum	Cubicmeters per year	110	0	400				
Low level waste, SNF management, maximum	Cubic meters per year	220	130	400				
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	6	0	5				
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	36	5				
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	8.5E-3				
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	4.1E-4	7.0E-5	1.4E-3				
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.9E-5	(b)				
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	4.7E-7	4.0E-8	(b)				

a. E indicates exponential notation. Refer to scientific notation in Appendix H, Glossary, for an explanation of this way of writing very large and very small numbers.

b. SRS did not quantify the worker dose for the maximum risk accident.

Table K-2. Summary of impacts by alternative.[a]

Alternative		No-Action	Decentralization	Decentralization	Decentralization	Planning Basis	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative							A	B	B	B	B
Option	Units	No-Action	A	B	C			1E	1W	2W	3E
Land for new facilities, minimum	Acres	17	28	28	28	30	25	72	102	72	132
Land for new facilities, maximum	Acres	18	45	45	45	47	47	139	139	83	173
Site area	Acres	1,182,139	1,133,389	1,133,369	1,127,314	1,127,314	1,127,314	1,127,314	1,127,314	1,127,314	1,991,314
Percent of site area, maximum		0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
SNF-related employment, minimum	Person-years per year	-178	52	117	308	500	482	743	743	846	1,518
SNF-related employment, maximum	Person-years per year	-178	889	954	1,145	1,093	923	1,430	1,430	1,095	1,766
Baseline site employment	Person-years per year	100,990	73,170	73,170	73,170	43,120	43,120	43,120	43,120	43,120	51,683
Percent of baseline site employment, minimum		-0.18	0.07	0.16	0.42	1.16	1.12	1.72	1.72	1.96	2.94
Percent of baseline site employment, maximum		-0.18	1.21	1.30	1.56	2.53	2.14	3.32	3.32	2.54	3.42
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	8.4E-5	8.8E-3	8.8E-3	8.8E-3	8.7E-3	9.7E-3	9.7E-3	9.7E-3	9.8E-3	9.7E-3
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	1.6E-2	4.7E-3	4.7E-3	4.7E-3	4.6E-3	4.6E-3	4.6E-3	4.6E-3	4.6E-3	4.6E-3
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.5E-6	1.5E-6	1.5E-6	1.5E-6	2.0E-7	2.0E-7	2.0E-7	2.0E-7	2.0E-7	2.0E-7
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	2.2E-6	6.5E-8	6.5E-8	6.5E-8	6.5E-8	6.5E-8	6.5E-8	6.5E-8	6.5E-8	8.5E-8
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	1.6E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5
Water use, SNF management, minimum	Million gallons per year	6.3	12.0	12.0	15.0	15.0	15.0	17.2	17.2	34.9	37.4
Water use, SNF management, maximum	Million gallons per year	6.3	131.6	131.6	134.6	135.2	134.4	135.8	135.8	146.8	137.1
Baseline water use, site operations	Million gallons per year	39,239	39,239	39,239	39,239	29,380	29,380	29,380	29,380	29,380	30,500
Maximum percent of baseline site water use		0.02	0.34	0.34	0.34	0.46	0.46	0.46	0.46	0.50	0.45
Electricity use, SNF management, minimum	Megawatt-hours per year	-8,529	9,571	9,571	19,571	19,650	24,650	24,510	24,510	26,500	47,410
Electricity use, SNF management, maximum	Megawatt-hours per year	-8,420	173,580	173,580	183,580	185,600	196,600	185,400	185,400	87,400	101,400
Baseline site electricity use	Megawatt-hours per year	1,619,067	1,619,067	1,619,067	1,619,067	1,208,000	1,208,000	1,208,000	1,208,000	1,208,000	1,391,100
Percent of site electricity use, minimum		-0.53	0.59	0.59	1.21	1.63	2.04	2.03	2.03	2.19	3.41
Percent of site electricity use, maximum		-0.52	10.72	10.72	11.34	15.36	16.27	15.35	15.35	7.24	7.29
Sewage, SNF management, minimum	Million gallons per year	10.3	13.9	13.9	13.9	13.9	13.7	14.6	14.6	15.0	18.5
Sewage, SNF management, maximum	Million gallons per year	10.3	16.5	16.5	16.5	16.9	17.0	18.8	18.8	17.2	19.8
Baseline site sewage	Million gallons per year	380	380	380	380	380	380	380	380	380	380
Percent of baseline site sewage, maximum		2.71	4.33	4.33	4.33	4.44	4.46	4.94	4.94	4.53	5.19

Table K-2. (continued).

Alternative		No-Action	Decentralization	Decentralization	Decentralization	Planning Basis	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative							A	B	B	B	B
Option	Units	No-Action	A	B	C			1E	1W	2W	3E
High level waste, SNF management, minimum	Cubic meters per year	0	0	0	0	0	0	0	0	6	6
High level waste, SNF management, maximum	Cubic meters per year	0	25	25	25	31	31	28	28	185	28
Transuranic waste, SNF management, minimum	Cubic meters per year	17	18	18	18	18	17	17	17	17	33
Transuranic waste, SNF management, maximum	Cubic meters per year	17	39	39	39	75	74	70	70	74	86
Mixed waste, SNF management, minimum	Cubic meters per year	1	0	0	0	1	1	1	1	1	1
Mixed waste, SNF management, maximum	Cubic meters per year	1	1	1	1	2	2	2	2	2	2
Low level waste, SNF management, minimum	Cubic meters per year	550	494	494	919	1,119	1,119	920	920	1,305	1,138
Low level waste, SNF management, maximum	Cubic meters per year	550	1,020	1,020	1,445	2,005	2,045	1,565	1,565	2,045	1,768
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	18	19	19	19	19	18	18	18	24	40
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	18	65	65	65	108	107	100	100	261	118
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	3.7E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	3.7E-3	3.0E-3	3.0E-3	3.0E-3	3.4E-3	3.7E-3	3.5E-3	3.5E-3	3.5E-3	3.5E-3
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	7.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.7E-2	9.4E-2	9.4E-2
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	7.4E-7	7.4E-7	7.4E-7	7.4E-7	5.6E-7	5.6E-7	6.6E-7	6.9E-7	4.7E-7	4.7E-7
Estimated maximum total fatalities from incident-free SNF transportation	Fatalities per year	2.2E-4	8.7E-3	8.8E-3	9.4E-3	1.1E-2	1.5E-2	1.4E-2	1.3E-2	1.3E-2	2.3E-2
Estimated maximum risk of cancer fatalities from all transportation accidents	Cancer fatalities per year	1.0E-7	2.3E-5	2.3E-5	2.4E-5	2.4E-5	2.8E-5	3.3E-5	2.4E-5	2.4E-5	3.6E-5
Estimated maximum risk of traffic fatalities from transportation accidents	Fatalities per year	1.2E-3	6.4E-3	6.6E-3	2.6E-2	1.8E-2	1.9E-2	2.1E-2	1.9E-2	1.8E-2	2.4E-2

Table K-2. (continued).

Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Centralization	Centralization	Centralization	Centralization	Centralization
Subalternative		B	B	B	B	B	B					
Option	Units	3W	4E	4W	5W	6E	6W	A	B	C	D	E
Land for new facilities, minimum	Acres	162	157	157	127	217	217	117	37	77	127	127
Land for new facilities, maximum	Acres	173	189	189	133	223	223	124	43	143	133	133
Site area	Acres	1,991,314	1,161,981	1,161,981	1,161,981	2,025,981	2,025,981	1,127,314	1,127,314	1,127,314	1,161,981	1,991,314
Percent of site area, maximum		0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01
SNF-related employment, minimum	Person-years per year	1,518	1,154	1,154	1,257	1,929	1,929	712	701	1,767	1,373	1,373
SNF-related employment, maximum	Person-years per year	1,766	1,786	1,786	1,451	2,122	2,122	1,328	895	2,030	1,566	1,566
Baseline site employment	Person-years per year	51,683	60,202	60,202	60,202	68,765	68,765	43,120	43,120	43,120	60,202	51,683
Percent of baseline site employment, minimum		2.94	1.92	1.92	2.09	2.80	2.80	1.65	1.63	4.10	2.28	2.66
Percent of baseline site employment, maximum		3.42	2.97	2.97	2.41	3.09	3.09	3.08	2.07	4.71	2.60	3.03
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	9.7E-3	3.2E-3	3.2E-3	3.3E-3	3.3E-3	3.2E-3	6.7E-4	8.3E-4	9.7E-3	3.2E-3	7.1E-4
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	4.6E-3	3.2E-2	3.2E-2	3.2E-2	3.2E-2	3.2E-2	4.6E-3	4.6E-3	4.6E-3	3.2E-2	4.6E-3
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	2.0E-7	3.1E-6	3.1E-6	3.1E-6	3.1E-8	3.1E-6	1.1E-8	2.0E-8	2.0E-7	3.1E-6	5.9E-8
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	8.5E-8	9.2E-6	9.2E-6	9.2E-6	9.2E-6	9.2E-6	6.5E-8	6.5E-8	6.5E-8	9.2E-6	6.5E-8
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	6.0E-4	2.0E-4	2.0E-4
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5
Water use, SNF management, minimum	Million gallons per year	37.4	17.2	17.2	34.9	37.4	37.4	16.4	31.3	38.8	33.8	33.8
Water use, SNF management, maximum	Million gallons per year	137.1	56.1	56.1	67.1	57.3	57.3	52.5	63.5	139.3	53.7	53.8
Baseline water use, site operations	Million gallons per year	30,500	36,060	36,060	36,060	37,180	37,180	29,380	29,380	29,380	36,060	30,500
Maximum percent of baseline site water use		0.45	0.16	0.16	0.19	0.15	0.15	0.18	0.22	0.47	0.15	0.18
Electricity use, SNF management, minimum	Megawatt-hours per year	47,410	34,510	34,510	36,500	57,410	57,410	11,510	13,500	44,410	34,410	34,410
Electricity use, SNF management, maximum	Megawatt-hours per year	101,400	163,400	163,400	65,400	79,400	79,400	140,400	42,400	132,400	56,400	56,400
Baseline site electricity use	Megawatt-hours per year	1,391,100	2,208,000	2,208,000	2,208,000	2,391,100	2,391,100	1,208,000	1,208,000	1,208,000	2,208,000	1,391,100
Percent of site electricity use, minimum		3.41	1.56	1.56	1.65	2.40	2.40	0.95	1.12	3.66	1.56	2.47
Percent of site electricity use, maximum		7.29	7.40	7.40	2.96	3.32	3.32	11.62	3.51	10.96	2.55	4.05
Sewage, SNF management, minimum	Million gallons per year	18.5	15.4	15.4	15.8	19.3	19.3	11.8	12.2	20.0	15.7	15.7
Sewage, SNF management, maximum	Million gallons per year	19.8	19.0	19.0	17.4	20.0	20.0	15.4	13.8	21.2	16.4	16.4
Baseline site sewage	Million gallons per year	380	580	580	580	580	580	380	380	380	580	380
Percent of baseline site sewage, maximum		5.19	3.27	3.27	3.00	3.44	3.44	4.05	3.64	5.56	2.82	4.30

Table K-2. (continued).

Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Centralization	Centralization	Centralization	Centralization	Centralization
Subalternative		B	B	B	B	B	B					
Option	Units	3W	4E	4W	5W	6E	6W	A	B	C	D	E
High level waste, SNF management, minimum	Cubic meters per year	6	0	0	6	6	6	0	6	6	6	6
High level waste, SNF management, maximum	Cubic meters per year	28	26	26	183	26	26	26	183	28	26	26
Transuranic waste, SNF management, minimum	Cubic meters per year	33	21	21	21	37	37	5	5	16	21	21
Transuranic waste, SNF management, maximum	Cubic meters per year	66	73	73	77	89	89	57	61	72	73	73
Mixed waste, SNF management, minimum	Cubic meters per year	1	1	1	1	1	1	1	1	1	1	1
Mixed waste, SNF management, maximum	Cubic meters per year	2	2	2	2	2	2	2	2	2	2	2
Low level waste, SNF management, minimum	Cubic meters per year	1,138	1,123	1,123	1,508	1,341	1,341	985	1,305	935	1,138	1,138
Low level waste, SNF management, maximum	Cubic meters per year	1,768	1,378	1,378	1,858	1,581	1,581	1,245	1,655	1,575	1,378	1,378
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	40	22	22	27	43	43	6	11	22	27	27
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	116	101	101	262	117	117	85	246	102	101	101
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	3.5E-3	3.4E-3	3.4E-3	3.4E-3	3.4E-3	3.4E-3	1.4E-3	1.4E-3	7.2E-3	3.4E-3	1.4E-3
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	1.3E-1	1.3E-1	9.7E-2	9.4E-2	1.3E-1	1.3E-1	9.7E-2	9.4E-2	9.4E-2	1.3E-1	1.3E-1
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	4.7E-7	6.6E-7	6.9E-7	4.7E-7	4.7E-7	4.7E-7	7.9E-7	4.7E-7	4.7E-7	4.7E-7	4.7E-7
Estimated maximum total fatalities from incident-free SNF transportation	Fatalities per year	2.3E-2	1.4E-2	1.4E-2	1.4E-2	2.2E-2	2.3E-2	3.2E-2	2.8E-2	4.3E-2	3.9E-2	4.0E-2
Estimated maximum risk of cancer fatalities from all transportation accidents	Cancer fatalities per year	2.9E-5	3.0E-5	2.4E-5	2.4E-5	3.5E-5	3.1E-5	1.3E-4	1.2E-4	5.1E-5	4.3E-5	1.3E-4
Estimated maximum risk of traffic fatalities from transportation accidents	Fatalities per year	2.5E-2	2.0E-2	1.9E-2	1.8E-2	2.4E-2	2.5E-2	2.8E-2	2.5E-2	3.6E-2	3.4E-2	3,3E-2

a. E indicates exponential notation. Refer to scientific notation in Appendix H, Glossary, for an explanation of this way of writing very large and very small numbers.

K. REFERENCES

DOE (U.S. Department of Energy), 1992, Order 5480.23, "Nuclear Safety Analysis Reports," U.S. Department of Energy, Washington, D.C., April 30.

Appendix L: Environmental Justice

(under separate cover)

Appendix M
FEIS Distribution

Table M-1. Distribution of the FEIS

Andrew A.
John Abbott
  Batelle Pacific Northwest Laboratories
Randy S. Acselrod
  Department of Health
Christopher Adams
JoAnn Adams
  Ola District Library
Michael Adams
William C. Adams
Tony Aducci
  U.S. DOE, Oakland Operations Office
Nico M. Aguilar, III
  Barnwell County Disaster Preparedness
Carol Aiken
Rowena Akana
  State of Hawaii
    Office of Hawaiian Affairs
Cheryl Alford
  Jason Associates, Inc.
Peter Allan
The Honorable Duane S. Allen
  Laborers' International Union
James Allen
  Arrakis, Inc.
Robert Allen
  EOP Group
Lane Allgood
  Pocatello INEL Outreach Office
Dr. Bruce Anderson
  Department of Health
    Office of Environmental Quality Control
Carl R. Anderson
Richard R. Anderson
Bill Andrews
  Harry Reid Center for Environmental Studies
Bruce Angle
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Jim Antizzo
  U.S. DOE, EM-36
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EM Site Specific Advisory Board - INEL
Joann Rice
Kevin Rice
The Honorable Norman Rice
City of Seattle
Sue Rice
Envirocare of Utah
William T. Richards
U.S. Department of Agriculture
Soil Conservation Service
The Honorable Bill Richardson
U.S. House of Representatives
Kermit W. Richardson and Janet E. Richardson
The Honorable Melvin M. Richardson
Idaho Senate

The Honorable Scott H. Richardson
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Steven D. Richardson
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Dr. Peter Rickards
Vote on INEL
W. Ricketts
The Honorable Tom Ridge
State of Pennsylvania
The Honorable Tim Ridinger
Idaho House of Representatives
Richard Riemer
STATCON Inc.
The Honorable Frank Riggs
U.S. House of Representatives
Ward Rigot
Dow Chemical Company
Charles D. Rilhury
The Honorable Joseph P. Riley, Jr.
City of Charleston
Mark Rinehart
Ralph Rinella
The Honorable Larry Ringer
City of College Station
The Honorable Richard Riordan
The Honorable Lynn Rivers
U.S. House of Representatives
The Honorable Tommy Rivers
City of Williston
The Honorable Charles S. Rohh
United States Senate
Jean C. Roberts
Lucy Roberts
The Honorable Pat Roberts
U.S. House of Representatives
Randy Roberts
Dave Robertson
U.S. Department of Energy, Idaho
Operations Office
Shaun Robertson
Shoshone-Bannock Tribes
Environmental Program
Mark Robinowitz
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Columbia University
Krumb School of Mines
Mark Robinson
Puget Sound Naval Shipyard
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Rich Roesler
The Yakima Herald-Republic
Hal Rogers
The Honorable Harold Rogers
U.S. House of Representatives
Keith Rogers
Las Vegas Review Journal
Kris Rogers
First Light Acupuncture
The Honorahle Dana Rohrabacher
U.S. House of Representatives
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U.S. House of Representatives
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International Technology (IT) Corp.
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The Honorable Roy Romer
State of Colorado
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James Rooks
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The Honorable Charlie Rose
U.S House of Representatives
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Idaho Falls Center For Higher Education
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Department of City Planning & Codes
Administration
The Honorable Pedro Rosselló
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Puerto Rico Federal Affairs
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Cheryl Runyon
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Rosemary Russell
David Rutherford
Metro Planning Commission
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Kansas State University
Elizabeth Ryan
Washington Office
State of Delaware
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Hallette R. Salazar
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United States Senate
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LITCO
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Lisa Sattler
Council of State Governments
Midwestern Office
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Kaibab Paiute Indian Tribe
Elmer Savilla
America's Eagle Magazine
Wendy Savkranz
The Honorable Thomas C. Sawyer
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The Honorable Jim Saxton
U.S. House of Representatives
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Science Applications International Corp
Michael Scalingi
Maryland University Training Reactor
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The Honorable Dan Schaefer
U.S. House of Representatives
The Honorable Dan Schaefer
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National Marine Fisheries Service
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EFA NW
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Georgia Environmental Protection Division
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The Honorable Jean Shaheen
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City of Ann Arbor
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CKY
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Paiute Indian Tribe of Utah
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Aiken County
William Sherman
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Dynamac Corporation Library
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Linda Sickles

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Karyn Sieger
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F.M.C
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Larry Silverman
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Rhode Island Nuclear Science Center
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Georgia Department of Natural Resources
Environmental Protection Division
Douglas Simpkins
University of Florida
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Erik Simpson
LITCO
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Lynn Sims
Don't Waste Oregon
Robert Singleton
Boundary County School District 101
Emma L. Sirhall
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American Samoa
Kathleen Sisneros
Waste and Water Management Division
Health Department
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U.S. House of Representatives
The Honorable Joe Skeen
U.S. House of Representatives
The Honorable Ike Skelton
U.S. House of Representatives
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U.S. House of Representatives
Committee on National Security
Lawrence Skinner
Lawrence Skinner
Nevadans Opposing Nuclear Extinction
Robert Skinner
American Nuclear Society
Idaho Section
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Dr. David Slaughter
University of Utah-Salt Lake City
Mechanical Engineering Dept.
The Honorable Louise McIntosh Slaughter
U.S. House of Representatives
Carol Slaughterbeck
Herrera Environmental Consultant
Robert H. (Bob) Slay
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Paul Sloca or Leo Williams
The Oak Ridger
The Honorable Jesse R. Smart
City of Bloomington

Jane Smiley
Arthur P. Smith
Ben L. Smith
The Honorable Christopher H. Smith
U.S. House of Representatives
The Honorable Christopher H. Smith
U.S. House of Representatives
Committee on International Relations
Deanna Smith
Snake River Alliance
Dennie Smith
General Electric Company
Desmond F. Smith
Eric Smith
Fran Smith
Hilton Head Island Packet
Gary W. Smith
B&W Nuclear Environmental Services
Gus Smith
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College of Engineering
The Honorable Kendall Smith
The Honorable Lamar S. Smith
U.S. House of Representatives
The Honorable Linda Smith
U.S. House of Representatives
Lois Smith
Matt Smith
Morgan Smith
Norfolk Naval Base
Neil Smith
University of Missouri-Rolla
The Honorable Nick Smith
U.S. House of Representatives
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Washington Office
State of Iowa
Renee Smith
KSRA-AM (960) and KSRA-FM (92.7)
The Honorable Robert C. Smith
United States Senate
Vicki Smith
Lorne R. Smithhart
Vicki Snitzler
U.S. Department of the Interior
Craters of the Moon National Monument
Rachel Snook
Recorder-Herald
Dickey Snow
Renee Snow
The Honorable Olympia J. Snowe
United States Senate
Keith Snyder
New York Times
Linda Soderquist
The Honorable Paul Soglin
The Honorable R. C. Soles
North Carolina General Assembly
The Honorable Gerald B. H. Solomon
U.S. House of Representatives
Ray Solomon
U.S. Department of Agriculture
U.S. Forest Service
Julie A Somers-Gulsvig
Vicky Song
Pennsylvania State University
Robert Sorenson
City of Tonopah
The Honorable Shiela Sorenson
Idaho Senate
Jim Souhy
Western Governors' Association
The Honorable Mark Souder
U.S. House of Representatives
Joseph M. Souki
Hawaii State House of Representatives
Sherry Southern
U.S. DOE, SROO
Robert E. Southland
Bob W Sower
Fred Sower
U.S. Geological Survey
Denver Federal Center
Linda Spagnola
State University of New York at Buffalo
The Honorable Molly Spearman
South Carolina House of Representatives
Elaine Specht
Energy & Transportation Network News
Scott Species
Fellowship of Reconciliation
The Honorable Arlen Specter
United States Senate
The Honorable Henry Speight
City of Ocala
Phillip D. Speight
City of Henderson
The Honorable Floyd Spence
U.S. House of Representatives
The Honorable Floyd D. Spence
U.S. House of Representatives
Committee on National Security
Thomas Spencer
KVEW-TV News
Carolyn W. Sperry
Robert D. Spies
Paul Spitalny
Dehra A. Spitzer
Markus Spitzer
Suzanne Spore
Donnie L. Sprague
The Honorable John M. Spratt, Jr.
U.S. House of Representatives
Elizabeth Springer
Tim Stallings
City of Oak Ridge
Edith Stanger
Bonneville County
Board of Commissioners
Lila A. Stanger
The Honorable Woodrow Stanley
City of Flint
The Honorable Fortney Pete Stark
U.S. House of Representatives
Jenny Stark
Suquamish Elementary School
Jim Starling
SOUNDINGS
Ron Staton
Associated Press
Carrie L. Stauffer
William C. Stauffer and Patricia Z. Stauffer
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U.S. House of Representatives
Charles Steele
Commonwealth of Massachusetts
Office of Federal-State Relations
Karen Dorn Steele
Seattle Post-Intelligencer
The Honorable Ralph J. Steele
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Selma A. Steele
William K. Steele
Veronica Steffens
Karen Stein
Dr. Ronald Stein
State University of New York at Buffalo
Shirley Stein
The Honorable Charles W. Stenholm
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Clint Stennett
The Honorable W. Clinton Stennett
Idaho Senate
Alan Stephens
Idaho State University
Edward Stern
U.S. Department of Labor
Occupational Safety and Health Administration
Alexander R. Stevens
Ed Stevens
The Honorable Ted Stevens
United States Senate
Brenda Stewart
The Honorable George Stewart
City of Provo
Mark Stewart and Margaret M. Stewart
Kevin Stigile
Roger Stillwell
Commonwealth of the Northern Mariana Islands
Washington Representative
James Stireman
Snake River Alliance
Dale A. Stirling
Landau Associates, Inc.
Gary Stivers
Environmental News Network
Jeri Stockdale
The Honorable Steve Stockman
U.S. House of Representatives
The Honorable Jim Stoicheff
Idaho House of Representatives
Don R. Stokes
The Honorable Louis Stokes
U.S. House of Representatives
Marilyn Stoknes
Bettie Stone
Gary Stone
The Honorable Ruby R. Stone
Idaho House of Representatives
L. George Stonhill and Sheila Stonhill
Mary Stori
Marty Story
Al Stotts
Sandia National Laboratory

Table M-2. (continued)

Dean Stout
Dr. "Raz" Stowe
Idaho State University
Department of Mathematics
Milan Straka
Halliburton NUS Environmental Corp.
Amy J. Strandell
Betty Stratten
Cindy Straushaugh
Snake River Alliance
Owen Straw
Punk Rock
Doreen Strawick
Richland City Council
Sandi Strawn
Batelle Pacific Northwest Laboratories
Mary Strawser
Jack Streeter
Streeter Real Estate
The Honorable La Vinna Stroud
The Honorable Mark Stubbs
Idaho House of Representatives
The Honorable Gerry E. Studds
U.S. House of Representatives
Betty Ann Stume
The Honorable Bob Stump
U.S. House of Representatives
The Honorable Bart Stupak
U.S. House of Representatives
Chris Sturges
Times Union
Mark Stutz
Fort St. Vrain, Public Service Company
Dan Suciu
Environmental Research & Development
A. Suer
Debbie Suhr
Steven Suhring
Mike Sujka
Dr. Jim Sullivan
U.S. Department of State
Office of Energy & Infrastructure
Marquerite Sullivan
Washington Office of the Governor
State of New Jersey
Michael Sullivan
Saratoga County (New York) Board of Supervisors
Amy Sumarmall
Huntingdon
The Honorable Allen Summers
Bishop Paiute Indian Tribe
The Honorable Don Sundquist
State of Tennessee
Mary Suntag
Erie County
Don Susla
IFPTE
The Honorable Dean Sutherland
Washington Senate
Barry Sutton
The Honorable Gertrude Sutton
Idaho House of Representatives
Mike Sutton
Richard Sutton
Pearl Harbor Survivors
Shelley Sutton
Thomas B. Sutton
The Honorable Sam Swafford
City of Dayton
Kerrigan A. Swan
John Swanson
Mary Swanson
Margaret Swartzman
Mark Swearingen
Marco Enterprises
The Honorable Bruce L. Sweeney
Idaho Senate
The Honorable Michael Sweeney
City of Hayward
Sallie Sweet
Pamela Swenson
The Honorable Bernie Ray Swiney
City of Loudon
Susan Switzer
Brad Swope
Savannah News-Press
Marcella Swords and Vincent McDermott
The Honorable Fife Symington
State of Arizona
Dana Takahashi
Richard Takahashi
Pearl Harbor Lions Club
Dr. Tim K. Takaro
Harborview Medical Center
Occupational & Environmental Medicine Program
The Honorable James M. Talent
U.S. House of Representatives
John Talkington and Edwina Talkington
Jerry Taniyama
Military-Civilian Advisory Council
Aiea-Pearl City Business Assn.
John Tanner
The Honorable John S. Tanner
U.S. House of Representatives
The Honorable Ben Tarver
City of Pleasanton
Deborah Tate
The Honorable Marvin Tate
City of Bryan
The Honorable Randy Tate
U.S. House of Representatives
Patricia Tatich
Planning & Community Development
The Honorable David Taub
City of Beaufort
The Honorable Paul Tauer
City of Aurora
Mike Taugher
Greeley Tribune
Carol Tauscher
The Honorable W. J. "Billy" Tauzin
U.S. House of Representatives
Committee on Commerce
The Honorable W. J. (Billy) Tauzin
U.S. House of Representatives
The Honorable Charles H. Taylor
U.S. House of Representatives
The Honorable Donald Taylor
City of Midland
The Honorable Gene Taylor
U.S. House of Representatives
Joe Taylor
Associated Press
Larry L. Taylor
Michael Taylor
Robert Taylor
South Carolina Radio Network
Ron Taylor
Washington Times
Steve T. Taylor
Tuss Taylor
Kentucky Department for Environmental Protection
Division of Waste Management
The Honorable W. O. Taylor
Idaho House of Representatives
Zach Taylor
Marlese Teasley
The Honorable James Tedisco
New York State Assembly
Terry Tehan
Rhode Island Nuclear Science Center
Thomas Teitge
The Honorable Frank Tejeda
U.S. House of Representatives
Richard Telfer
Chief Frank Temoke
Western Shoshone Elders Council
Jan TenBruggencats
Honolulu Advertiser
Ray Tenpenny and Peggy Sue Tenpenny
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U.S. Department of Agriculture
Soil Conservation Service
Phillip S. Teumim
State of New York Department of Public Service
Meryle Teusher
Joanna C. Tewell
Pierre Theriot
The Honorable Craig Thomas
United States Senate
David Thomas
Illinois Hazardous Waste Research and Information Center
Tim Thomas
The Honorable William M. Thomas
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Angle Thompsen
Angie Thompson
Federal Emergency Management Agency
The Honorable Bennie G. Thompson
U.S. House of Representatives
Blake Thompson
Pave the Wilderness
Chuck Thompson
Dick Thompson
Northern Nef, Inc.
The Honorable Fred Thompson
United States Senate
The Honorable James Thompson
Citizens Advisory Committee
The Honorable Tommy G. Thompson
State of Wisconsin
The Honorable William Thornberry
U.S. House of Representatives
The Honorable J. L. Thorne
Idaho Senate
The Honorable Ray Thornton
U.S. House of Representatives

The Honorable Karen L. Thurman
U.S. House of Representatives
The Honorable Strom Thurmond
United States Senate
The Honorable Strom Thurmond
United States Senate
Committee on Armed Services
The Honorable Todd Tiahrt
U.S. House of Representatives
The Honorable Jay Tibshraeny
City of Chandler
Catherine A. Tice
Woodward-Clyde Federal Services
Leo Tierney
Union Pacific Railroad
Jackie Tillett
The Honorable Fred Tilman
Idaho House of Representatives
Kent Tingey
Idaho State University
The Honorable Keith Tinno
Shoshone-Bannock Tribes
Fort Hall Business Council
The Honorable John H. Tippets
Idaho House of Representatives
Verna L. Tippett
Al Tiringoli
Bruce Todd
City of Austin
Lisa R. Todd
Megan Todd
Suquamish Elementary School
Moses Todd
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Stuart Toler
Niles Toole
Toole Supply Company, Inc.
R. L. Toole
Carolina Metals, Inc.
Rick Toole
W. R. Toole Engineers
Mrs. Fred Topik
Mark Torf
TEM
The Honorable Peter G. Torkildsen
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The Honorable Esteban Edward Torres
U.S. House of Representatives
The Honorable Robert G. Torricelli
U.S. House of Representatives
Solveig Torvik
Seattle Post-Intelligencer
Patricia Jean Tousignant
EM Site Specific Advisory Board - SRS
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The Honorable Edolphus Towns
U.S. House of Representatives
Ben Toyama
The Honorable James A. Traficant, Jr.
U.S. House of Representatives
Jack Travelstead
Marine Resource Commission
Fishery Management
James Travis
WSMV-TV
Robert R. Trenkle
Laborers' Local #872
Dorothy L. Trenor
Wilbur Trieble
Saratoga County, New York
Town of Milton
Kelly Abe Trifonovitch
KHET TV-11
Todd Trigsted
Dr. Gerald Tripard
Washington State University
Nuclear Radiation Center
John Trivellin
Hanover Fire Administration
Robert E. Trojanowski
Nuclear Regulatory Commission
Region II
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Doris G Troxel
Sarajane M. Troxel
Scott Tschirgi
Ray Tsukimuru
Aerotest Operations, Inc.
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Danielle Tucker
KHVH
The Honorable Jim Guy Tucker
State of Arkansas
The Honorable Tim Tucker
Idaho Senate
The Honorable Walter R. Tucker III
U.S. House of Representatives
Gary Tumlin
Patricia Tummons
Environment Hawai'i
Eloise Tungpalan
Hawaii State Senate
Tildy Turchinetz
Johnnie Turnbill
Kaye Turner
Lisa Turner
Fremont Herald/Chronicle
The Honorable Michael R. Turner
City of Dayton
Roger Turner
Roger Turner
Shoshone-Bannock Tribes
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Tennessee Department of Health
The Honorable Jerry T. Twiggs
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William A. Tyler
The Honorable Robert A. Underwood
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Richard Unger
The Honorable Fred Upton
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Steve Usdin
Nuclear Remediation Week
David F. Utterback, Ph.D., CIH
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Uldis Vanags
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Heart of America Northwest
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Champlain College
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Bishop Paiute Indian Tribe
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Vegwert & Thomas, Chartered
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U.S. Department of Veterans Affairs
Veterans Administration Medical Center
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University of Florida
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U.S. Air Force
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City of Tacoma
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Vincent Vieten
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State of Indiana
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George L. Vivian
U.S. Bureau of Mines
Idaho National Engineering Laboratory

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The Honorable Harold L. Volkmer
U.S. House of Representatives
The Honorable Barbara F. Vucanovich
U.S. House of Representatives
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City of Salem
Marty Wade
Mike Wade
R. P. Wadkins
Dr. Wagner
University of Massachussetts-Lowell
Loree Wagner
KOMO-TV News
Paul Wagner
Peter Wagner
Honolulu Star Bulletin
The Honorable Rob Wagner
Robert J. Wagner
State University of New York
Russell Wagner
The Honorable Mac Wagoner
City of Dubois
The Honorable Leigh Wai Doo
Honolulu City Council
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U.S. Environmental Protection Agency
Region IV
The Honorable Enid Waldholtz
U.S. House of Representatives
Amy Walker
Arthur H. Walker
The Honorable Charles Walker
Georgia State Senate
John Walker
Aiken Chamber of Commerce
Norvia R. Walker
Allendale County Disaster Preparedness
The Honorable Paul Walker
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Commissioners
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Merrill Wall
Shivwits Southern Band of Paiutes
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Stevens Publishing Corporation
Gary Wallbaum
Robert Waller
Halliburton NUS Environmental Corp.
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Mike Walsh
Montana Office of the Governor
Curtis Walters
The Honorable George Walters
National City
Myrna J. Walters
Public Utilities Commission
Barbara A. Walton
John Wamer
The Honorable Zach Wamp
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Fred Wanzenried
Cia Smalley Ward
State of New Mexico
The Honorable Michael Ward
City of Irvine
The Honorable Mike Ward
U.S. House of Representatives
The Honorable John W. Warner
United States Senate
Sharon Warner
Pam Warnken
Chamber of Commerce of Hawaii
Military Affairs Council
Camilla Warren
EM Site Specific Advisory Board - SRS
Charlie Warren
City of Hood River
Jeffrey Warren
Jim Warren
NC Warn
Sandra Warren
Aerotest Operations, Inc.
Dennis Washburn
Rotary Club of Pearl Harbor
James Washburn
Isaac Washington
South Carolina Black Media
Jim Washington
The Honorable Maxine Waters
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North Carolina Division of Emergency
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Harriet Watson
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Kelley Watson
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Development Commission
Matthew Weatherley-White
Joseph Weaver
Chuck Webb
David R G Webb
The Honorable Gloria O. Webb
City of Portsmouth
The Honorable Wellington Webb
Stephen Weeg
Constance Weeks
Jerry Wegman
The Honorable Susan Weiner
City of Savannah
Melva Weir
Minnesota Legislative Relation
The Honorable Bill Welch
City of State College
The Honorable William F. Weld
State of Massachusetts
The Honorable Curt Weldon
U.S. House of Representatives
The Honorable Dave Weldon
U.S. House of Representatives
The Honorable Jerry Weller
U.S. House of Representatives
Matthew Wells
The Honorable Paul Wellstone
United States Senate
The Honorable Herman Welm
City of San Ramon
The Honorable Stella Welsh
City of Orem
Chris Wentz
State of New Mexico Radioactive Waste
Task Force
Marsha Werle
City of Emmett Public Library
Robert Werth and Wendy Werth
R. L. Wesley
Harold Wessell
The Ballston Journal
Peggy Wessner
Steve West
State of Idaho
Office of Environmental Health
The Honorable William Westbrook
T. Weste
Kevin Westervelt
The Honorable R. Clair Wetherell
Idaho Senate
David Wetmore
Washington Office of the Governor
State of California
Kirk Whatley
Alabama Department of Public Health
Division of Radiation Control
The Honorable "Moon" Wheeler
Idaho Senate
Paige Wheeler
Kathy Whitaker
U.S. DOE, Idaho Operations Office
Charles E. White
The Honorable Del White
Nez Perce Tribal Executive Committee
The Honorable Juanita M. White
South Carolina House of Representatives
The Honorable Rick White
U.S. House of Representatives
The Honorable Rick White
U.S. House of Representatives
Sue White
The Honorable Edward Whitfield
U.S. House of Representatives
The Honorable Christine Whitman
State of New Jersey
The Honorable Lin Whitworth
Idaho Senate
The Honorable Roger Wicker
U.S. House of Representatives
Frank Wicks
Kirk Wicks
Judith E. Widener
The Honorable Raymond J. Wieczorek

Richard E. Wiethorn
Douglas Wiggins
  Seneca Nation of Indians Environmental Protection
Thomas Wiggins
Bernard Wilcox
The Honorable Don Wilde
  City of Mud Lake
The Honorable Gayle Ann Wilde
  Idaho House of Representatives
The Honorable Richard Wilder
  Fort Independence Indian Tribe
Edna Wiler
  RIMS
Steve Wilhelm
  Puget Sound Business Journal
Beaurine H. Wilkins
  EM Site Specific Advisory Board - SRS
J. R. Wilkinson
  Confederated Tribes of the Umatilla Indian Reservation
    Hanford Environmental Restoration Program
Dennis Williams
  Augusta NAACP
Doug Williams
Dr. J. Williams
  University of Arizona
    Nuclear Energy Department
Janice Williams
Kent Williams
  Madison Middle School
Leroy Williams
The Honorable Marshall Williams
  South Carolina Senate
The Honorable Pat Williams
  U.S. House of Representatives
Paul Williams
The Honorable Robin Williams
  Georgia House of Representatives
Theresa E. Williams
Thomas E. Williams
  U.S. Department of Energy, Idaho Operations Office
Xenia Williams
The Honorable Rudy Willis
  Owens Valley Board of Trustees
    Paiute Professional Center
Steve Wills
  School District 411
The Honorable Charles Wilson
  U.S. House of Representatives
Christopher B. Wilson
George Wilson
Kay W. Wilson
The Honorable Pete Wilson
  State of California
Jan Wimberly
Chuck Winder
Tom Winston
  Ohio Environmental Protection Agency
John Winters
  Augusta Chronicle
Richard Winters
  U.S. Department of the Interior
    National Park Service
The Honorable Robert E. Wise, Jr.
  U.S. House of Representatives
Sandra Wisecaver
  Mountain Express
Hazel Wison
Rick Wolcott
  Dow North America
The Honorable Frank R. Wolf
  U.S. House of Representatives
Nelson Wolff
  Military Plaza
Jeanette Wolfley
  Shoshone-Bannock Tribes
Donna Wong
  Hawaii's Thousand Friends
Jeannine Wood
  Idaho Senate
The Honorable JoAn E. Wood
  Idaho House of Representatives
Mark S. Wood
The Honorable Martha S. Wood
Thomas Wood
Wade Woodland
The Honorable Cheryll N. Woods-Flowers
  City of Mount Pleasant
Karen Woodward
Mark Woodward
The Honorable Lynn C. Woolsey
  U.S House of Representatives
The Honorable William D. Workman
  City of Greenville
Annie Worth
Bill Worth
Marjorie Worthington
Jane Wrenn
Alden Wright
Catherine Wright
Creed Wright
The Honorable Thomas Wright
  North Carolina General Assembly
Harold Wulke
Connie Wurster
The Honorable Ron Wyden
  U.S House of Representatives
Don Wyman
The Honorable Albert Russell Wynn
  U.S House of Representatives
The Honorable Paul Wynn
Kenneth Yager
Forrest Yandell
The Honorable Sidney R. Yates
  U.S House of Representatives
Roy J. Yee
  KEMS Kewalo
Margaret M. Yeoman
Diana Yerpe
  Cultural Resource
Robert M. Yohe
  Idaho State Historical Society
Nohoni Yonamine
  Hawaii State House of Representatives
Jon Yoshishige
  Honolulu Advertiser
The Honorable C. W. Bill Young
  U.S. House of Representatives
The Honorable Daniel Young
  City of Santa Ana
Diana G. Young
The Honorable Don Young
  U.S. House of Representatives
The Honorable Don Young
  U.S. House of Representatives
    Committee on Resources
Doug Young
  Office of Policy and Initiatives
Linda Young
  MTC
Richard Young
The Honorable Ronnie Young
  City of Aiken
Tin Hu Young
Karen Yourish
  Weapons Complex Monitor
The Honorable Raymond Yowell
  Western Shoshone National Council
Neva Yribarren
Rafiq Zaidi
Nell Zajac
  Heart of America Northwest
The Honorable Terrence Zaleski
  City of Yonkers
Sally Zanover
Emma Zaratian
Carl W. Zeh
Hank Zeile
The Honorable William H. Zeliff, Jr.
  U.S. House of Representatives
Barbara Zepeda
  Washington Demonstration Council
Steve Zerguhurdt
  The Sun
Terry Zerkle
  City of Tempe
Bob Ziel
  KID Radio
The Honorable Dick Zimmer
  U.S. House of Representatives
Walter Zimmermann
  KITV TV-4
David Zink
James Zitzelberger
Frank Zollo
  Knolls Action Project
Marian Zucco
  Big Pine Indian Tribe
William Zuercher
Anthony J. Zuvela
  Suquamish Elementary School

  Ammon City Council
  Bannock County
    Highway Department
  Bannock County
    Planning and Development Services
  Bingham County
    City of Blackfoot
  Bingham County
    Road Superintendent
  Bingham County
    Sheriff's Department
  Bonneville County
    Civil Defense and Disaster Relief
  Boulder City
  Butte City Council
  Butte County
    Sheriff's Department
  Chesapeake Bay Sierra Club
  Churchill County

Table M-2. (continued)

Managers Office
City of Arco
City of Arimo
City of Blackfoot
Water & Sewer Department
City of Caliente
City of Cincinnati
City of Declo
Declo City Council
City of Downey
Downey City Council
City of Dubois
City of Firth
City of Firth
City of Hagerman
City of Hamar
City of Idaho Falls
City of Indian Springs
City of Needles
City of Oak Ridge
Environmental Quality Advisory Board
City of Pahrump
Advisory/Planning Board
City of Ririe
City of Sugar City
Clark County Managers Office
Clark County Nuclear Waste Division
Clearwater Memorial Library
Clinton Courier News
Confederated Tribes and Bands of the Yakama
County of Nye
Nuclear Waste Protection Office
Defense Nuclear Agency
Nevada Operations Office
Egan & Associates, P.C.
McGil Special Services Inc.
Egan & Associates, P.C.
Tri-State Motor Transit Co.
Environmental Advisory Council
County Legislature
Environmental Protection Agency
Pacific Islands Contact
Esmerelda County Commission
Eureka County Commission
Fred's Signs and Art
Hawaii Navy News
Heritage Conservation and Recreation Service
Division of Environmental Compliance and Review
Hood River News
Indian People's Muskogee Tribal Town Confederacy
INEL Boise Office
Jefferson County
Jefferson County Board of County Commissioners
Journal and Guide
KCMU Radio
KCTS TV-9
Newsroom
Kelly Temporary Services
KEPR-TV
KING-TV 5 News
Newsroom
KLAS-TV
KLVX-TV
KNDI-TV News
KNEV
KONA Radio
KORD Radio News
KOTY Radio
KROW/KBUL News
KSTW TV-11
Newsroom
KTNV-TV
KVBC-TV Channel 3
KVEW-TV
Lander County Commission
City of Battle Mountain
Lincoln County Commission
City of Pioche
Madison County
National Council of the Muskogee Creek
Navy News
Nevada Test Site Economic Adjustment
TAS
Nye County Commission
City of Round Mountain
Nye County Nuclear Waste Repository
Project Office
OK95/KALE Radio
Peach State Public Radio
Pearl City Neighborhood Board No. 21
Rexburg City Council
Rexburg Standard Journal
Rigby City Council
Rocky Mountain Peace Center
Salmon Public Library
South Carolina Engineer
Spokesman-Review
Stanley City Council
Sun Newspaper
T. A. Rivard, Inc.
Tacoma News Tribune
Teamsters Local 533
The Daily Times
The Idahonian
The Morning News
The Sho-Ban News
Town of Shelley Police Department
U-102 Radio Station
U.S. Army Corps of Engineers
U.S. Department of Agriculture
U.S. Department of Agriculture
Soil Conservation Service
U.S. Department of Commerce
Economic Development Administration
U.S. Department of Health and Human Services
National Institutes of Health
U.S. Department of Labor
Occupational Safety and Health Administration
U.S. Department of the Interior
Bureau of Indian Affairs
U.S. Department of Veterans Affairs
Regional Office-Loan Gty. (026)
U.S. Naval Administrative Unit
WAGA-TV 5
WAGT-TV
Washington Office of the Governor
Commonwealth of Pennsylvania
WASTREN, Inc.
WATE-TV
WATO Radio Station
WCBD-TV
WCSC-TV
Weaver Farms
WFOG
White Bird City Council
White Pine County Commission
WIS-TV
WJBF-TV
WLTX-TV
WNOR
WNTS
WOLO-TV
Worldwatch Institute
WOWI
WRAP
WRDW-TV
WSB-TV
WTAR
WTOC-TV
WXIA-TV 11
Yuchi Tribal Organization, Inc.

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