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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
Appendix D
Part A

Naval Spent Nuclear Fuel Management

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Appendix D
to Volume 1 of
Department of Energy
Programmatic Spent Nuclear Fuel Management
and
Idaho National Engineering Laboratory
Environmental Restoration and
Waste Management Programs
Environmental Impact Statement

Naval Spent Nuclear Fuel Management

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SUMMARY

INTRODUCTION

Volume 1 to the Department of Energy's Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Management Programs Environmental Impact Statement evaluates a range of alternatives for managing naval spent nuclear fuel expected to be removed from U.S. Navy nuclear-powered vessels and prototype reactors through the year 2035. The Environmental Impact Statement (EIS) considers a range of alternatives for examining and storing naval spent nuclear fuel, including alternatives that terminate examination and involve storage close to the refueling or defueling site. The EIS covers the potential environmental impacts of each alternative, as well as cost impacts and impacts to the Naval Nuclear Propulsion Program mission.

This Appendix covers aspects of the alternatives that involve managing naval spent nuclear fuel at four naval shipyards and the Naval Nuclear Propulsion Program Kesselring Site in West Milton, New York. This Appendix also covers the impacts of alternatives that involve examining naval spent nuclear fuel at the Expended Core Facility in Idaho and the potential impacts of constructing and operating an inspection facility at any of the Department of Energy (DOE) facilities considered in the EIS. This Appendix also considers the impacts of the alternative involving limited spent nuclear fuel examinations at Puget Sound Naval Shipyard. This Appendix does not address the impacts associated with storing naval spent nuclear fuel after it has been inspected and transferred to DOE facilities. These impacts are addressed in separate appendices for each DOE site.

BACKGROUND

The Naval Nuclear Propulsion Program is a joint U.S. Navy and DOE program responsible for all matters pertaining to naval nuclear propulsion. The Program is responsible for the nuclear propulsion plants aboard over 120 nuclear-powered warships powered by over 140 naval reactors and for nuclear propulsion work performed at six naval shipyards and two private shipyards. Removal of spent nuclear fuel from ships is ending at two of those shipyards as a result of recent decisions on base closures, and nuclear propulsion work at one of the private shipyards has not involved handling spent nuclear fuel for more than 15 years. The Program is also responsible for two government-owned, contractor-operated laboratories, two moored training ships, three land-based prototype reactors, and the Expended Core Facility located at the Naval Reactors Facility. The Naval Reactors Facility is located at the Idaho National Engineering Laboratory (INEL).

NAVAL SPENT NUCLEAR FUEL MANAGEMENT

Naval spent nuclear fuel is the fuel removed from naval nuclear propulsion plants. Naval fuel is designed to meet the demanding requirements needed to support long-term operation in a warship. To meet these requirements, it is designed to withstand battle shock and to retain its radioactivity so as to minimize radiation dose to the ships' operating personnel who must live and work in close proximity to the reactor. Even after decades of service, the spent nuclear fuel retains its strength and high integrity.

For nearly 40 years, naval spent nuclear fuel has been shipped by rail in shielded shipping containers from naval shipyards and prototypes to the Expended Core Facility in Idaho where it is removed from the shipping containers and placed into water pools at the Expended Core Facility. All fuel is examined for specific characteristics and for abnormalities. Selected fuel is given more detailed examination. Naval fuel examinations provide assurance that operations of shipboard reactors can continue without restriction. These examinations have significantly contributed to the longer core lives and continued safe performance of current naval reactor designs. This work has also resulted in substantial reduction in the amount of spent nuclear fuel generated by the Naval Nuclear Propulsion Program.

DESCRIPTION OF ALTERNATIVES

The EIS considers five general alternatives for spent nuclear fuel management. The general alternatives are described in Chapter 3 of Volume 1. Naval spent nuclear fuel would be managed under each of these general alternatives as follows.

No Action

Naval reactors would be refueled and defueled as planned. Naval spent nuclear fuel would be stored in transport casks at the Navy or DOE facility where defueling was conducted. (Fuel generated from ships at Newport News Shipbuilding would be transferred to Norfolk Naval Shipyard.) No further spent nuclear fuel examination would be conducted. This alternative would require a phase-in period while additional containers are procured for spent nuclear fuel storage. During an approximately 3-year period, spent nuclear fuel would be transported in shipping containers to the Expended Core Facility in Idaho. The containers would be unloaded and used to support additional refuelings and defuelings.

Decentralization

For naval spent nuclear fuel, three options are considered. Each option would require a phase-in period while facilities are developed. The length of the phase-in period would depend on the option and mode of storage selected. During the phase-in period, spent nuclear fuel would be transported in shipping containers to the Expended Core Facility in Idaho. The containers would be unloaded and used to support additional refuelings and defuelings.

a. Store naval spent nuclear fuel at the Navy or DOE facility where defueling is conducted. (Fuel generated from ships at Newport News Shipbuilding would be transferred to Norfolk Naval Shipyard.) At each storage location, dry storage in shipping containers and dry casks as well as wet storage in a water pool facility are considered.

b. Modify the existing water pool facility at Puget Sound Naval Shipyard to conduct the maximum practical amount of naval spent nuclear fuel examinations at that site. Store naval spent nuclear fuel at the Navy or DOE facility where defueling is conducted. (Fuel generated from ships at Newport News Shipbuilding would be transferred to Norfolk Naval Shipyard.) At each storage location, dry storage in shipping containers and dry casks as well as wet storage in a water pool facility are considered.

c. Ship naval spent nuclear fuel to the Expended Core Facility for examination, then return the fuel after examination to the Navy or DOE facility where defueling is conducted. (Fuel generated from ships at Newport News Shipbuilding would be transferred to Norfolk Naval Shipyard.) At each storage location, dry storage in shipping containers and dry casks as well as wet storage in a water pool facility are considered.

1992/1993 Planning Basis

The historic practice of transporting all spent nuclear fuel removed from naval reactors to the Expended Core Facility in Idaho for examination would resume. Following examination, fuel would be transferred to DOE for management at the Idaho Chemical Processing Plant pending final disposition.

Regionalization

The overall Regionalization alternative includes two options. The first option involves managing spent nuclear fuel at three DOE sites (Hanford Site, the INEL, and the Savannah River Site) based on fuel type. Under this option, the historical practice of transporting spent nuclear fuel removed from naval reactors to the Expended Core Facility in Idaho for examination would resume. Following examination, fuel would be transferred to DOE for management at the Idaho Chemical Processing Plant pending final disposition.

The second overall option involves managing spent nuclear fuel at a Western Regional Site and an Eastern Regional Site, based primarily on the originating location of the fuel. Under this option, naval fuel would be allocated to one site, either the western or the eastern site, for examination and storage. This Appendix evaluates the potential impacts of examining naval spent nuclear fuel at all of the potential sites.

Centralization

The Centralization alternative would collect <u>all</u> of the DOE's current and future spent nuclear fuel at one DOE site. The Hanford Site, the INEL, the Nevada Test Site, the Oak Ridge Reservation, and the Savannah River Site have been considered as candidates for this single site. If the INEL were selected, then naval spent nuclear fuel would be examined at the Expended Core Facility and would be stored at the Idaho Chemical Processing Plant. If a site other than INEL were selected, then the Expended Core Facility would be shut down and a new or modified facility for examination and additional storage facilities would be constructed at the selected site.

SITES CONSIDERED FOR NAVAL SPENT NUCLEAR FUEL MANAGEMENT

Naval Shipyards and Prototypes - The EIS evaluates four naval shipyards, Puget Sound Naval Shipyard at Bremerton, Washington; Norfolk Naval Shipyard at Portsmouth, Virginia; Portsmouth Naval Shipyard at Kittery, Maine; and Pearl Harbor Naval Shipyard at Pearl Harbor, Hawaii, for management of naval spent nuclear fuel only. The EIS also evaluates the Kenneth A. Kesselring Prototype Site at West Milton, New York. The four shipyard locations are industrial in nature and located near harbor areas. The Kesselring Site is a 3900-acre facility located in the mid-eastern sector of New York State in a wooded rural environment.

Idaho National Engineering Laboratory - This is the location of the Naval Reactors Facility which is also the present location of the Expended Core Facility. It is located in southeastern Idaho and occupies about 890 square miles of desert. The Idaho National Engineering Laboratory is presently used for industrial and support operations associated with energy research and waste management activities, grazing, recreational uses, and environmental research. It is remote from urban areas and occupies a controlled federal reservation which is largely undisturbed from its natural state.

Savannah River Site - The Savannah River Site in South Carolina is the location of one of the Department of Energy's weapons production sites. The P, K, and L Reactors at this location produced plutonium and tritium in support of the nation's nuclear weapons program. The Savannah River Site is located in the eastern United States and is in a heavily wooded environment which is returning to a more natural state from its previous agricultural uses. It is 310 square miles in area.

Hanford Site - The Hanford Site in the State of Washington is the location of one of the Department of Energy's weapons production sites. The N-Reactor at this site was used by the DOE through the years for the production of plutonium in support of the nation's nuclear weapons program. The Hanford Site is in the western United States on open, vacant desert land. It is 560 square miles in area which is largely undisturbed from its original state.

Oak Ridge Reservation - The Oak Ridge Reservation in Tennessee is the location of one of the Department of Energy's facilities which was primarily used to support the nation's nuclear weapons program. The Y-12 Plant at this location was used for processing highly enriched uranium for fuel elements used in the Savannah River reactors. The Oak Ridge Reservation is located in the eastern United States and is in a heavily wooded environment. It is 55 square miles in area, and consists of three industrialized areas separated by undeveloped forest land.

Nevada Test Site - The Nevada Test Site in Nevada has been a location for performing nuclear weapons testing. This site has been used by the DOE for activities in support of the national nuclear weapons program. The Nevada Test Site is in the western United States and is located in open, vacant desert land. It is 1350 square miles in area.

ANALYSES

This EIS evaluates the potential environmental impact of each alternative, including both the construction of new facilities and management operations at those facilities (transport, receipt, handling, examination, and storage of naval spent nuclear fuel). In general, accident analyses focus on accidents which have the probability to occur at least once every 10 million years. The range of accidents considered includes those resulting from human errors or mechanical failure such as airplane crashes into storage facilities and improper spent nuclear fuel handling, as well as natural disasters such as earthquakes and tornadoes. Both radiological and non-radiological impacts were considered. The cumulative impacts of spent nuclear fuel management and other operations at these facilities have also been evaluated.

RESULTS AND COMPARISON OF ALTERNATIVES

Implementation of some of the alternatives would require construction or modification of facilities for storage of naval spent nuclear fuel at naval sites or a replacement for the Expended Core Facility at a DOE site. The locations for any new facilities would be selected from space already available on existing federally owned property, so no additional land would be withdrawn from public use at any site. The only exception to this might occur if the Barnwell Nuclear Fuel Plant at Savannah River were to be purchased and removed from the public domain. New facility locations would be chosen to avoid impacts on the cultural, archaeological, aesthetic, or scenic values of the area and to ensure that the rights or interests of Native American or Native Hawaiian groups would not be infringed. No site listed in the National Register of Historic Places would be affected. Ecologically sensitive areas, such as those in the vicinity of any threatened or endangered species, would be avoided. Construction activities associated with any naval spent nuclear fuel storage or examination facility would comply with all applicable laws and regulations, using established procedures for preserving air and water quality and previously unknown archaeological or cultural artifacts encountered and for minimizing such impacts as noise and disturbance or destruction of habitat.

No new naval spent nuclear fuel storage or examination facility would release water carrying radioactive or hazardous material to the environment. In 40 years of receipt, transportation, handling, and examination of naval spent nuclear fuel, the Naval Nuclear Propulsion Program has never had a release of radioactivity that has had a significant effect on the environment. Based on the operations that would be performed and the controls that would be in place, the impacts on air, water, ecological, or geological resources of any naval facility considered would be negligible. Furthermore, experience has shown that since naval spent nuclear fuel management is a low-intensity industrial activity, its contributions to noise and traffic would be inconsequential and its utility needs would generally be within the capabilities of the candidate sites. The Hanford Site and Nevada Test Site are possible exceptions to this because they are already operating at or near their electrical utility capacities and may require additional capacity to accommodate a new Expended Core Facility.

In the unlikely event of any accident involving naval spent nuclear fuel, it is estimated that no more than 210 acres of land would be affected for the most severe case, and in the other accidents analyzed, smaller areas of land would be affected. The affected area would require decontamination and during this cleanup, access controls would have to be established. However, due to the limited land area affected, it is judged that these restrictions would only be temporary and the impact on issues such as economics, treaty rights, tribal resources, ecology, and land use would be small and limited in time. The remediation actions would be simpler in rural areas than in urban areas, but, provided that prudent controls and remediation operations were promptly implemented, the affected land and buildings could be recovered in either case. As demonstrated in the accident analyses in this appendix, the human health effects would not be large and the effects on wildlife and other biota would also not be large, partly due to the relatively small area affected and partly because of the limited effects of the accident.

The radiological and non-radiological impacts of all the alternatives considered would be small. After consideration of the full range of environmental impacts and other effects associated with the management of naval spent nuclear fuel, it is judged that for all of the alternatives considered, the impacts on the ecology, cultural and aesthetic values, air and water resources, geology, and such areas as noise, traffic, and utilities, normally associated with most daily activities, would be so small and differ so little among alternatives for naval spent nuclear fuel that they would be of little assistance in differentiating among the alternatives.

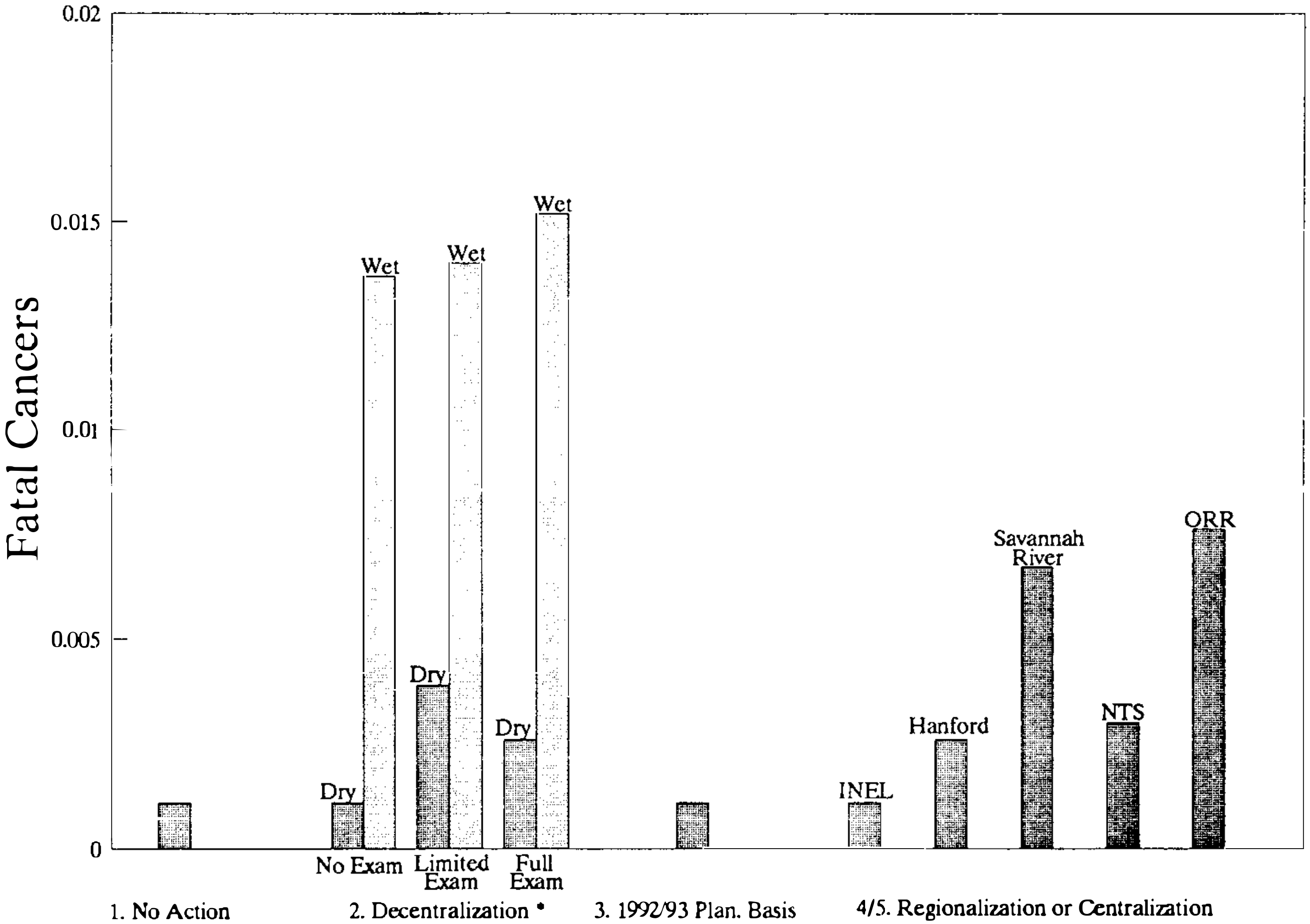
The areas of impact which are of special interest to the public or which provide the most distinct contrasts among the alternatives are public health, socioeconomics, cost, and the Naval Nuclear Propulsion Program mission.

Public Health Impacts

A primary concern for most people is the risk to the public from exposure to radiation or radioactive material for each of the alternatives. The exposure could be a result of normal operations or an accident. A practical method often used to characterize the public risk resulting from federal actions such as these is to estimate the number of prompt fatalities or cancer fatalities that might result.

The analyses in this EIS show that there would be no prompt fatalities from the radiation exposure associated with accidents (or normal operations) for any of the alternatives considered and that there would be no latent cancer fatalities under any of the alternatives. However, for the No Action and Decentralization alternatives, under which naval spent nuclear fuel would be stored at a naval shipyard, the risks to a member of the public would be higher than for other alternatives.

Figure S-1 provides an overall comparison of the alternatives in terms of the calculated increase in the number of cancer fatalities that might occur in the general population over 40 years of operation for each alternative. It is important to emphasize that these cancer fatalities are calculated results rather than actual expected fatalities. This is because the expected number of such fatalities during normal operations is so small as to be indistinguishable relative to the larger number of such deaths expected from naturally occurring conditions and other man-made effects not related to naval spent nuclear fuel operations. This is not meant to trivialize the importance of radiation-induced cancer fatalities but, rather, is meant to put the issue in perspective. In all the alternatives, thousands of years of facility operation and transportation of naval spent nuclear fuel would be required before a single additional fatal cancer might be expected to occur. To provide some perspective, the naturally occurring radioactive materials in fertilizer used to produce food crops contribute about 1 to 2 millirem per year to an average American's exposure to radiation. Using the same calculational method used to determine the cancer fatality risk for the Naval Nuclear Propulsion Program



* The risk of cancer fatalities varies under the decentralization alternative depending on the mode of storage. The greatest risk occurs when using wet storage in water pools. The smallest risk occurs during dry storage in shipping containers or storage casks.

Figure S-1. Risk from normal operations by alternative (fatal cancers to the general population over 40 years from facility operations and transportation).

alternatives, the exposures from consuming food grown with fertilizer result in 125 to 250 cancer fatalities annually in the United States.

The most severe risks for a facility accident were determined to be from an airplane crash into a dry storage container at the Pearl Harbor Naval Shipyard. This accident was calculated to result in 26 cancer fatalities and had a probability of occurring about once every 100,000 years. This accident has been calculated to produce a risk of less than 0.0003 additional cancer fatalities per year. The risks from all other accidents associated with examination or storage of naval spent nuclear fuel were much less than this. In general, the risks from facility accidents tended to be worse for the No Action and Decentralization alternatives, because for these alternatives fuel would be stored at sites which are located close to large population centers. For transportation accidents, the potential risks varied with the distances to be traveled, being least for the No Action and the Decentralization - No Examination alternatives which would involve transportation over short distances to storage locations near where the fuel is removed from reactors.

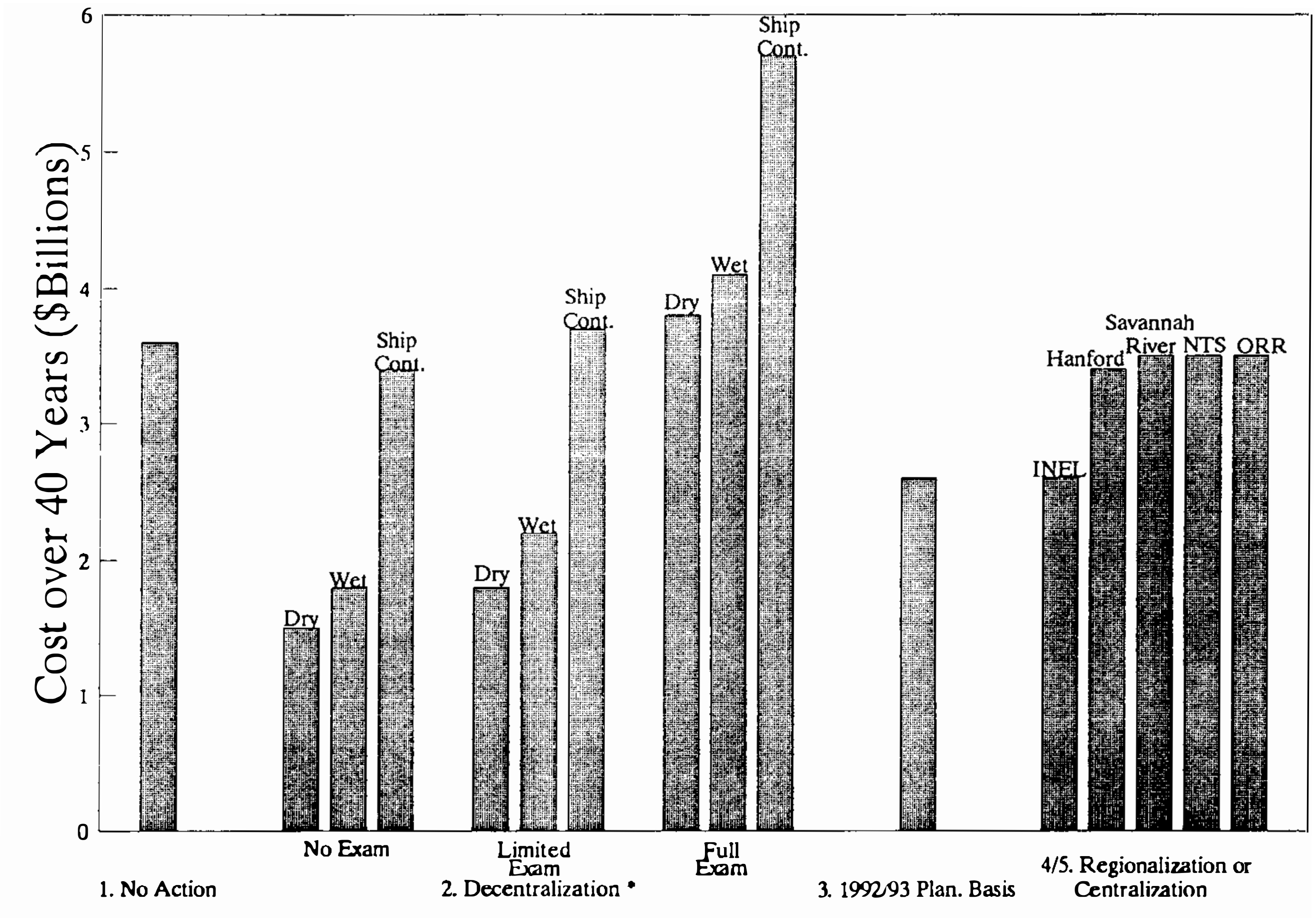
Socioeconomic and Cost Impacts

The socioeconomic impacts of implementing each of the alternatives would differ somewhat and are summarized in Table S-1. The primary socioeconomic impact of the alternatives considered would be on employment. Nation-wide employment levels would not vary significantly among alternatives for managing naval spent nuclear fuel and therefore do not provide a basis to distinguish among the alternatives. The maximum impact on local employment levels would be caused by alternatives requiring development of new naval spent nuclear fuel examination capability at a DOE facility other than INEL while terminating these activities at INEL. Continuing current practices of transporting naval spent nuclear fuel to the Expended Core Facility at INEL for examination followed by transfer to the DOE for storage would result in the minimum disruption of employment levels.

As shown in Figure S-2, there are large differences in the costs associated with all alternatives. These costs include the costs that would be incurred from construction of new facilities and containers, naval spent nuclear fuel transportation, and facility operation. In general, lower costs are associated with those alternatives that support examination of naval spent nuclear fuel with existing facilities and those alternatives that terminate or severely curtail spent nuclear fuel examination. The higher costs are associated with those alternatives that require construction of a new Expended Core Facility and those alternatives that use shipping containers for storage.

Table S-1. Summary of potential socioeconomic impacts.

Alternative	Long-term Impacts at INEL	Long-term Impacts at Other Sites
1. No Action	Lose 500 jobs	Add 50-100 jobs at naval sites
2. Decentralization		
- No Examination	Lose 500 jobs	Add 50-200 jobs at naval sites
- Limited Examination	Lose 500 jobs	Add 110-260 jobs at naval sites
- Full Examination	No change	Add 50-200 jobs at naval sites
3. 1992/1993 Planning Basis	No change	No change
4/5. Regionalization or Centralization		
- Idaho National Engineering Laboratory	No change	No change
- Hanford Site	Lose 500 jobs	Add 500 permanent jobs and some construction jobs at Hanford
- Savannah River Site	Lose 500 jobs	Add 500 permanent jobs and some construction jobs at Savannah River
- Nevada Test Site	Lose 500 jobs	Add 500 permanent jobs and some construction jobs at NTS
- Oak Ridge Reservation	Lose 500 jobs	Add 500 permanent jobs and some construction jobs at ORR



* The cost varies under the decentralization alternative depending on the mode of storage. The most expensive options are those that use shipping containers for storage; the least expensive options are those that use immobile dry storage containers.

Figure S-2. Summary of costs by alternative (facility and transportation costs over 40 years).

Mission Impacts

Two important components of Naval Nuclear Propulsion Program operations are the safe management of naval spent nuclear fuel and support of the Navy's fleet of nuclear-powered warships. Based on the analyses in this EIS, all alternatives considered would allow safe storage of naval spent nuclear fuel until a permanent repository becomes available. However, some of the alternatives would not provide equal levels of Fleet support. Alternatives which limit or terminate naval spent nuclear fuel examination would severely impact ongoing research and development work. Naval spent nuclear fuel examination results are used to confirm the adequacy of design features, explore material performance, and confirm or adjust computer predictions of fuel performance. This information contributes to the design and manufacturing of new naval reactor cores as well as the safe operation of nuclear-powered warships. Of the alternatives allowing full examination at the INEL, Hanford Site, Savannah River Site, Oak Ridge Reservation, or Nevada Test Site, examination at the INEL would have the smallest mission impact due to the presence of existing facilities and equipment for performing this work, and the presence of a highly skilled work force, all of which would need to be relocated or reassembled if a new examination site were selected.

CONCLUSION - PREFERRED ALTERNATIVE

The Navy's preferred alternative for the management of naval spent nuclear fuel would continue the historic, technically sound and safe practice of conducting refueling and defueling of nuclear-powered warships and prototypes as planned, transporting naval spent nuclear fuel to the Expended Core Facility at INEL for full inspection and examination, and transferring naval spent nuclear fuel to the DOE facility for storage pending availability of a method for permanent disposition. This preferred alternative is based on consideration of environmental, socioeconomic, cost, and mission impacts of each alternative.

The analyses contained in this EIS demonstrate that the environmental impacts of implementing any of the alternatives would be very small for normal operations and accident conditions. The analysis results do not provide a basis to distinguish among the alternatives in most of these areas. The socioeconomic impacts of the alternatives also do not provide a basis to distinguish among the alternatives.

The Navy's preferred alternative is, therefore, based on impacts to the Navy's mission and on cost. Alternatives that limit or terminate naval spent nuclear fuel examination would adversely affect Fleet support and the development of new naval reactors. Primarily because of the existing infrastructure, examination followed by storage at INEL would best support the Naval Nuclear Propulsion Program mission and would be the least cost alternative allowing for full examination of naval spent nuclear fuel.

The alternatives which involve the Navy's preferred alternative are: 1992/1993 Planning Basis alternative and the Regionalization and Centralization alternatives that include the use of the Expended Core Facility at INEL.

1. INTRODUCTION

This appendix describes the alternatives which have been evaluated for the examination and storage of spent nuclear fuel from U. S. naval nuclear shipboard and prototype reactors. The spent fuel is removed during reactor refuelings and defuelings at naval and commercial shipyards and at the prototype sites. The alternatives include a range of options for managing naval spent fuel through the year 2035. The options for spent fuel examination include ceasing all examinations, examining a limited amount of fuel at a naval shipyard, and performing a full range of examinations at the current facility (Idaho National Engineering Laboratory) or at another Department of Energy (DOE) facility. The options for naval spent fuel storage include storage at the refueling and defueling sites (in some cases, it is necessary to move the fuel to the closest acceptable Navy shipyard), storage at the current facility, or storage at another DOE facility. Spent fuel transportation aspects will depend on the examination and storage alternatives selected.

Naval spent fuel examination, whether at a naval or DOE site, will remain the responsibility of the Naval Nuclear Propulsion Program. This appendix therefore addresses the environmental impacts of naval spent fuel examination. This appendix also addresses the environmental impacts of long-term storage of spent fuel at naval shipyards and prototype sites. The environmental impacts of long-term spent fuel storage at DOE facilities are addressed in the Environmental Impact Statement appendices applicable to those sites.

2. BACKGROUND

2.1 NAVAL NUCLEAR PROPULSION PROGRAM OVERVIEW

The Naval Nuclear Propulsion Program is a joint Navy/Department of Energy (DOE) organization responsible for all matters pertaining to naval nuclear propulsion pursuant to Presidential Executive Order 12344, enacted as permanent law by Public Law 98-525 (42 USC 7158). The Program is responsible for:

a. The nuclear propulsion plants aboard over 120 warships powered by over 140 naval reactors.

b. Moored Training Ships located in Charleston, South Carolina used for naval nuclear propulsion plant operator training.

c. Nuclear propulsion work performed at eight shipyards (six public and two private).

d. Two DOE government-owned, contractor-operated laboratories devoted solely to naval nuclear propulsion research, development, and design work.

e. Three land-based prototype naval reactors used for research and development work and training of naval nuclear propulsion plant operators.

f. The Expended Core Facility, located at the Naval Reactors Facility which is a part of the Idaho National Engineering Laboratory.

More detailed discussion is available in the references listed in Section 2.6 (DOE/DOD 1994; Duncan 1990; Hewlett and Duncan 1974).

2.2 HISTORY AND MISSION OF THE PROGRAM

In 1946, at the conclusion of World War II, Congress passed the Atomic Energy Act, which established the Atomic Energy Commission (AEC) to succeed the wartime Manhattan Project, and gave it the sole responsibility for developing atomic energy. At that time, Captain Hyman G. Rickover was assigned to the Navy Bureau of Ships, the organization responsible for naval ship design. Captain Rickover recognized the military implications of successfully harnessing atomic power for submarine propulsion, and that it would be necessary for the Navy to work with the AEC to develop such a program. By 1949, Captain Rickover had forged an arrangement between the AEC and the Navy that led to the formation of the Naval Nuclear Propulsion Program. In 1954, the nuclear submarine USS NAUTILUS put to sea and demonstrated the basis for all subsequent U.S. nuclear-powered warship propulsion designs. In the 1970's, government restructuring moved the AEC part of the Naval Nuclear Propulsion Program from the AEC (which was disestablished) to what became the Department of Energy. Although the Naval Nuclear Propulsion Program grew in size and scope over the years, it retained its dual responsibilities within the Department of Energy and the Department of the Navy, and its basic organization, responsibilities, and technical discipline have remained much as when it was first established.

By eliminating altogether the need for oxygen for propulsion, nuclear power offered a way to drive a submerged submarine without the need to resurface frequently. In addition, nuclear power offered a way to drive a submerged submarine at high speed without concern for fuel consumption.

Nuclear propulsion, though originally developed for submarines, significantly enhances the military capability of surface ships. Nuclear propulsion provides virtually unlimited high-speed endurance without dependence on tankers and their escorts. Moreover, the space normally required for propulsion fuel in oil-fired ships can be used for weapons and aircraft fuel in nuclear-powered ships.

Naval fuel is designed to meet the very stringent operational requirements for naval nuclear propulsion reactors. Because of its military design, it will maintain its integrity indefinitely under the far less demanding conditions encountered during land-based storage. Naval fuel is designed to operate in a high-temperature and high-pressure environment for many years. Current designs are capable of over 20 years of successful operation. Measurements of the corrosion rates for current naval fuel designs have shown that naval spent nuclear fuel could be safely stored for periods far, far longer than the 40 years considered in this Environmental Impact Statement (EIS) in the cool water or air used for storage. Naval fuel uses highly corrosion-resistant materials for fuel and cladding which can withstand high-intensity radiation and harsh environments. As a result, the fuel is very strong and has very high integrity. The fuel is designed, built, and tested to ensure that the fuel construction will contain and hold the radioactive fission products. Naval fuel totally contains fission products within the fuel - there is no fission product release from the fuel in normal operation. Since the nuclear reactor core contains a large quantity of fission products, it is essential to contain them within the nuclear fuel in order to minimize radiation exposure to a ship's crew. Naval fuel is extremely rugged. It can withstand combat shock loads which are well in excess of 10 times the seismic loads for which commercial nuclear power plant fuel is designed. It routinely operates with rapid changes in power level since naval ships must be able to change speed quickly in operational situations. Naval fuel consists of solid components which are non-explosive, non-flammable, and non-corrosive. The ruggedness of naval fuel is demonstrated by the fact that two nuclear-powered ships were lost at sea in the 1960's, and subsequent environmental monitoring shows no release of fission products from the fuel despite the catastrophic nature of the loss of the ships (NNPP 1994a). Also, naval spent nuclear fuel examined after 28 years of storage in a water pool exhibited no detectable deterioration. Although spent nuclear fuel is highly radioactive, it is not regarded as "waste"; it requires special handling procedures, shielding, and other measures to isolate it from people and the environment.

The integrity of naval nuclear fuel is due in part to a long-standing program of examination of spent fuel after it has been removed from prototype reactor plants and operating ships. These examinations have been conducted at the Idaho National Engineering Laboratory (INEL) since the beginning of the Naval Nuclear Propulsion Program. Construction and early operation of the original INEL Expended Core Facility (ECF) occurred between 1957 and 1962. The original building contained a water pool and nine shielded cells connected to the water pool by a transfer tunnel. As examination requirements changed, the ECF underwent several expansion programs.

The first and second expansions, in 1962 and 1963, were prompted by the initiation of irradiated test specimen examinations at ECF. In the 1970's, the third expansion occurred with the addition of new, larger hot cells. The fourth expansion (1979-1987) included the extension of the ECF building and water pools for the addition of the Breeding Nondestructive Assay Facility. This addition was for the receipt and examination of the Light Water Breeder Reactor nuclear fuel following its operation in the former PWR Shippingport Atomic Power Station. The work at ECF has continued at or near capacity, receiving, handling, and examining spent fuel from naval reactor plants.

The examinations of naval spent nuclear fuel at ECF are essential to meeting the goals of the Naval Nuclear Propulsion Program. The primary goals that are supported by the ECF examinations are:

- Continued safety of naval reactors
- The design of new reactors having extended lifetimes
- Improvements in nuclear fuel performance
- Demonstration of satisfactory operation of existing naval reactors by providing confirmation of their proper design and allowing maximum depletion of their fuel
- Validation of design models for new core types.

The goal of the extended lifetime reactor design is to have the reactor core last for the life of the ship. Such a design would eliminate the need to refuel the reactor during its useful lifetime. It would also reduce the cost of fueling the ship, and would increase the time that such a ship would be in active service rather than being refueled.

This EIS assumes that the extended-lifetime goal is partially achieved. Based on current technology, the EIS assumes that each of the three SEAWOLF submarines will need to be refueled once during the period to the year 2035. Based on anticipated developments supported by new data from the examinations of naval spent nuclear fuel at ECF, this EIS also assumes that each of the New Attack Submarine Class will not need to be refueled during the period to 2035.

If the examinations of naval spent nuclear fuel at ECF are terminated and the goal of a life-of-the-ship core is not achieved, more naval spent nuclear fuel will be created than is expected. The number of shipments of naval spent nuclear fuel during the period from 1995 to 2035 would increase from about 580 to about 630 and the corresponding amount of naval spent nuclear fuel would increase from 65 metric tons of heavy metal (MTHM) to about 70 metric tons of heavy metal.

Similarly, the goals for safety, improved fuel performance, and satisfactory operation of naval reactors will depend on continuing the examinations of naval spent nuclear fuel at ECF.

2.3 REGULATORY FRAMEWORK

The Naval Nuclear Propulsion Program includes activities conducted by both the U.S. Navy and the Department of Energy. Executive Order 12344, enacted as permanent law by Public Law 98-525, and the Atomic Energy Act of 1954 establish the responsibility and authority of the Director of the Naval Nuclear Propulsion Program (who is also the Deputy Assistant Secretary for Naval Reactors within the Department of Energy) for all facilities and activities that comprise the Program. These executive and legislative actions establish that the Director is responsible for all matters pertaining to naval nuclear propulsion, including direction and oversight of environmental, safety, and health matters for all program facilities and activities.

The federal permits, licenses, and other entitlements listed below may need to be obtained to implement the alternative selected. Existing federal permits, licenses, and entitlements will be modified as required. Applicable state and local permits, licenses, and entitlements will be obtained or modified, as necessary.

- National Pollutant Discharge Elimination System (NPDES) Permit as required by the Federal Water Pollution Control Act (FWPCA), 33 U.S.C. § 1251 et seq.

- NPDES General Permit for Stormwater Discharges from Construction Sites as required by the FWPCA, 33 U.S.C. § 1251 et seq.

- Permit to emit hazardous air pollutants (radionuclides) under the Clean Air Act (CAA), 42 U.S.C. § 7401 et seq., as amended by the Clean Air Act Amendments of 1990.

- Department of Energy Certificate of Compliance for Radioactive Materials Packages in accordance with the Atomic Energy Act (AEA), 42 U.S.C. § 2011 et. seq.

2.4 NAVAL SPENT NUCLEAR FUEL

2.4.1 Summary of Naval Spent Nuclear Fuel Operations

For approximately 40 years, naval spent nuclear fuel has been shipped by rail to the Naval Reactors Facility at the INEL, where it is removed from the shielded shipping containers and placed into the water pools at the ECF. All spent fuel received at the ECF is visually examined externally for evidence of any unusual condition such as unexpected corrosion, unexpected wear, or structural defects. After the fuel assembly structural components have been removed, the interior of the assembly is examined for the conditions discussed above. In addition, the assembly is examined for distortions from irradiation, heat, or the fission process which could interfere with the even distribution of primary coolant and consequent heat removal. The inspection also checks for possible flow obstructions due to foreign material or excessive corrosion product buildup. About 10 to 20 percent of the spent naval reactor cores are given more detailed examinations for such purposes as confirming the adequacy of new design features, exploring materials performance concerns, and obtaining detailed information to confirm or adjust computer predictions of neutron physics, heat transfer, or hydraulic flow and distortion. These detailed examinations may include metallography to determine corrosion film thicknesses, dimensional measurements to determine fuel assembly distortion, and radiochemical analysis to determine core depletions, as well as other inspections. As discussed below, the examination program is essential in supporting the Navy's continued safe operation of naval reactors and design of new, improved fuel having a longer lifetime.

Examination of all spent naval fuel is essential to the mission of the Navy for three reasons: to provide data on current reactor performance, to validate models used to predict future performance, and to support research to improve reactor design.

Naval fuel examinations provide real data on reactor cores installed in ships currently operating in the fleet. This information is essential to validate calculational models and analyses. Through the years, the Naval Nuclear Propulsion Program has built a substantial technical database from examinations of earlier reactor core types. The Program predicts the performance of current core types with calculational models supported by this database. Essentially no information exists yet on core types that will form the backbone of the nuclear fleet for the foreseeable future (Trident class submarines, LOS ANGELES class submarines, and NIMITZ class aircraft carriers). Data from these reactor core types are necessary to validate basic assumptions of current models, provide a measure of variability which exists between individual cores and within a single core, and identify any unanticipated effects of operation that have not been evaluated or accounted for in current models.

Confidence in the validity of engineering models is essential for assurance that ship operations can continue without restriction. Since reactors operating in the fleet are not taxed to the limits of their design during peacetime operations, the Program requires a technically sound basis for continuing to conclude that we have a robust design. Prototype reactors cannot by themselves provide this information, as their operation is not identical to that of a warship. The fact that a core operated satisfactorily with no indication of a problem during a normal shipboard lifetime does not guarantee that the core would have been acceptable under the worst case conditions for which it was designed. The examination of spent nuclear fuel from each core provides the assurance needed that there are no unexpected technical issues not evaluated and addressed in the models that would affect continued unrestricted operation.

Data from examinations also contribute significantly to improvements in reactor design. Improvements in calculational models and analyses have enabled the Program to increase both the lifetime and the performance of reactor cores. For example, the reactor cores installed in the USS NAUTILUS in the 1950's operated for 2 years. Current reactor cores are designed to last over 20 years, a significant technical accomplishment unique to naval fuel. The Navy is seeking to develop a life-of-the-ship (30-year) core for the New Attack Submarine which is still in the design stages. This core will further reduce the amount of spent fuel generated in the long-term, as ships will not require refueling during their lifetime. Continuing data from current core types are essential if this effort is to succeed.

In the final analysis, examination of naval spent nuclear fuel absorbs considerable resources. In a time of extremely tight budgets, the Navy would not be performing such examinations unless they were judged to be necessary to support the conduct of technical work. Examinations done over the last 37 years have played a key role in achieving over 4500 reactor-years of safe nuclear reactor operations, having nuclear-powered warships steam over 100,000,000 miles, and increasing core lifetimes from 2 years to over 20 years. The record shows there is no reason for reducing the technical basis upon which safe naval reactor design and operation are founded, and that basis includes, as a key cornerstone, the examination of naval spent nuclear fuel.

A limited quantity of naval fuel is retained following examination for reference and further study. After examination, most spent fuel is loaded into shielded containers and transferred to the DOE's Idaho Chemical Processing Plant (ICPP) at the INEL for storage. The transportation of naval spent nuclear fuel from shipyards and prototypes is described in Attachment A. The receipt and handling at ECF of the spent fuel from naval reactors is described in Attachment B.

The Naval Nuclear Propulsion Program evaluates small samples of both fuel and non-fuel materials for possible use in naval reactor systems. The samples are irradiated at the INEL Test Reactor Area and then examined at ECF. A typical sample undergoes several cycles of irradiation and examination over several months or years.

The basic process for managing naval spent nuclear fuel starts with the spent fuel from the reactor plant loaded in a container. There are many stringent control steps in the actual process that are necessary to ensure the safety and health of the workers, the public, and the environment. These controls have been established by the conservative philosophy of the Naval Nuclear Propulsion Program and, as a minimum, meet the applicable regulations of federal and state agencies. Those controls will also apply to any and all of the alternatives that are being considered for the management of naval spent nuclear fuel.

Historically, the main steps that have been used for many years for managing spent fuel consist of the following:

Step 1. The process starts with spent fuel that has been removed from the reactor and loaded in a shielded shipping container at a prototype site or shipyard authorized to perform naval reactor refuelings or defuelings.

Step 2. The loaded shipping container is transported by rail to the ECF at the INEL.

Step 3. The spent fuel is received at ECF.

Step 4. The spent fuel is separated from structural material and examined in the ECF water pool.

Step 5. The spent fuel is transferred, in a shielded container, to the ICPP.

At the ICPP, naval spent nuclear fuel is stored in water pools to shield workers from radiation. Naval nuclear fuel is designed to operate for decades in high-temperature water without substantial corrosion. This means that it can be stored in the cool water in storage pools with very, very little corrosion for centuries because the rate of corrosion, which is very slow at the temperatures inside naval reactors, decreases rapidly as the temperature of the water around the fuel decreases. Experience at the Expended Core Facility and the Idaho Chemical Processing Plant has shown that naval spent nuclear fuel has not degraded during many years in water pools.

2.4.2 Facilities Related to Naval Spent Nuclear Fuel

The shipyards that perform the refueling and defueling operations are also responsible for shipping the naval spent nuclear fuel to the facility where structural material is removed and examinations are conducted. Since 1957, these operations have been conducted at the ECF at INEL. After the specified operations and examinations are complete, ECF is responsible for transferring the spent fuel to ICPP, the storage location.

The operations at the shipyards for removing the spent fuel from the ship require the use of special, heavily shielded equipment to remove the spent fuel from the reactor to the shipping container (which is also heavily shielded) while protecting the workers from the radiation from the spent fuel. The shipping containers are designed and tested to transport the spent fuel by rail while protecting the workers and any nearby persons from the radiation of the spent fuel. At ECF, the spent fuel is unloaded from the shipping containers with special, heavily shielded transfer casks to protect the workers from radiation. The spent fuel is removed from the transfer cask in the water pool where the depth of the water is sufficient to shield the workers from the radiation of the exposed spent fuel modules. The subsequent machining operations and examinations of the spent fuel are performed in the water pool under the required depth of water, or in a heavily shielded cell where certain operations and examinations can be performed safely. After the work on the spent fuel is completed, the spent fuel is loaded into a shielded transfer cask (under water) for transit to the storage location, such as the ICPP. These are the main pieces of special equipment and facilities that are required to perform the necessary operations with naval spent nuclear fuel. There are many other pieces of equipment and apparatus that are also used along with the main equipment to do the necessary work safely and efficiently.

2.5 PLANNED REDUCTIONS IN THE NUMBER OF NUCLEAR-POWERED NAVAL VESSELS

Following the successful operation of the USS NAUTILUS in 1954, the number of nuclear-powered submarines and surface ships in the U.S. Navy grew steadily until it reached a peak of just over 150 ships in 1987. Report NT-94-2 provides a graph of the total number of nuclear-powered vessels in the U.S. Navy over the years since the beginning of the Naval Nuclear Propulsion Program (NNPP 1994b). Since 1988, the number of nuclear-powered vessels in the U.S. Navy has decreased. The Navy has been able to accomplish its mission with fewer ships, partly because the ships and crews became more capable over the years and partly because the development of longer-lived nuclear reactor cores makes it possible for nuclear-powered ships to spend more time on duty and less time in shipyards being refueled. A major factor in the reduction in the number of nuclear-powered vessels is that, since the end of the Cold War, the Navy has embarked on a program to reduce the number of warships in its fleet. With the Navy downsizing from a fleet of almost 600 warships to a fleet of just over 300, the number of nuclear-powered warships is also diminishing. The actual size of the nuclear-powered fleet by the year 2000 is expected to be between 80 and 90 vessels having between 95 and 110 reactors (since surface ships have two or more reactors).

Figure 2-1 shows the peak number of nuclear-powered naval vessels in 1987 and the number of nuclear-powered ships in the fleet for each of the next 10 years under current planning. This planned reduction reflects the most recent changes in the mission of the U.S. Navy, including the effects of the end of the Cold War. Under this plan, the number of nuclear-powered naval vessels will be reduced by the end of the next 10 years to approximately one-half the number at its peak. The Navy is moving ahead with this plan, but it should be remembered that such plans may change in the future if Congress alters the Navy's mission in the light of world developments.

This plan for reducing the number of nuclear-powered naval vessels was used in the development of environmental impacts in this Environmental Impact Statement (EIS). For example, the planned reduction in the number of ships in future years is incorporated into all of the impacts associated with examination or storage of naval spent nuclear fuel reported in this EIS. Similarly, the timing and number of naval spent nuclear fuel shipments used in the calculation of impacts associated with transportation are based on this plan.

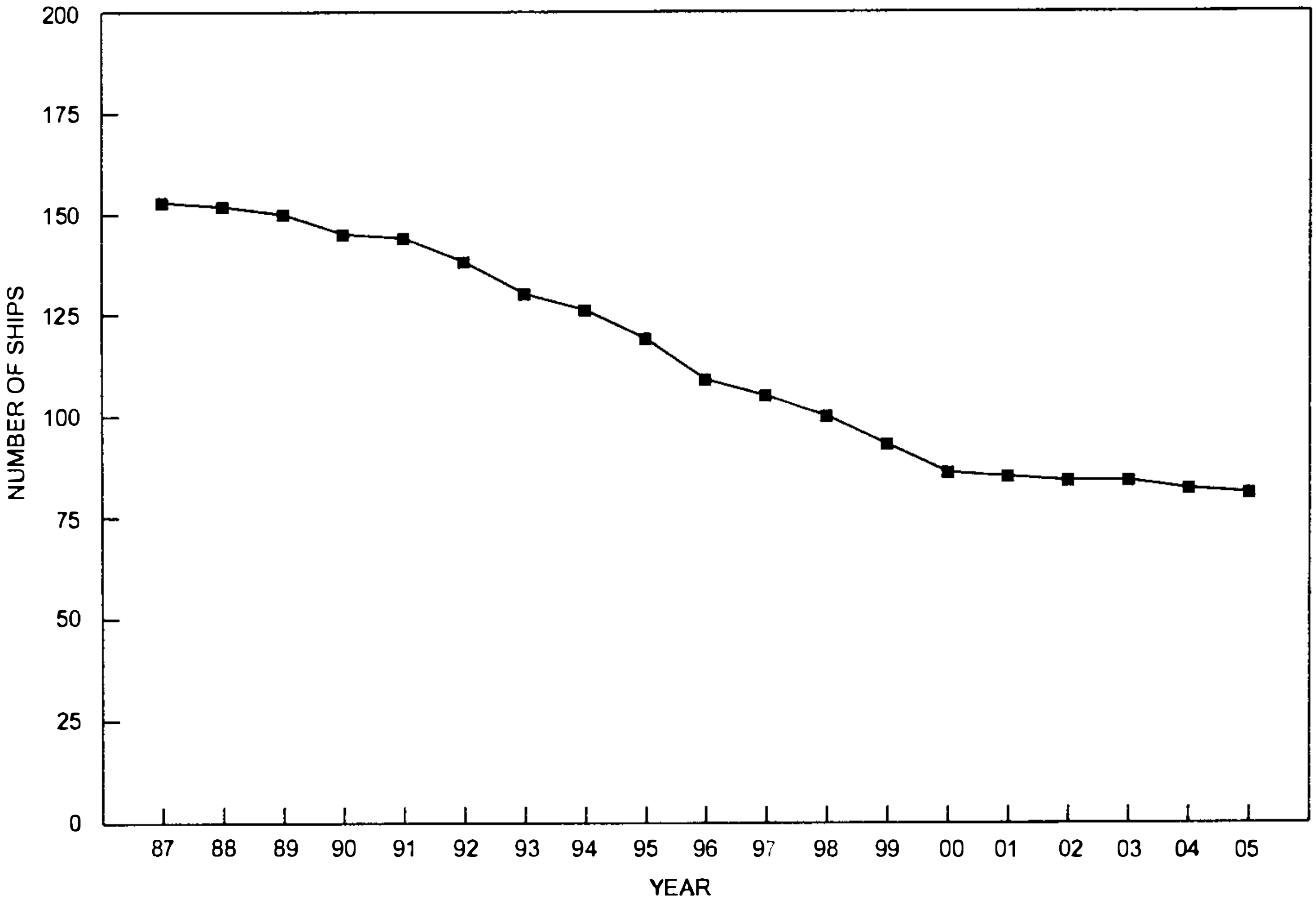


Figure 2-1. Total number of nuclear-powered ships in the United States Navy.

2.6 REFERENCES

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3. ALTERNATIVES

This section describes the alternatives which were evaluated for the management of naval spent nuclear fuel removed during reactor refuelings and defuelings at naval and commercial shipyards and at the prototype sites. Since Chapter 3 of Volume 1 provides a complete description of the Department of Energy's alternatives for all types of spent nuclear fuel under its cognizance, the descriptions in this section are limited to aspects of the alternatives related to naval spent nuclear fuel.

1. No Action: Spent fuel from naval reactors at naval shipyards and prototype sites would be stored in shielded containers at facilities close to the refueling and defueling sites. There would be no spent fuel examinations.

2. Decentralization: There are three different variations to this alternative. The first is similar to the No Action alternative except that additional spent fuel storage options would be pursued. In the second variation, a limited amount of spent fuel would be examined in detail at Puget Sound Naval Shipyard to provide information on nuclear fuel performance. This limited amount of fuel would be stored at the examination site and the remainder would be stored at or near the refueling and defueling sites. In the third variation, all spent fuel would be shipped to the Idaho National Engineering Laboratory (INEL) Expended Core Facility (ECF) and examined as it has been in the past, then returned for storage to facilities at or near the refueling and defueling sites; all planned ECF improvements, including the dry cell expansion (Attachment B), would be completed.

3. 1992/1993 Planning Basis: Spent fuel would continue to be received, examined, and stored at INEL as it has been in past years. All planned ECF improvements, including the dry cell expansion (Attachment B), would be completed.

4. Regionalization: Current and future naval spent nuclear fuel would be received, examined, and stored at the Hanford Site, INEL, the Savannah River Site, the Nevada Test Site, or the Oak Ridge Reservation. If INEL were the site selected for Regionalization of naval spent nuclear fuel, then this alternative would be essentially the same as the 1992/1993 Planning Basis alternative.

5. Centralization: Current and future spent fuel would be collected and stored at one Department of Energy (DOE) site. Examination and storage facilities would be constructed, as necessary. All examinations would be performed at that one site. There would be no difference between the Regionalization and the Centralization alternatives for naval spent nuclear fuel.

This section also describes other alternatives which were considered and then eliminated from detailed analysis.

3.1 NO ACTION

This alternative is restricted to the minimum actions deemed necessary for continued safe and secure handling and storage of naval spent nuclear fuel. It is important to note that this alternative is not a status quo condition. Naval reactors would be refueled and defueled as planned. Naval spent nuclear fuel would be stored in shipping containers at a Navy or DOE facility. These shipping containers would be modified and recertified as discussed in Section D.1.2.1 of Attachment D. No further naval spent nuclear fuel examination would be conducted and research and development activities associated with examination of the spent fuel would not be performed. The Expended Core Facility at INEL would be shut down.

Under this alternative, the transportation of naval spent nuclear fuel to INEL would be ended after about 3 years, during which additional shipping containers would be purchased and actions to prepare naval sites to serve as storage locations would be completed (see Section 3.8). The spent fuel from naval reactors at naval shipyards or active prototype sites would be stored at a naval shipyard or prototype, in most instances where it was removed from the reactor during servicing. The spent fuel would be removed from the reactors and placed directly into shipping containers for storage without detailed examination. Newport News Shipbuilding, a private shipyard located in Newport News, Virginia, does refueling and defueling work for the Navy. Spent fuel removed from ships refueled or defueled at Newport News Shipbuilding would be transported to the nearest naval site, Norfolk Naval Shipyard, in Portsmouth, Virginia. Norfolk Naval Shipyard is about 10 miles (about 250 miles by rail) from Newport News Shipbuilding. The spent fuel would be stored in such a way that it would be protected from damage or intruders and that workers, the public, and the environment would be protected. The fuel would remain in storage until the DOE is prepared to take receipt of the fuel.

Since no additional spent fuel examinations would be performed at ECF, the work associated with examination of test specimens irradiated in the Advanced Test Reactor at INEL would be transferred to another site at INEL. The selected site might require modifications to accommodate this work.

If this alternative and its minimum actions were selected, it would be necessary to construct and certify approximately 500 additional shipping containers and to construct the associated rail spur tracks for the naval sites to be able to store the spent fuel from all of the nuclear-powered ships that will be refueled or defueled until the time that a permanent disposal facility becomes operational. During the period of time when containers would not yet be available, naval spent nuclear fuel would be transported in shipping containers to the Expended Core Facility at INEL. These containers would be unloaded and used to support additional refuelings and defuelings.

A major result of this and any other alternative which precludes detailed examination of naval spent nuclear fuel is that the furtber development of improved nuclear fuel for U.S. Navy ships would be hindered. Examination of spent fuel provides useful information on the performance of existing fuel system designs. Without a continuing flow of such information, eventually confidence in the ability of naval nuclear fuel to perform satisfactorily under design conditions would decrease. This information is also important in developing improvements in future fuel designs.

In this context, an alternative which would leave the spent nuclear fuel onboard nuclear-powered warships was considered. Under such an alternative, refueling and defueling operations would cease and the nuclear-powered warships would be retired in place at piers at Navy facilities. As discussed in Section 3.6.3 of this Appendix, it was determined that this approach to a "no action" alternative would actually involve many actions, including a large expansion of pier space, with the resultant ecological impacts, an increased number of naval personnel assigned to monitoring the retired nuclear-powered ships, a large reduction in work force at several shipyards, and a reduction in the number of operating nuclear-powered warships beyond that planned. Consequently, it was concluded that this could not be considered a "no action" alternative and a more appropriate, and feasible, approach for the No Action alternative was used as a basis for this Environmental Impact Statement.

Attachment D contains a more detailed description of storing naval spent nuclear fuel at or close to its removal location.

3.2 DECENTRALIZATION

Under this alternative, DOE would maintain existing naval spent nuclear fuel in storage at INEL, and new naval spent nuclear fuel would be stored at or near the sites where it was removed from reactors. Three different variations of this Decentralization alternative have been considered. In general, these variations are similar to the No Action alternative with regard to their location and method for long-term storage of spent nuclear fuel. At each storage location under all three options, storage in shipping containers, dry storage casks, and wet storage in water pools has been considered. All of them would require a transition period while facilities are developed (see Section 3.8).

3.2.1 Store Naval Spent Nuclear Fuel at or Close to Locations Where Removed Without Examination

Similar to the No Action alternative, this alternative would include storage of the spent fuel from reactors at naval shipyards or active prototype sites close to the locations where it was removed during refueling or defueling. The spent fuel would be placed directly into storage without detailed examination. Storage would be in water pools, dry casks, or shipping containers. The spent fuel would be protected from damage or intruders, and workers, the public, and the environment would be protected. The fuel would remain in storage until a permanent disposal site became available.

No further naval spent nuclear fuel examination would be conducted. Without this examination program, further development of improved nuclear fuel for U.S. Navy ships would be hindered. Naval spent nuclear fuel examination provides useful information on the performance of existing fuel system designs. A continuing flow of such information is needed to prevent confidence in the ability of naval nuclear fuel to perform satisfactorily under design conditions from decreasing over time. Information from examination of naval spent nuclear fuel is also important in developing improvements in future designs. In addition, the work associated with examination of irradiated test specimens, which is also essential to the development of advanced designs, would no longer be performed at the Expended Core Facility at INEL and would have to be relocated to other facilities at INEL. The Expended Core Facility at INEL would be shut down.

The environmental effects associated with this alternative would be determined primarily by the choice among water pool, dry storage casks, or shipping container storage. The shipping containers could be mobile storage casks, which could also be used for shipping. Like the other options under this alternative, a transition period would be required during which it would be necessary to design, construct, and certify enough shipping containers or dry storage casks to store the spent fuel from all nuclear-powered ships being refueled or defueled or to design, construct, and certify water pools for fuel storage at naval sites. During this transition period, naval spent nuclear fuel would continue to be shipped to the Expended Core Facility at INEL where the shipping containers would be unloaded and used to support additional refuelings and defuelings.

Attachment D contains a more detailed description of storing naval spent nuclear fuel at or close to its removal location.

3.2.2 Examine a Limited Amount of Naval Spent Nuclear Fuel in the Puget Sound Naval Shipyard Water Pit Facility and Store All Naval Spent Nuclear Fuel at Navy Facilities

Under this alternative, the existing water pool facility at Puget Sound Naval Shipyard, originally built to support the refueling of nuclear-powered aircraft carriers, would be modified to conduct the maximum amount of naval spent nuclear fuel examinations practical at that site. The difference between this alternative and the one described in the preceding section is that only a small amount of spent nuclear fuel could be examined to provide information on nuclear fuel performance for use in the development of improved nuclear fuel.

The only existing facility available within the Naval Nuclear Propulsion Program, other than the facility at ECF, which could be used to examine spent fuel from naval reactors is the water pool at the Puget Sound Naval Shipyard at Bremerton, Washington. However, the use of this facility for visual and dimensional examinations of high-priority spent fuel assemblies would require removal of the presently installed aircraft-carrier refueling equipment. As a result, Puget Sound would no longer have the capability to refuel nuclear-powered aircraft carriers. This facility has no shielded cells for performing destructive examinations of spent fuel. Although this alternative would provide a limited capability for examination and analysis of spent fuel, the ability to sustain further development of the advanced nuclear reactors needed to ensure the safety and performance superiority of U.S. Navy ships would be jeopardized. Continuous performance of naval spent nuclear fuel examinations at Puget

Sound Naval Shipyard would preclude the performance of aircraft-carrier refuelings at Puget Sound because the needed water pit would no longer be available.

The limited amount of spent fuel examined in the modified facility and all naval spent fuel removed from reactors at Puget Sound Naval Shipyard would be stored at that shipyard. The naval spent fuel removed at other naval shipyards or active prototype sites would be stored at a site close to the location where it was removed during refueling or defueling. The limited amount of fuel to be examined would be transported from the originating site to Puget Sound Naval Shipyard in the shipping containers currently used for naval spent nuclear fuel.

Like the other options under this alternative, a transition period would be required for development of facilities utilizing shipping containers, dry storage casks, or water pools for fuel storage at naval sites. During this transition period, naval spent nuclear fuel and test specimens would continue to be shipped to the Expended Core Facility at INEL where the shipping containers would be unloaded and used to support additional refuelings and defuelings.

Under this option, the Expended Core Facility at INEL would be shut down after the end of the transition period. The examination of irradiated test specimens would be performed as discussed under the No Action alternative (Section 3.1).

Attachment D contains a more detailed description of the examination and storage of naval spent nuclear fuel for this alternative. The transportation of fuel to be inspected at Puget Sound Naval Shipyard is described in Attachment A.

3.2.3 Examine All Naval Spent Nuclear Fuel at the INEL and Return to Naval Facilities for Storage

Under this option, all naval spent nuclear fuel would be shipped to the Expended Core Facility at the INEL for examination. After examination, this fuel would be returned to a naval or DOE facility for long-term storage near the location where the fuel was removed from a reactor. The examination of spent fuel under this alternative would be performed at the INEL Expended Core Facility as has been done in past years. As with other options under this alternative, the naval spent nuclear fuel would be stored in shipping containers, dry storage casks, or water pools. All planned improvements to the Expended Core Facility, including the dry cell expansion, would be completed.

The receipt, examination, and preparation for storage for this alternative would be the same as described in more detail in Attachment B, and the storage would be the same as that described in Attachment D for shipyard and prototype storage. Transportation of the spent fuel would be accomplished in the same manner as described in Attachment A.

3.3 1992/1993 PLANNING BASIS

The practice of transporting spent nuclear fuel removed from naval reactors to the Expended Core Facility in Idaho for examination would be resumed. Following examination, the spent nuclear fuel would be transferred to DOE for management at the Idaho Chemical Processing Plant pending final disposition. All planned improvements in fuel examination capability for naval spent nuclear fuel at INEL, including the ECF dry cell expansion, would be completed. Operation of an ECF Dry Cell Facility is included in the supporting analysis and the assumptions of this Environmental Impact Statement.

The shipment of naval spent nuclear fuel from shipyards and prototypes to INEL is described in Attachment A, and receipt and handling at INEL of the spent fuel from naval reactors and active prototypes is described in Attachment B. Attachment B also includes a description of the ECF Dry Cell Facility.

3.4 REGIONALIZATION

Two options have been considered under this alternative. Under the first Regionalization option considered, DOE would manage all spent nuclear fuel at the Hanford, INEL, and Savannah River sites, allocating each type of spent nuclear fuel to one of these sites according to its characteristics, such as the type of cladding. Under the second option, spent nuclear fuel under DOE cognizance would be managed at one DOE site in the eastern portion of the United States and one DOE site in the western part of the United States, with all spent nuclear fuel assigned to one of these two sites on the basis of its point of origin. The eastern site would be either the Savannah River Site or the Oak Ridge Reservation, and the western site would be the Hanford Site, INEL, or the Nevada

Test Site. The Expended Core Facility at INEL would be shut down in all cases where INEL would not be used for naval spent nuclear fuel examination and storage.

3.4.1 Regionalization Using Storage at Three Sites (Hanford, INEL, and Savannah River)

This option under the Regionalization alternative would result in all naval spent nuclear fuel being managed at the INEL in the same manner as the 1992/1993 Planning Basis alternative because all naval nuclear fuel has similar characteristics and would be managed at a single site. Under DOE plans, all Zircaloy-clad fuel would be managed at the INEL and since naval fuel is Zircaloy-clad, it would be assigned to INEL. The practice of transporting spent nuclear fuel removed from naval reactors to the Expended Core Facility in Idaho for examination would be resumed. Following examination, the fuel would be transferred to DOE for management at the Idaho Chemical Processing Plant pending final disposition. All planned improvements in fuel examination capability for naval spent nuclear fuel at INEL would be completed.

3.4.2 Regionalization Using Storage at Only Two Sites

Under this option, DOE would collect all spent nuclear fuel at one existing large DOE site in the eastern United States (either the Oak Ridge Reservation or the Savannah River Site) and at one existing large DOE site in the western part of the country (either the Hanford Site, INEL, or the Nevada Test Site). Spent nuclear fuel would be collected at one or the other of these two sites, based on its original location. Only one of the two locations would be used for examination and storage of naval spent nuclear fuel under this option, but the impacts of managing naval spent nuclear fuel at all of the possible sites have been evaluated because the site for naval spent nuclear fuel has not been chosen.

A new naval spent nuclear fuel examination facility would have to be constructed at the site selected if it were other than INEL, and the Expended Core Facility at INEL would be shut down. The new facility would have capabilities equivalent to those of the existing Expended Core Facility at INEL and would support all examinations and experimental work required for the development of naval reactors. The new examination facility would be operated by the Naval Nuclear Propulsion Program.

Naval spent nuclear fuel would be removed from naval reactors and transported by rail to the new examination facility, as described in Attachment A. The fuel would be unloaded and examined in the water pools and shielded cells constructed for this purpose, in a manner similar to that described in Attachment B. After completion of all examination work, the naval spent nuclear fuel would be transferred to storage facilities operated by the DOE at the same site. None of the DOE sites considered in this alternative, other than INEL, currently has facilities adequate to store the amount of spent nuclear fuel involved in this option. Therefore, the DOE would have to construct new storage facilities suitable for spent nuclear fuel, including naval spent nuclear fuel, if this option were selected.

It should be understood that the Navy would operate only one facility for examination of all naval spent nuclear fuel, and all naval spent nuclear fuel examined during the period covered by this Environmental Impact Statement would be stored at the same DOE site where the examinations would be performed. Therefore, there are no differences for management of naval spent nuclear fuel between the Regionalization alternative and the Centralization alternative (described in the next section) for the same site.

3.5 CENTRALIZATION

As implied by its name, this alternative would collect all current and future DOE spent nuclear fuel at one DOE site. The sites analyzed include the Hanford Site, INEL, the Savannah River Site, the Oak Ridge Reservation (ORR), and the Nevada Test Site (NTS). As in the Regionalization alternative, the Navy would operate a facility for examination of naval spent nuclear fuel at only one DOE site, and all naval spent nuclear fuel examined during the period evaluated would be stored at the DOE site where it was examined, so there are no differences between the Regionalization alternative and the Centralization alternative for management of naval spent nuclear fuel.

If INEL were chosen as the DOE site for centralized long-term storage of naval spent nuclear fuel, the Expended Core Facility would continue to operate. After examination at the Expended Core Facility, naval spent nuclear fuel would be transferred to the Idaho Chemical Processing Plant. There would be no need to modify the Expended Core Facility since it is a safe, modern facility providing all the capabilities needed for naval spent nuclear fuel examinations. However, any planned facility changes to provide improved or additional fuel handling and examination capability, such as the ECF Dry Cell Facility, would be completed.

If a DOE site other than INEL were chosen for the centralized long-term spent nuclear fuel storage facility, then the Expended Core Facility at INEL would be closed. A new naval spent nuclear fuel examination facility would need to be constructed at the selected site, or an existing facility would have to be modified to perform the needed examinations of naval spent nuclear fuel. This facility would provide capabilities equivalent to those of the existing Expended Core Facility at INEL. Similarly, additional spent nuclear fuel storage facilities would have to be constructed at the selected site since there are insufficient facilities at other sites suitable for storage of spent nuclear fuel from INEL.

Adjacent to the Savannah River Site is the site of the Barnwell Nuclear Fuel Plant. This privately owned facility is not being used currently. It could be purchased at an undetermined price, annexed to the Savannah River Site, and subsequently modified to provide capabilities equivalent to those at the Expended Core Facility. Similarly, at Hanford there exists the Fuels and Materials Examination Facility (FMEF) that could be modified to provide capabilities equivalent to those at the Expended Core Facility. It is expected that the modifications to either of these two facilities would cost less than the construction of a new Expended Core Facility.

Shipments of naval spent nuclear fuel to the Expended Core Facility in Idaho would resume during the first 3 years of the time required to construct a new naval spent nuclear fuel examination facility at the selected location (see Section 3.8). All naval spent nuclear fuel would be transferred to the central site after the new facilities were placed into operation.

The receipt, handling, and storage of naval spent nuclear fuel for this alternative are described in Attachments B and E, and transportation of the spent fuel is described in Attachment A.

3.6 ALTERNATIVES ELIMINATED FROM DETAILED ANALYSIS

Several other alternatives were considered in addition to those described above. However, these other alternatives were not analyzed to the same depth as those described above. These alternatives and the reasons for not analyzing them in detail are discussed in this section.

3.6.1 Use Other Combinations of Sites for Examination and Storage of Naval Spent Nuclear Fuel

Some variations of alternatives can be conceived in which spent fuel would be shipped from the site at which it was removed from a reactor to some other facility for examination or preparation for storage and subsequently shipped to another facility for storage. Evaluating all such combinations for examination, treatment, and storage as separate alternatives would be complicated because of the large number of alternatives which could result. Furthermore, detailed treatment of such a large number of alternatives would complicate the evaluation of environmental effects.

However, it is not necessary to consider each of these combinations individually because the processes involved and the possible environmental effects generally can be represented by combinations of the effects of alternatives already discussed. For example, the impacts of examining spent fuel at a DOE site other than INEL followed by shipment back to a shipyard for storage would be essentially the same as those for examination of fuel under the alternative of examination and storage of the fuel at the alternate DOE site, described in Section 3.5, except for transportation. Continuing the example, the effects of storing the naval spent nuclear fuel at a shipyard as part of such an alternative would be the same as those for storing spent fuel at the shipyard without inspection, described in Section 3.2.1. The effects of shipping the fuel back and forth between the DOE site and a shipyard for such an approach would be approximately double the effects of shipment to the DOE site for inspection and storage because the same sites are involved but a second trip would be required to return the fuel from the inspection site to the storage site.

In a similar fashion, the effects of other possible combinations of inspection and storage sites can be deduced from combinations of the alternatives discussed in earlier sections. In order to avoid complication and confusion, these alternative combinations were not explicitly analyzed in this statement.

3.6.2 Examine or Store Spent Nuclear Fuel from Naval Reactors in Foreign Facilities

It would be physically possible to examine and store spent nuclear fuel from naval reactors in foreign countries. The naval spent nuclear fuel could be shipped safely to a foreign country and safe storage could be established. However, the characteristics of naval fuel are classified pursuant to the requirements of the Atomic Energy Act of 1954, as amended. Such characteristics include the fuel's geometry, what requirements govern its design, how it is manufactured, and how it operates in a naval reactor. These characteristics can be deduced from physical nondestructive examination of the fuel and from more intrusive means of inspection.

Information classified under the Atomic Energy Act may not be provided to foreign governments or foreign interests unless the President determines that such access is in the defense interests of the United States, a government-to-government agreement allowing such access is reached, and proper Congressional review is afforded to ensure acceptance by the legislative branch.

Characteristics of long-lived U.S. naval fuel, which constitutes virtually all of the naval spent nuclear fuel evaluated in this Environmental Impact Statement, have never been provided to any foreign country. It has been long-standing U.S. policy not to provide such information and there is no agreement currently in existence with any foreign country providing for such access.

U.S. naval fuel also utilizes highly enriched uranium suitable for use in nuclear weapons. Naval spent nuclear fuel remains highly enriched even after it has completed use in a naval reactor. As such, the Nuclear Non-Proliferation Act, implementing requirements of the Treaty for the Non-Proliferation of Nuclear Weapons, imposes severe restrictions on the transfer of such material to foreign countries. These restrictions are in addition to those arising from the classified nature of the fuel described above.

Foreign nations provide no unique capabilities or advantages for examination or storage of naval spent nuclear fuel. In fact, only four other countries (the United Kingdom, France, Russia, and the Peoples Republic of China) build and operate nuclear-powered warships, and none has naval reactor fuel having the long-lived performance characteristics of U.S. naval reactor fuel. Thus, U.S. capabilities for the examination of such long-lived fuel are unique and special.

There are also technical and environmental reasons why processing of naval spent nuclear fuel in foreign facilities is unreasonable. As is discussed in this Environmental Impact Statement, naval spent nuclear fuel is not expected to require any processing or stabilization - it will likely be suitable for direct emplacement in a geologic repository owing to its inherent structural strength and integrity, made necessary by its military application. Processing naval spent nuclear fuel is more difficult than commercial or DOE fuel for those same reasons, and doing such reprocessing abroad would result in the production of highly enriched uranium in a foreign country, creating concerns over non-proliferation and nuclear material safeguards.

Based on these considerations, the alternative of processing or storing naval spent nuclear fuel in foreign countries is not a reasonable alternative, and thus was eliminated from detailed analysis.

3.6.3 Do Not Remove Naval Spent Nuclear Fuel from Nuclear-powered Ships

Nuclear-powered warships represent about 40 percent of the Navy's major combatants. The size of the Navy fleet is based on ensuring that the Navy has sufficient ships in active service at all times to meet the country's defense commitments, as established by Congress and the President.

It is physically possible to retain spent fuel in the reactors in nuclear-powered vessels and moor the ships at shipyards until a decision on the ultimate disposition of spent nuclear fuel is reached, making those ships for which refueling was planned unavailable for further service. However, this approach would result in these ships being unavailable once their currently installed reactor fuel reaches the end of useful life. This is impractical because the ships would have to be replaced (a process that of necessity takes many years and in most instances requires ships that have not been designed) or the Navy would be forced to operate without the full complement of ships required to execute national policies. Since the entire submarine fleet is nuclear-powered, including the fleet of ballistic missile submarines which comprise the least vulnerable part of the nation's strategic deterrent, and our attack submarines which seek out opposing ballistic submarines as well as play a crucial role in littoral warfare, failure to refuel these units would result in a unilateral decrease in the nation's strategic deterrent.

Also of particular importance in this regard is the commencement of refueling NIMITZ Class aircraft carriers which form the backbone of the Navy's fleet. Of twelve operating carriers, six are NIMITZ Class, with three more under construction to replace older, conventionally powered carriers scheduled for retirement. Refueling of the USS NIMITZ is scheduled to begin in 1998, but refueling preparations are already underway for this first-of-a-kind effort. These preparations entail emptying, by late 1995, spent nuclear fuel from the earlier refueling of the USS ENTERPRISE and defueling of the USS LONG BEACH. This spent nuclear fuel is at Newport News Shipbuilding and Drydock Co. in a special support facility which is required for the NIMITZ Class refuelings. Once the facility is emptied, it would then be reconfigured for use, including refurbishment, maintenance, and extensive training of refueling personnel.

If the facility cannot be emptied, the USS NIMITZ and subsequent NIMITZ Class carriers (USS DWIGHT D. EISENHOWER, USS CARL VINSON, USS THEODORE ROOSEVELT, USS ABRAHAM LINCOLN, and others) which are scheduled for refueling in succession after the USS NIMITZ could not be refueled to rejoin the fleet at the time they would be required for service. In effect, the Navy would have far fewer carriers than would be needed to fulfill national security requirements. These requirements include maintaining continued forward presence in peacetime (which is essential to deter aggression, encourage global stability, and promote interoperability with our allies) and timely crisis response. National security requirements also include ability to field forces sufficient to engage in two simultaneous regional conflicts (such as Operation Desert Storm), as well as operations other than war, such as Somalia and Haiti. The national security need to ensure that the USS NIMITZ is refueled and returned to service in the fleet on schedule was certified by the Secretary of Defense in October 1994 and accepted by the Governor of Idaho in January 1995, when he allowed shipment of naval spent nuclear fuel from the Newport News Shipbuilding and Drydock Co. to continue. Additional shipments would be required after the Record of Decision is issued on this EIS in June 1995 to complete unloading the facility by late 1995.

Additionally, 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 as a result of the use of waterfront space 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. For example, dredging would be required along with disposal of dredge spoils; such activities have been an environmental concern at several Navy facilities.

While this method for storing naval spent nuclear fuel would cause some increase in construction activities, in the long run it would result in the idling of skilled workers as the shipyards ran out of room and work schedules were disrupted by the loss of ship servicing work. Mooring the ships without removing the naval spent nuclear fuel would also utilize highly trained Navy nuclear ship operators in the unproductive task of watching over shutdown ships. The resources dedicated to providing the additional moorings would produce no improvements in a shipyard's ability to perform its mission and would actually decrease its capabilities. The radiological effects on the environment or people in the vicinity would be negligible as long as the nuclear-powered vessels and propulsion plants were maintained under the same procedures and discipline used for operating ships, since the environmental effects of operating U.S. Navy nuclear-powered vessels are well documented and known to be negligible.

Separately, the costs of maintaining the ships with spent nuclear fuel remaining installed under Navy operating procedures and providing the additional piers and waterfront services and utilities would be large. The costs of this approach would be high both for ships which are to be decommissioned and for ships which would normally be refueled and returned to duty. One cost would result from the need to assign qualified nuclear operators to monitor vessels awaiting refueling or defueling. In the case of ships which are being decommissioned at the end of their life, the primary cost of this alternative would be the cost to maintain qualified nuclear operators, shipboard equipment, and associated shipyard support, including security, to ensure nuclear and radiological safety for the workers and the public. This would be more expensive than removal of the spent fuel for storage.

Thus, in summary, this alternative would be costly and would involve extensive actions which would have an effect on the environment due to construction activities. This alternative would also not permit continued service of many Navy ships and only postpone decisions on a satisfactory storage location. As a result of these considerations, this alternative was eliminated from detailed analysis.

3.7 COMPARISON OF ALTERNATIVES

This section provides a comparison of the alternatives as they relate to the activities which fall under the Naval Nuclear Propulsion Program (NNPP). The comparison focuses on those areas which are projected to have the most significant impacts. As discussed in Sections 5.1 through 5.6, the impacts projected for most impact categories are very small or nonexistent. Such impact categories include: land use, cultural resources, aesthetic and scenic resources, geology, water resources, ecological resources, noise, utilities and energy, waste management, and irreversible and irretrievable commitment of resources. Consequently, the impacts in these areas provide no basis for distinguishing among alternatives.

It is important to note that in the No Action alternative and in two of the options of the Decentralization alternative, examination of naval spent nuclear fuel would cease or be seriously reduced and important scientific information would be lost. Beyond this issue, the principal differences among the alternatives occur in the categories of occupational and public health and safety (including normal operations and accidents for facility operations and transportation operations), cumulative impacts, and socioeconomics. Even in these areas, the overall impacts and the differences are small and represent the few unavoidable adverse effects that remain after the years of experience have been factored into the operations and the necessary mitigative measures have been applied.

DOE has adopted two quantitative safety goals to limit the risks of fatalities associated with its nuclear operations. The goals are:

- The risk to an average individual in the vicinity of a DOE nuclear facility for prompt fatalities that might result from accidents should not exceed one-tenth of one percent (0.1%) of the sum of prompt fatalities resulting from other accidents to which members of the population are generally exposed.

- The risk to the population in the area of a DOE nuclear facility for cancer fatalities that might result from operations should not exceed one-tenth of one percent (0.1%) of the sum of all cancer fatality risks resulting from all other causes.

A comparison of the calculated risks associated with each of the Naval Nuclear Propulsion Program alternatives indicates that the implementation of any of these alternatives would be well within the DOE facility safety goals.

3.7.1 Summary of Impacts

The most salient of the environmental impacts are summarized below. These impacts are presented under two categories:

- Human Health Impacts
- Other Impacts.

3.7.1.1 Human Health Impacts. Table 3-1 provides an overall comparison of the alternatives. This comparison is presented in terms of the increase in the number of cancer fatalities that could occur in the general population for any given year after an alternative has been implemented and has achieved a stable level of operation. This increase in the risk of developing fatal cancers is broken down to show how much risk increase is associated with normal operations, the highest risk facility accident, and transportation operations. For example, it is calculated that for the 1992/1993 Planning Basis alternative in which naval spent nuclear fuel would continue to be received, examined, and prepared for storage at the ECF at INEL, there would be:

- an increase of about 0.0000009 cancer fatalities per year for the general population around INEL (i.e., about one additional cancer fatality nationwide in 1,000,000 years among the 116,000 people who live within a 50-mile radius of INEL) due to normal ECF operations.

- an increase of 0.000026 cancer fatalities per year for the general population along the transportation routes due to normal transportation of naval spent nuclear fuel from the shipyards to the ECF.

- an increase of 0.00000017 cancer fatalities per year for the general population due to the facility accident with the highest risk (in this case it would be the accidental draining of a water pool used for examination and storage of naval spent nuclear fuel).

Table 3-1. Risk (fatal cancers to the general population per year) by alternative.

Alternative	Normal Operations Risk: Storage at NNPP Sites	Normal Operations Risk: Examination	Transportation Incident-Free Risk	Most Severe Risk from a Facility Accident	Transportation Accident Risk[3]
1. No Action	2.2×10^{-5}	N/A	4.3×10^{-6}	2.6×10^{-4}	1.1×10^{-7}
2. Decentralization					
● No Exam					
- Dry Storage	2.2×10^{-5}	N/A	4.3×10^{-6}	2.6×10^{-4}	1.1×10^{-7}
- Water Pool Storage	3.4×10^{-4}	N/A	4.3×10^{-6}	1.1×10^{-5}	1.1×10^{-7}
● Limited Exam					
- Dry Storage	2.2×10^{-5}	6.5×10^{-5}	1.1×10^{-5}	2.6×10^{-4}	2.2×10^{-7}
- Water Pool Storage	2.7×10^{-4}	6.5×10^{-5}	1.1×10^{-5}	1.1×10^{-5}	2.2×10^{-7}
● Full Exam					
- Dry Storage	2.2×10^{-5}	8.5×10^{-7}	4.1×10^{-5}	2.6×10^{-4}	1.5×10^{-6}
- Water Pool Storage	3.4×10^{-4}	8.5×10^{-7}	4.1×10^{-5}	1.1×10^{-5}	1.5×10^{-6}
3. 1992/1993 Planning Basis[1]		8.5×10^{-7}	2.6×10^{-5}	1.7×10^{-7}	1.0×10^{-6}
4/5. Regionalization or Centralization[1][2]					
● INEL	-	8.5×10^{-7}	2.6×10^{-5}	1.7×10^{-7}	1.0×10^{-6}
● Hanford	-	4.0×10^{-6}	6.0×10^{-5}	4.7×10^{-7}	1.7×10^{-6}
● S. River	-	1.8×10^{-5}	1.5×10^{-4}	9.6×10^{-6}	1.1×10^{-5}
● NTS	-	9.0×10^{-8}	7.5×10^{-5}	7.2×10^{-8}	7.5×10^{-6}
● ORR	-	5.0×10^{-5}	1.4×10^{-4}	8.4×10^{-6}	3.6×10^{-6}

(1) For alternatives 3, 4, and 5, the risk due to storage of naval spent nuclear fuel is not included in this evaluation. It is included in the evaluation of the individual DOE sites.

(2) Both the Regionalization and Centralization alternatives would locate an ECF at one of the five DOE sites. For this reason, the risk is the same for these alternatives.

(3) Some of the alternatives would involve a limited number of shipments by sea from Pearl Harbor to Puget Sound. Even though the probability of a severe accident involving a shipboard fire and release of radioactivity would be less than 10^{-7} per year, the risk of such an accident has been calculated and is discussed in Attachment F, Section F.1.4.4. The risk of such an accident has been calculated to be 3.5×10^{-6} per year.

- an increase of 0.000001 cancer fatalities per year for the general population due to risks of transportation accidents.

Table 3-1 shows that the cancer risks due to Naval Nuclear Propulsion Program activities for any of the alternatives are small. In all of these cases, thousands of years of repetition of the alternate action would be required before a single additional fatal cancer would occur. Risk is defined as the product of the probability of occurrence of an event leading to radiation exposure and the level of impact of exposure to radiation in terms of the increased number of fatal cancers that would result. A discussion of the key points in the development of an estimate of cancer fatalities is provided below; more detailed discussions of the parameters, analyses, and results are provided in Attachments A and F.

The increased number of fatal cancers is based on the calculated increase in exposure to radiation that would be seen by the general public as a result of each of the alternatives. The average annual exposure to a member of the population in the U.S. from background radiation is approximately 0.3 rem (300 millirem). The average annual collective exposure to all of the population in the U.S. from background radiation is approximately 69 million person-rem. When people are exposed to additional radiation, the number of additional radiation-induced cancer and other health effects needs to be considered. An estimate for radiation-induced cancer can be briefly summarized as follows:

- In a typical group of 10,000 persons who do not work with radioactive material, a total of about 2000 (20 percent) will normally die of cancer.

- If each of the 10,000 persons received an additional 1 rem of radiation exposure (10,000 person-rem) in their lifetime, then an estimated 5 additional cancer deaths (0.05 percent) might occur.

- Therefore, the likelihood of a person contracting fatal cancer during their lifetime could be increased nominally from 20 percent to 20.05 percent by exposure to 1 additional rem of radiation.

The "factor" for such a person to contract a fatal cancer, considering all possible organs, can be expressed as 0.0005 fatal cancers per rem of exposure. This is mathematically equivalent to 5.0 fatal cancers from 10,000 person-rem of collective exposure to a large group of persons.

Further, a collective exposure of 10,000 person-rem would be expected to produce, on the average, approximately 7.3 health detriments due to non-fatal and fatal cancers and severe genetic defects. These are two of the factors for the health detriments that may result from exposure to additional radiation. The results in this section are given in terms of fatal cancers. The total number of health detriments is the ratio 7.3/5.0 or 1.46 times these values.

The number of detrimental health effects which might result from exposure of a large group of people to low levels of radiation has been the subject of debate for many years. The calculations of health effects performed in this Environmental Impact Statement use the relation recommended by the International Commission on Radiological Protection because it is well-documented and kept up-to-date by the council. It also is widely accepted by the scientific community as representing a method which produces estimates of health effects that will not be exceeded. However, there are others who believe that exposure to low levels of radiation produces more health effects than would be estimated using the International Commission on Radiological Protection relation. On the other hand, a growing number of researchers believe that the International Commission on Radiological Protection relation overestimates the number of detrimental health effects produced by low levels of radiation. In fact, the possibility of no risk from the levels of radiation resulting from routine naval spent nuclear fuel management cannot be excluded (CIRRPC 1992). Clearly, using a relation developed by one or the other of these groups would produce a larger or smaller estimate of the number of health effects than the values presented in this statement. All of the results of analyses of normal operations and hypothetical accidents in Appendix D include the calculated exposure in addition to the number of health effects in order to permit independent calculations using any relation between radiation exposure and health effects judged appropriate.

The risks associated with all of the alternatives are low compared to the risks encountered in daily life. The risks of normal operations may be placed in perspective by considering other commonly encountered risks. For example, the average American is exposed to approximately 0.5 millirem each year from the radioactivity released from combustion of fossil fuels (NCRP 1987), which produces a lifetime risk of an average individual dying from cancer of about 1 chance in 50,000. As a further comparison, the naturally occurring radioactive materials in fertilizer used to produce food crops contribute about 1 to 2 millirem per year to an average American's exposure to radiation (NCRP 1987). This results in a risk of death from cancer between 1 chance in 12,500 and 1 chance in 25,000.

A frame of reference for the risks from accidents associated with spent nuclear fuel management alternatives can be developed by comparing them to the risks of death from other accidental causes. For example, the risk of death in a motor vehicle accident is about 1 chance in 80 (NSC 1993). Similarly, the risk of death for the average American from fires is approximately 1 chance in 500 and the risk of death from accidental poisoning is about 1 chance in 1000 (NNPP 1994b).

It must be remembered that no member of the public will receive as much as one one-thousandth of a rem from 40 years of the normal operations associated with any of the alternatives considered. Examining the results shown in the tables of radiation exposures (Attachments A and F) shows that the principal source of the difference in the exposures associated with radiation and radioactive materials released from normal operations and from hypothetical accidents for the alternatives is the number of people who live in the vicinity of the alternative sites and where they live relative to the facility itself. When the emissions from the sources are essentially the same, the resulting impacts depend directly on the size of the surrounding population, on the way the population is distributed around the site in terms of the distances and directions from the particular facility, and on the characteristics of the local meteorology.

3.7.1.2 Other Impacts. The principal impact in the employment portion of the socioeconomics category is the number of jobs created by the construction and operation of a new (or modified) facility. The magnitude of the effect is relatively small in populations of the sizes under consideration, except to those people who benefit either directly or indirectly from the jobs. The creation of the jobs has some negative impacts: the jobs may be created at a distant location, or the jobs created locally may cause some small but adverse effect on the local community in terms of additional people and an increased need for additional public services.

The cost of operating and constructing new facilities or modifying existing ones to achieve the necessary capabilities for handling and storing spent fuel is an important economic impact. Depending on the site affected and the alternative under consideration, the cost may be as much as 5.7 billion dollars for construction and 40 years of operation.

In the unlikely event of a serious accident involving naval spent nuclear fuel, it is estimated that only about 210 acres of land would be affected for the most severe case (this is described in more detail in Attachment F), and in the other accidents analyzed, smaller areas of land would be affected. The affected area would require decontamination, and during this cleanup access controls would have to be established. However, due to the limited land area affected, it is judged that these restrictions would only be temporary and the impact on issues such as economics, treaty rights, tribal resources, ecology, and land use, would be relatively small and limited in time. The remediation actions would be simpler in rural areas than in urban areas; however, provided that prudent controls and remediation operations were promptly implemented, the affected land and buildings could be recovered in either case. As demonstrated in the accident analyses in Attachments A and F and summarized above, the human health effects are not large and the effects on wildlife and other biota would also not be large, partly due to the limited area affected.

Examination of naval spent nuclear fuel and irradiated test specimens has been conducted at the ECF at INEL since 1957. This program has made and continues to make important contributions to the safety, cost, and operational performance of naval nuclear propulsion plants. However, the No Action alternative and two of the Decentralization alternatives would result in substantial curtailment of this program. The Centralization, Regionalization, 1992/1993 Planning Basis, and the Decentralization - Full Examination alternatives would maintain the needed examination capability.

The safety of operating naval reactor plants has benefitted directly from the ECF examination programs. The result has been the construction of rugged reactor cores that are more tolerant of extreme conditions (such as corrosion, high temperatures, and intense radiation) without release of any fission products. The Naval Nuclear Propulsion Program's commitment to improved safety continues to be driven by two major issues:

- Protection of the Environment - In more than 40 years of operating and maintaining reactors in very demanding conditions, the Naval Nuclear Propulsion Program has never experienced a reactor accident, criticality accident, or a release of radioactivity that has had a significant effect on the environment.

- Personnel Safety - The importance of ensuring the integrity of the fuel is emphasized by the fact that the sailors onboard the ships live in very close proximity to an operating reactor 24 hours a day. Any release of radioactivity from the fuel into the reactor coolant would increase the radiation exposure of the ship's crew.

Since the inception of the Naval Nuclear Propulsion Program, the useful lifetime of naval reactors has been extended by more than a factor of 10. The examination programs at ECF played a major role in making this improvement possible. As a result of the extended reactor lifetimes, billions of dollars in ship refueling costs and spent nuclear fuel storage costs have been saved. In addition, longer reactor lifetimes permit the ships to spend a larger fraction of their lifetime on sea duty rather than in the shipyards, thus saving costs by reducing the number of ships required. Further reductions in nuclear propulsion plant costs are being pursued through improvements in many areas of nuclear fuel systems.

The improvements in nuclear fuel performance that have been developed in part through the knowledge gained from the examination program have contributed to improved ship operational characteristics. Major improvements have been made in power density, maneuverability, stealth, and simplicity. These improvements translate into important tactical advantages for our ships. Maintaining this advantage with ever improving technologies elsewhere in the world is vitally important to the safety of our sailors and to protecting our national interests.

In the final analysis, the most important differences are:

- The transfer of jobs associated with the Expended Core Facility among the alternative sites considered for locating the examination facility, or the outright loss of these jobs at INEL.

- The costs if new facilities are required.

- The loss or maintenance of naval spent nuclear fuel examination capability.

Sections 3.7.2, 3.7.3, and 3.7.4 provide additional summary information on the principal areas of impact.

3.7.2 Impacts Due to Normal Operations

During normal operations, there are public impacts due to direct radiation or due to the release of radioactive materials to the environment. These impacts are presented in the form of potential cancer fatalities due to exposure to the small amounts of radiation involved or radioactive materials released. It is important to emphasize that these cancer fatalities are calculated results rather than actual expected fatalities. This is because the expected number of such fatalities during normal operations is so small as to be unmeasurable and indistinguishable relative to the larger number of such deaths expected from naturally occurring conditions and other man-made effects not related to naval spent fuel operations. This is not meant to trivialize the importance of radiation-induced cancer fatalities but, rather, is meant to put the issue in perspective.

Table 3-2 presents a summary comparison of the calculational prediction of the number of fatal cancers per year that might be expected due to normal operations within each of the alternatives under consideration for naval spent nuclear fuel handling. This table provides the calculated impacts to the entire population. The impacts to selected individuals including workers are provided in Attachments A and F. Table 3-2 reflects the two possibilities (water pool and dry storage) for storing naval spent nuclear fuel at the Navy sites. In the case of dry storage at Navy sites, the impact from normal operations is due to calculated levels of direct radiation from storage casks at the shipyards. The environmental releases that were used to calculate the water pool values in the table are based on measured releases from the existing Expended Core Facility at the INEL. Also, the way in which direct radiation or environmental releases impact the population would be a function of the population distribution and the meteorological conditions present at the release location. To account for these differences, actual data on the population and meteorology for the various specific sites were used. The data in Table 3-2 are for a typical year in the future when the situation has stabilized at each location (that is, capabilities consistent with those described for the stated alternative have been achieved and are in operation at a facility at the indicated site).

All alternatives have some estimated number of fatalities, albeit a very small fraction. The lowest estimated number of cancer fatalities is associated with the 1992/1993 Planning Basis, Regionalization at INEL, and Centralization - INEL alternatives. The largest single estimate for the total number of cancer fatalities is only 0.00038 per year for the Decentralization - Full Examination alternative. Another way to view this is that if this alternative is selected and operations continue for

Table 3-2. Fatal cancers per year to the general population from normal operations.

Alternative	INEL	Puget Sound	Pearl Harbor	Portsmouth	Norfolk	Kesselring	Transportation	Total
1. No Action	-	1.2×10^{-6}	9.3×10^{-9}	2.3×10^{-7}	2.1×10^{-5}	4.1×10^{-12}	4.3×10^{-6}	2.7×10^{-5}
2. Decentralization								
• No Exam								
- Dry Storage	-	1.2×10^{-6}	9.3×10^{-9}	2.3×10^{-7}	2.1×10^{-5}	4.1×10^{-12}	4.3×10^{-6}	2.7×10^{-5}
- Water Pool Storage	-	6.5×10^{-5}	7.0×10^{-5}	2.3×10^{-5}	1.4×10^{-4}	4.1×10^{-5}	4.3×10^{-6}	3.4×10^{-4}
• Limited Exam								
- Dry Storage	-	6.6×10^{-5}	9.3×10^{-9}	2.3×10^{-7}	2.1×10^{-5}	4.1×10^{-12}	1.1×10^{-5}	9.8×10^{-5}
- Water Pool Storage	-	6.5×10^{-5}	7.0×10^{-5}	2.3×10^{-5}	1.4×10^{-4}	4.1×10^{-5}	1.1×10^{-5}	3.5×10^{-4}
• Full Exam								
- Dry Storage	8.5×10^{-7}	1.2×10^{-6}	9.3×10^{-9}	2.3×10^{-7}	2.1×10^{-5}	4.1×10^{-12}	4.1×10^{-5}	6.4×10^{-5}
- Water Pool Storage	8.5×10^{-7}	6.5×10^{-5}	7.0×10^{-5}	2.3×10^{-5}	1.4×10^{-4}	4.1×10^{-5}	4.1×10^{-5}	3.8×10^{-4}

Alternative	INEL	Hanford	Savannah River	NTS	ORR	Transportation	Total
3. 1992/1993 Planning Basis	8.5×10^{-7}	-	-	-	-	2.6×10^{-5}	2.7×10^{-5}
4/5. Regionalization or Centralization							
• INEL	8.5×10^{-7}	-	-	-	-	2.6×10^{-5}	2.7×10^{-5}
• Hanford	-	4.0×10^{-6}	-	-	-	6.0×10^{-5}	6.4×10^{-5}
• S. River	-	-	1.8×10^{-5}	-	-	1.5×10^{-4}	1.7×10^{-4}
• NTS	-	-	-	9.0×10^{-8}	-	7.5×10^{-5}	7.5×10^{-5}
• ORR	-	-	-	-	5.0×10^{-5}	1.4×10^{-4}	1.9×10^{-4}

10,000 years, between three and four extra cancer fatalities might be expected in that entire time period due to normal operations.

3.7.3 Impacts Due to the Most Severe Accidents

Accidents may occur during operation of naval spent nuclear fuel handling and storage facilities and during transportation of naval spent nuclear fuel. Specific accidents considered to be more severe than all other reasonably foreseeable accidents were analyzed to determine their potential impacts on the general population. For sites with spent fuel storage in water pools, the facility accident analyzed was a drained water pool or an accidental criticality since these produced the greatest consequences. For sites with dry spent fuel storage, the facility accident analyzed was an airplane crash if its probability was greater than 1×10^{-7} per year (1 chance in 10 million per year); otherwise, a wind-driven missile was the accident analyzed. Details of analyses of foreseeable accidents which might occur during fuel handling and storage are described in Attachment F. Details of the transportation accident analyses are described in Attachment A.

In Table 3-3, the potential impacts of facility and transportation accidents with the greatest consequences are expressed in terms of fatal cancers per accident. These are calculated by using the relation that 0.0005 cancer fatalities could occur for each person-rem of exposure for the general population. The impacts are based on hypothetical occurrences of the accidents and do not reflect the very low probabilities of the accidents actually occurring. For each alternative, the maximum impact of either a facility or transportation accident is listed rather than a total of the individual impacts since it is reasonable that only one severe accident would occur at one time.

For facility accidents, the greatest potential impact is associated with dry spent fuel storage at the Pearl Harbor Naval Shipyard. This is due to an airplane crash into a dry storage container. For transportation accidents, the risks vary with the distances to be traveled, being least for the No Action and the Decentralization - No Examination alternatives which involve only minimal transportation to local storage.

Table 3-4 lists the most severe risks (probability of occurrence times the number of fatal cancers) from facility accidents in terms of potential cancer fatalities per year.

Table 3-3. Most severe consequences (fatal cancers to the general population) from an accident.+

Alternative	INEL(1)	Puget Sound(2)	Pearl Harbor(3)	Portsmouth(3)	Norfolk(3)	Kesselring(3)	Transportation(5)	Maximum
1. No Action*	-	0.017	26	9.0	16	7.5	0.013	26
2. Decentralization								
● No Exam								
- Dry Storage	-	0.017	26	9.0	16	7.5	0.013	26
- Water Pool Storage	-	0.51	1.1	0.34	0.60	0.25	0.013	1.1
● Limited Exam								
- Dry Storage	-	0.017	26	9.0	16	7.5	0.065	26
- Water Pool Storage	-	0.51	1.1	0.34	0.60	0.25	0.065	1.1
● Full Exam								
- Dry Storage	0.017	0.017	26	9.0	16	7.5	1.7	26
- Water Pool Storage	0.017	0.51	1.1	0.34	0.60	0.25	1.7	1.7

Alternative	INEL(1)	Hanford(1)	Savannah River(4)	NTS(4)	ORR(4)	Transportation	Maximum
3. 1992/1993 Planning Basis	0.017	-	-	-	-	2.1	2.1
4/5. Regionalization or Centralization							
● INEL	0.017	-	-	-	-	2.1	2.1
● Hanford	-	0.047	-	-	-	2.1	2.1
● S. River	-	-	4.8	-	-	2.1	4.8
● NTS	-	-	-	0.18	-	2.1	2.1
● ORR	-	-	-	-	8.4	2.1	8.4

\+ Based on accidents with a probability of occurrence of 1×10^{-7} or greater.

* Dry storage is the only option considered under the No Action alternative.

(1) The most severe accident is a drained water pool.

(2) The most severe accident involving storage or examination in a water pool is a drained water pool. For the dry storage alternatives, the most severe accident is mechanical damage from a wind-driven missile. The limited exam - dry storage option at Puget Sound also includes examination in a water pool; the consequences shown for this option are due to accidents occurring during dry storage operations only.

(3) The most severe accident is from a plane crash for dry storage and a drained water pool for water pool storage.

(4) The most severe accident is from a plane crash.

(5) Some of the alternatives would involve a limited number of shipments by sea from Pearl Harbor to Puget Sound. Even though the probability of a severe accident involving a shipboard fire and release of radioactivity would be less than 10^{-7} per year, the risk of such an accident has been calculated and is discussed in Attachment F, Section F.1.4.4. The most severe consequences of such an accident have been calculated to be 51.5 cancer fatalities.

Table 3-4. Most severe risk to the general population from a facility accident.

Alternative	INEL(1)	Puget Sound(2)	Pearl Harbor(3)	Portsmouth(3)	Norfolk(3)	Kesselring(3)	Maximum
1. No Action	-	1.7×10^{-7}	2.6×10^{-4}	9.0×10^{-7}	1.6×10^{-5}	7.5×10^{-7}	2.6×10^{-4}
2. Decentralization							
● No Exam							
- Dry Storage	-	1.7×10^{-7}	2.6×10^{-4}	9.0×10^{-7}	1.6×10^{-5}	7.5×10^{-7}	2.6×10^{-4}
- Water Pool Storage	-	5.1×10^{-6}	1.1×10^{-5}	3.4×10^{-6}	6.0×10^{-6}	2.5×10^{-6}	1.1×10^{-5}
● Limited Exam							
- Dry Storage	-	1.7×10^{-7}	2.6×10^{-4}	9.0×10^{-7}	1.6×10^{-5}	7.5×10^{-7}	2.6×10^{-4}
- Water Pool Storage	-	5.1×10^{-6}	1.1×10^{-5}	3.4×10^{-6}	6.0×10^{-6}	2.5×10^{-6}	1.1×10^{-5}
● Full Exam							
- Dry Storage	1.7×10^{-7}	1.7×10^{-7}	2.6×10^{-4}	9.0×10^{-7}	1.6×10^{-5}	7.5×10^{-7}	2.6×10^{-4}
- Water Pool Storage	1.7×10^{-7}	5.1×10^{-6}	1.1×10^{-5}	3.4×10^{-6}	6.0×10^{-6}	2.5×10^{-6}	1.1×10^{-5}

Alternative	INEL(1)	Hanford(1)	Savannah River(4)	NTS(4)	ORR(4)	Maximum
3. 1992/1993 Planning Basis	1.7×10^{-7}	-	-	-	-	1.7×10^{-7}
4/5. Regionalization or Centralization						
● INEL	1.7×10^{-7}	-	-	-	-	1.7×10^{-7}
● Hanford	-	4.7×10^{-7}	-	-	-	4.7×10^{-7}
● S. River	-	-	9.6×10^{-6}	-	-	9.6×10^{-6}
● NTS	-	-	-	7.2×10^{-8}	-	7.2×10^{-8}
● ORR	-	-	-	-	8.4×10^{-6}	8.4×10^{-6}

* Dry storage is the only option considered under the No Action alternative.

(1) The most severe accident is from a drained water pool.

(2) The most severe accident involving storage or examination in a water pool is a drained water pool. For the dry storage alternatives, the most severe accident is mechanical damage from a wind-driven missile. The limited exam - dry storage option at Puget Sound also includes examination in a water pool; the risks shown for this option are due to accidents occurring during dry storage operations only.

(3) The most severe accident is from a plane crash for dry storage and a drained water pool for water pool storage.

(4) The most severe accident is from a plane crash.

3.7.4 Cumulative, Socioeconomic, and Cost Impacts

A summary of the estimated cumulative impacts from the radiological operations associated with each of the alternatives evaluated in detail is presented in Table 3-5. It is based on achieving a stable level of operation by 1995 for any given alternative. The impacts are expressed as fatal cancers to the population within 80 kilometers (50 miles) and apply to the reasonably foreseeable impacts for the 40-year period ranging from 1995 to 2035. The impacts were based on annual results for normal operations multiplied by 40. The impacts due to both wet and dry storage are presented. For the cumulative effect of storage at Navy shipyards and prototypes, the sum over all the Navy sites was used to provide a comparison for the same amount of fuel. The total for each alternative was then calculated by summing the fatal cancers for transportation, receipt and examination operations, and storage. The results show that the impacts for all alternatives would be negligible.

The historical impact of transportation and ECF operations for the period ranging from 1958 to 1995 was calculated to be about 0.001 fatal cancers. This is the total number of fatal cancers that are estimated among the several million people along transportation routes coupled with the 116,000 people located within 50 miles of INEL. This estimate was based on the calculated incident-free transportation results from Attachment A, and the calculated results of normal operations and storage from Attachment F. The calculated results from Attachment F were adjusted from an annual basis (1995) to the historical basis by multiplying by 38 years and by a factor of 1.7 to take into consideration the variations in the number of ships and operations. No extra factor was applied to the estimates of the historical impact or the future impact to account for the vulnerabilities that might be associated with facility or spent fuel aging because naval spent nuclear fuel is very strong and has very high integrity (Section 2.2), and historical experience has disclosed no important vulnerability. The factor of 1.7 represents the ratio of the average to the current radiation exposures received by all military and civilian personnel in the Naval Nuclear Propulsion Program during the historical period (NNPP 1994a). In the case of the Limited Examination alternative, the analysis includes both the material shipped to Puget Sound for examination and storage, as well as the material stored there and at other sites from defuelings without examination.

Table 3-6 presents the cumulative impact from the radiological operations to a hypothetical maximally exposed worker and a hypothetical maximally exposed individual at the site boundary. The impacts are presented in terms of the likelihood of fatal cancer for the affected individual. These

Table 3-5. Summary of cumulative impacts (fatal cancers to the general population).

Alternative	Fatal Cancers (1995-2035)[1] Transport[2]	Exam Operations[3]	Storage[3] (Dry) [Wet]	Total (Dry) [Wet]
1. No Action	1.7×10^{-4}	0	(9.0×10^{-4})**	(0.0011)**
2. Decentralization				
• No Exam	1.7×10^{-4}	0	(9.0×10^{-4}) [0.014]	(0.0011) [0.014]
• Limited Exam	4.2×10^{-4}	0.0026	(9.0×10^{-4}) [0.011]	(0.0039) [0.014]
• Full Exam	0.0017	3.4×10^{-5}	(9.0×10^{-4}) [0.014]	(0.0026) [0.015]
3. 1992/1993 Planning Basis	0.0011	3.4×10^{-5}	*	0.0011
4/5. Regionalization or Centralization				
• INEL	0.0011	3.4×10^{-5}	*	0.0011
• Hanford	0.0024	1.6×10^{-4}	*	0.0026
• Hanford/FMEF	0.0024	1.6×10^{-4}	*	0.0026
• S. River	0.0060	7.2×10^{-4}	*	0.0067
• S. River/Barnwell Plant	0.0060	7.2×10^{-4}	*	0.0067
• Nevada Test Site	0.0030	3.6×10^{-6}	*	0.0030
• Oak Ridge Reservation	0.0055	0.0020	*	0.0075

Notes:

1 Fatal cancers for 1958-1995 were calculated to be about 0.001 for transport and ECF operations. Fatal cancers were calculated at 5.0×10^{-4} fatal cancers per person-rem.
2 Values from Attachment A.
3 Values from Attachment F.
*DOE storage, not NNPP.
**There is no wet storage under the No Action alternative.

Table 3-6. Likelihood of fatal cancer from cumulative radiation dose.

	Maximally Exposed Worker		Maximally Exposed Individual	
	Total Radiation Dose (rem)	Likelihood of Fatal Cancer	Total Radiation Dose (rem)	Likelihood of Fatal Cancer
1. No Action	4.7	0.0019	0.12	6.0×10^{-5}
2. Decentralization				
• No Exam	4.7	0.0019	0.12	6.0×10^{-5}
• Limited Exam	4.7	0.0019	0.12	6.0×10^{-5}
• Full Exam	4.7	0.0019	0.12	6.0×10^{-5}
3. 1992/1993 Planning Basis	3.4	0.0014	1.0×10^{-5}	5.0×10^{-9}
4/5. Regionalization or Centralization				
• INEL	3.4	0.0014	1.0×10^{-5}	5.0×10^{-9}
• Hanford	3.4	0.0014	9.6×10^{-6}	4.8×10^{-9}
• Hanford/FMEF	3.4	0.0014	1.8×10^{-5}	9.0×10^{-9}
• S. River	3.4	0.0014	1.9×10^{-5}	9.5×10^{-9}
• S. River/Barnwell Plant	3.4	0.0014	1.5×10^{-4}	7.5×10^{-8}
• Nevada Test Site	3.4	0.0014	1.4×10^{-5}	6.8×10^{-9}
• Oak Ridge Reservation	3.4	0.0014	0.0040	2.0×10^{-6}

values were determined based on a projected 40-year exposure at the location of the affected individual. The radiological doses for workers represent the largest average dose from the particular facilities involved in an alternative. The average radiation dose for workers was selected by using the 1993 annual average shipyard or DOE site radiation exposure summaries (NNPP 1994b; NNPP 1994c). The radiological doses for maximum off-site individuals are the largest values calculated for a person located at the site boundary, closest to any facility involved under an alternative. These doses are based on the values for these individuals presented in Attachment F.

Employment impacts were determined from the nature of each alternative based on the experience at INEL. Table 3-7 presents a summary of potential socioeconomic impacts at each of the various sites for each of the alternatives evaluated in detail. The results indicate that as many as 500 long-term jobs and several hundred shorter-term construction jobs might be lost or gained at an affected site depending on the alternative selected.

Cost impacts were estimated from the nature of each alternative based on experience at INEL. Table 3-8 presents a summary of the cost impacts for each of the alternatives evaluated in detail. The summary provides the costs which would be incurred from construction as well as transportation and operation costs over the next 40 years. In all alternatives, there would be large costs, ranging up to $5.7 billion. For three of the alternatives involving continued operation of the ECF at INEL (1992/1993 Planning Basis, Regionalization at INEL, and Centralization at INEL), there would be only minor construction cost impact; however, the cost of continued ECF operation for an additional 40 years would be $2.6 billion. The cost values considered in preparing Table 3-8 include facility construction costs ranging from zero for alternatives involving no new facilities to a high of $800 million for those requiring a new facility with full examination capability. The transportation costs depend on destination and logistics and range from a low of $10 million to a high of $110 million. Fuel storage container costs range from a low of zero for those alternatives utilizing water pool storage to a high of $3.2 billion for shipping containers on railcars for the No Action alternative. Also included are operating costs over 40 years ranging up to $2.6 billion for the various alternatives, and Idaho ECF shutdown costs for those alternatives in which the present ECF is shut down.

Table 3-7. Summary of potential socioeconomic impacts.

Alternative	Impacts Associated with the Affected Site: INEL	Hanford	Savannah River	Nevada Test Site	ORR	Five NNPP Sites: Exam.	Five NNPP Sites: Store
1. No Action	Lose 500 jobs	No change	No change	No change	No change	No change	Add 50-100 jobs
2. Decentralization							
• No Exam	Lose 500 jobs	No change	No change	No change	No change	No change	Add 50-200 jobs
• Limited Exam	Lose 500 jobs	No change	No change	No change	No change	Add 60 jobs at Puget Sound	Add 50-200 jobs
• Full Exam	No change	No change	No change	No change	No change	No change	Add 50-200 jobs
3. 1992/1993 Planning Basis	No change	No change	No change	No change	No change	No change	No change
4/5. Regionalization or Centralization							
• INEL	No change	No change	No change	No change	No change	No change	No change
• Hanford	Lose 500 jobs	Gain 500 perm. jobs and some const. jobs	No change	No change	No change	No change	No change
• S. River	Lose 500 jobs	No change	Gain 500 perm. jobs and some const. jobs	No change	No change	No change	No change
• Nevada Test Site	Lose 500 jobs	No change	No change	Gain 500 perm. jobs and some const. jobs	No change	No change	No change
• Oak Ridge Reservation	Lose 500 jobs	No change	No change	No change	Gain 500 perm. jobs and some const. jobs	No change	No change

Table 3-8. Summary of cost impacts over 40 years.

	Cost ($ Billions)
No Action	3.6
Decentralization	
- No Exam	1.5 - 3.4*
- Limited Exam	1.8 - 3.7*
- Full Exam	3.8 - 5.7*
1992/1993 Planning Basis	2.6
Regionalization or Centralization	
- INEL	2.6
- Hanford	3.4
- Savannah River	3.5
- Nevada Test Site	3.5
- Oak Ridge Reservation	3.5

* The cost varies under this alternative depending on the mode of storage. The most expensive options are those that use shipping containers for storage; the least expensive options are those that use immobile dry storage containers.

The largest cost ($3.8 to $5.7 billion) would be needed for new storage facilities or containers in addition to the ECF operational costs under the Decentralization - Full Examination alternative. Approximately $0.8 billion would be needed for the construction of new receipt, handling, and examination facilities at the alternative site if a Regionalization or Centralization alternative other than INEL were selected, thereby resulting in a cost of $3.5 billion over 40 years of operation. Somewhat less than $800 million would be needed for modifications to existing facilities if either of those options at Hanford or Savannah River were selected. Also, if the alternative involving the Barnwell Nuclear Fuel Plant at Savannah River were selected, additional funds would be needed to buy the Barnwell Plant as well as to modify it to meet the Program needs.

A hidden cost associated with the No Action alternative and two of the Decentralization alternatives is the loss or major reduction in the capability to examine naval spent nuclear fuel. Full examinations of naval spent nuclear fuel at the Expended Core Facility at INEL have been conducted since 1957. The examinations are a critical aspect of the Naval Nuclear Propulsion Program's ongoing advanced fuel research and development program. The information derived from the examinations at ECF provides engineering data on nuclear reactor environments, material bebavior, and design performance. These data contribute to the Naval Nuclear Propulsion Program in two very significant ways.

First, this information is used to support the design of new reactors having extended lifetimes. For example, such examinations have contributed to extending the life of naval fuel from 2 years for the first reactor core in USS NAUTILUS to over 20 years for the latest nuclear-powered warships. The ultimate goal is to develop naval nuclear fuel that lasts the life of the ship; this would mean that no refuelings would be needed. Longer-lived fuel allows fewer refuelings, saves money in the costs of fuel and in the costs of work on ships, makes ships available for longer periods of service, and creates less spent nuclear fuel. Second, information from these examinations has supported the operation of existing naval reactors by providing confirmation of proper design and allowing the fuel they contain to be used for the longest possible time.

Thus, the examinations of naval spent nuclear fuel are an integral part of the outstanding record of nuclear safety of the Naval Nuclear Propulsion Program. In over 4500 reactor-years of operation and more than 300 refuelings and defuelings of naval reactors, there has never been a nuclear reactor accident, criticality accident, or any release of radioactivity that has had a significant effect on the environment. Preventing release of radioactivity from the fuel is extremely important to the safety of the Navy personnel who operate the nuclear-powered warships since they must live aboard ship in close proximity to the reactor 24 hours a day.

While it is difficult to quantify the benefits of an outstanding safety record, increased core life yields an understandable economic gain. The gain is in a reduction in the number of reactor cores that must be procured and in the number of refuelings. Another gain is the increased on-line availability of nuclear-powered warships which is reflected in a decreased number of ships required. It is estimated that by achieving life-of-the-ship fuel and thus eliminating the need for any refuelings, a savings of approximately $5 billion will accrue for a force structure of less than 100 ships. The improvement in life from 2 years to 20 years has already avoided the need to perform 15 refuelings over the lifetime of each ship and reduced that to a single refueling.

3.8 TRANSITION PERIOD

A transition period would be required before any of the alternatives considered for naval spent nuclear fuel management could be fully implemented, except for those which would resume the historical practice of shipping naval spent nuclear fuel to the Expended Core Facility at INEL, followed by transfer to the Idaho Chemical Processing Plant for storage. This transition period would be needed to obtain the necessary additional funding and to build the necessary facilities and equipment.

For example, if the Record of Decision were to identify that the alternative of Centralization at Savannah River had been selected, a new Expended Core Facility would have to be funded and built at the Savannah River Site before shipments of naval spent nuclear fuel from shipyards could be directed to Savannah River. Similarly, if the No Action alternative were selected, additional shipping containers would have to be built since the available shipping containers for naval spent nuclear fuel will all be filled and waiting at the shipyards in June 1995.

Impacts of all alternatives evaluated for naval spent nuclear fuel management are low. Thus, the impacts of combinations of alternatives would also be low. The Environmental Impact Statement focuses on impacts at the time of full implementation in order to simplify the discussion and to calculate ceilings for the impacts. By doing so, it assures that impacts greater than those analyzed would not occur if one alternative were used for a small fraction of the 40-year period followed by a shift to another alternative for the remainder of the 40 years. This section discusses a transition period which is believed to represent a rapid but practical shift from the situation in June 1995 to full implementation of the ultimate alternative selected in the Record of Decision. This transition period would be about the same length for any alternative.

It is expected that the transition period would consist of 3 years of shipments of containers from the shipyards or prototypes to ECF at INEL beginning with issue of the Record of Decision in June 1995, and include approximately 80 total shipments. This would result in shipping to INEL the containers which had been filled and at the shipyards at that time. Many of the containers would then be emptied at ECF and returned to the shipyard where they would be reloaded. During this 3-year period, some of these containers would make a second trip to ECF at INEL for unloading after being returned to the shipyard. After these 3 years of shipments, no further shipments to INEL would be made, and the Expended Core Facility at INEL would be shut down. The shipping containers would then be refilled during the next 3 years, but kept at the shipyards or shipped to the location of the new examination or storage facilities.

If an alternative which does not continue storage of naval spent nuclear fuel at INEL were selected, procurement and contract actions to implement the course of action selected in the Record of Decision would be initiated during these two 3-year periods. In accordance with the course of action selected in the Record of Decision, additional shipping containers or immobile dry storage casks would be built or construction of water pools would be initiated at shipyards or a new ECF at a DOE site would be started. It is assumed that these procurements or construction would have proceeded sufficiently that the shift to the selected option would be in full swing at this time.

3.9 PREFERRED ALTERNATIVE FOR NAVAL SPENT NUCLEAR FUEL

The specific elements discussed in each category of environmental impacts have been evaluated to determine the Navy's preferred alternative for managing naval spent nuclear fuel until means for permanent disposition become available. The costs and mission impacts have also been considered in selecting a preferred alternative.

Environmental Impacts: This Environmental Impact Statement (EIS) documents the potential environmental impacts of each alternative for naval spent nuclear fuel management. It considers environmental impacts under normal operations and hypothetical accident conditions on resources such as water quality and wetlands, air quality, land use, and public health. This EIS considers a range of potential accident initiators, such as natural hazards, transportation, and fuel handling.

The analyses demonstrate that the environmental impacts of implementing any of the alternatives would be very small for both normal operations and accident conditions. All alternatives would result in radiological impacts well below established DOE safety performance goals (SEN-35-91) of one tenth of one percent of the risk of fatal cancers from all sources (including natural causes). The impacts from any of the alternatives in non-radiological areas would also be extremely small. The analysis results do not provide a basis to distinguish among the alternatives in most of these areas.

Socioeconomic Impacts: The socioeconomic impact of implementing each of the alternatives would differ somewhat. The primary determinant of socioeconomic impact of the alternatives considered is employment. Total nation-wide employment levels would not vary significantly among alternatives for managing naval spent nuclear fuel, and therefore do not seem to provide a basis to distinguish among the alternatives. The maximum impact on existing employment levels would arise from alternatives requiring development of new naval spent nuclear fuel examination capability at a DOE facility other than INEL while terminating these activities at INEL. Resuming current practices of transporting naval spent nuclear fuel to the ECF at INEL for examination followed by transfer to the DOE for storage would result in the minimum disruption of employment levels.

Mission Impacts: Two important components of Naval Nuclear Propulsion Program operations are the safe management of naval spent nuclear fuel and support of the Navy's fleet of nuclear-powered warships. Based on the analyses in this EIS, all alternatives considered would allow safe storage of naval spent nuclear fuel until permanent disposition. However, some of the alternatives would not provide equal levels of Fleet support. Alternatives which limit or terminate naval spent nuclear fuel examination would severely impact ongoing research and development work. Naval spent nuclear fuel examination results are used to confirm the adequacy of design features, explore material performance, and confirm or adjust computer predictions of fuel performance. This information contributes to design and manufacturing of new naval reactor cores as well as understanding of operating ships. Each spent naval reactor core has its own unique manufacturing and operating history. Consequently, examination of each reactor core provides an opportunity to obtain new information relevant to reactor core performance. As discussed in Section 2.4.1 of this Appendix, the technical feedback obtained through this examination program is essential to extending the lifetime of naval reactor cores and assuring their operational safety. It is also important to understand that because of their long service lives, the first of the naval cores currently being used in LOS ANGELES Class submarines are just now being removed from operating reactors and becoming available for examination. The first cores from NIMITZ Class aircraft carriers and OHIO Class submarines have yet to be removed. These cores are the basis for all of the current fleet designs and are the starting point for new designs. Of the alternatives allowing full examination at the INEL, Hanford Site, Savannah River Site, Oak Ridge Reservation, or Nevada Test Site, examination at the INEL would have the smallest mission impact due to the presence of existing facilities and equipment for performing this work, and the presence of a highly skilled work force, all of which would need to be relocated or reassembled if a new examination site were selected.

Cost Impacts: There are large differences in the costs associated with all alternatives. Few additional costs would be associated with continuing the historic practice of shipping naval spent nuclear fuel to INEL for examination, followed by transfer to the DOE for storage pending permanent disposition. Alternatives involving developing facilities for storage of naval spent nuclear fuel at naval shipyards or developing examination facilities at a DOE site other than INEL would involve billions of dollars in additional costs, relative to historic practices, without any discernible improvement in safety or reduced environmental impacts.

Based on the analyses presented in this EIS, the Navy prefers an alternative which resumes the historic, technically sound, and safe practice of conducting refueling and defueling of nuclear-powered warships and prototypes as planned, transporting naval spent nuclear fuel to the Expended Core Facility at the INEL for full inspection and examination, and transferring naval spent nuclear fuel to the DOE for storage at that site. As summarized above, this preferred alternative avoids disruption of research and development work, minimizes disruption to existing employment levels and infrastructure, represents the lowest cost, and does not involve appreciable environmental impact. This preferred alternative can be accommodated under the 1992/1993 Planning Basis, Regionalization, or Centralization at Idaho.

3.10 REFERENCES

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4. AFFECTED ENVIRONMENT

4.1 NAVY AND PROTOTYPE SITES FOR NAVAL SPENT NUCLEAR FUEL

4.1.1 PUGET SOUND NAVAL SHIPYARD: BREMERTON, WASHINGTON

4.1.1.1 Overview

The Puget Sound region lies in the northwest corner of Washington State as shown on Figure 4.1.1-1. The region is defined by the Olympic Mountain Range to the west and the Cascade Mountain Range to the east. The lowlands contrast dramatically with the mountains, with numerous channels, bays, and inlets on the inland sea that is Puget Sound. The Puget Sound Naval Shipyard is located inside the city limits of Bremerton, Washington at 47° 33' 30" north latitude and 122° 38' 8" west longitude. Bremerton is located in Kitsap County on the Sinclair Inlet 14 miles across Puget Sound west of Seattle and about 20 air miles northwest of Tacoma. Topography in the Bremerton area is characterized by rolling hills with an elevation range from sea level to +200 feet above mean sea level (msl) in West Bremerton and ranging up to ±300 feet above msl in East Bremerton (area east of Port Washington Narrows). The predominant native vegetation in the area are douglas fir, cedar, and hemlock. Within a distance of 25 to 40 miles in a westerly direction from Bremerton, the Olympic Mountains rise to elevations of 4,000 to 7,000 feet. The higher peaks are covered with snow most of the year and there are several glaciers on Mount Olympus (elevation 7,954 feet). In an easterly direction and within a distance of 60 miles, the Cascade Range rises to average elevations of 5,000 to 7,000 feet with snowcapped peaks in excess of 10,000 feet.

Puget Sound Naval Shipyard is the largest activity of the Bremerton Naval Complex, which also includes the Fleet and Industrial Supply Center, Puget Sound and Naval Sea Systems Command Detachment, and Planning and Engineering for Repair/Alteration of Aircraft Carriers. Tenant activities include Naval Inactive Ship Maintenance Facility, Naval Reserve Center, and the Defense

Printing Service. Figure 4.1.1-2 provides a shipyard vicinity map, and Figure 4.1.1-3 illustrates the Puget Sound Naval Shipyard.

4.1.1.2 Land Use

Kitsap County has historically been a semi-rural county. Roughly 80 to 85 percent of Kitsap County's total area is either forest, farmland, or undeveloped. The city of Bremerton and the surrounding vicinity is the largest population and economic center in the county and therefore has a lower percentage of agriculture and undeveloped land. Most development in Kitsap County is clustered around the commercial nodes of Bremerton, Port Orchard, Bainbridge Island, Kingston, Poulsbo, Silverdale, and Gorst, and near the shorelines.

The second largest land use category is residential, which is further broken down into low and medium density housing. More land area is devoted to single-family (low density) residential than to multi-family (medium density) development in this area.

Other land use delineations are parks and open space; commercial, which includes industry; mining; and much of the Navy buildings. The nearby land uses are typical of an area developed to a moderate intensity. The area contains residential, commercial, industrial, educational, and recreational facilities. The local waters support recreational and commercial activities including regularly scheduled ferry traffic.

Bremerton Naval Complex includes a total of approximately 1,347 acres consisting of uplands and submerged lands. Puget Sound Naval Shipyard has 327 acres of upland and is highly developed. Puget Sound Naval Shipyard also owns about 338 acres of submerged tidelands. The waterfront dry dock area is the high-security portion of the shipyard where most production takes place. It includes production shops, administration, and some public works and supply functions. The upland area of the shipyard is the military support area which 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, steel yard, public works shops, and parking.

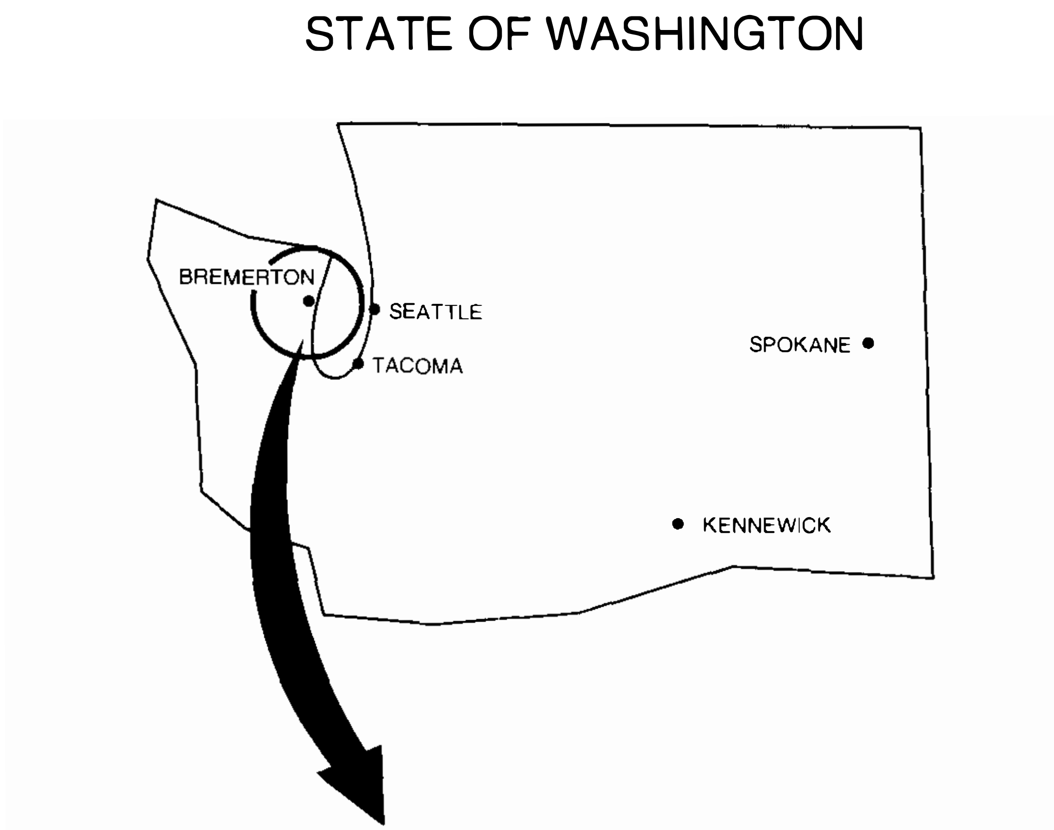


Figure 4.1.1-1. Location of Puget Sound Naval Shipyard within Washington.

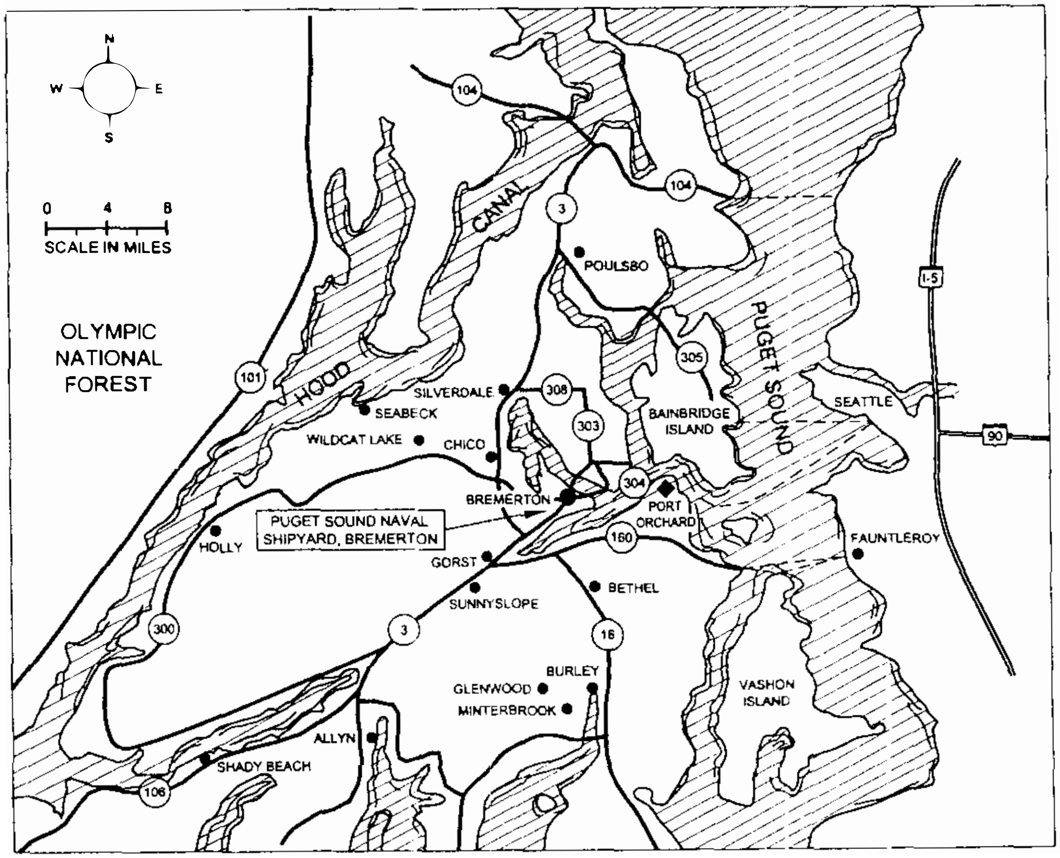


Figure 4.1.1-2. Puget Sound Naval Shipyard vicinity map.

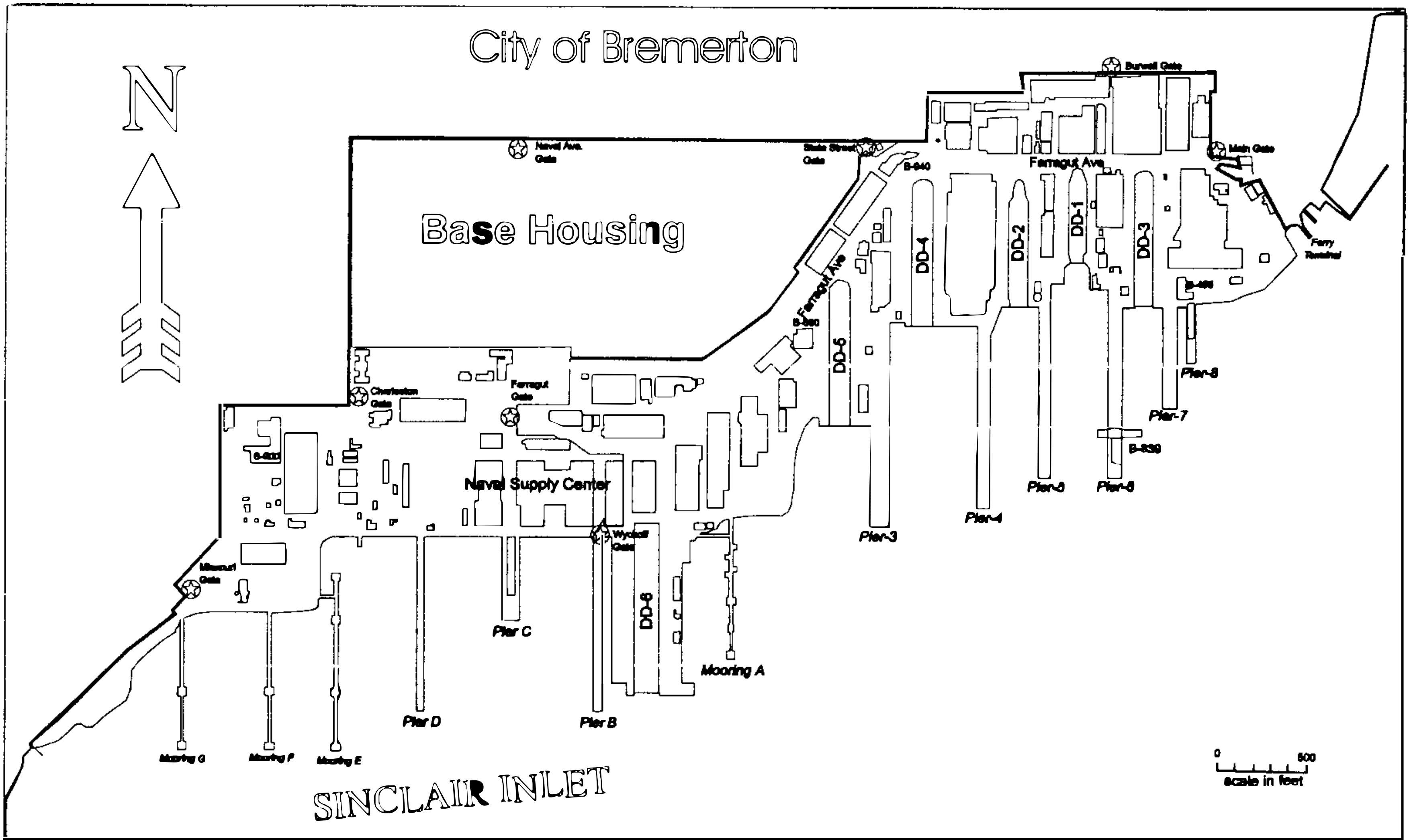


Figure 4.1.1-3. Puget Sound Naval Shipyard site map.

4.1.1.3 Socioeconomics

Bremerton is the largest city within Kitsap County. The major population centers in Kitsap County other than Bremerton include Port Orchard, Poulsbo, Silverdale, Bainbridge Island, and Kingston. Kitsap County also has two reservations: the Port Madison Indian Reservation governed by the Suquamish Tribe, and the Port Gamble Indian Reservation governed by the S'Klallam Tribe.

The region surrounding the shipyard, within 50 miles, contains a population of approximately 3 million. Figure 4.1.1-4 provides a population distribution rose centered on the shipyard and covering a 50-mile radius. During 1989, Kitsap County ranked 7th as the most populous county in the state (Washington SESD 1990). According to the 1990 census, Kitsap County was the fifth fastest growing county in the state with a 28.9% growth rate for the decade for a total population of 189,731. The most recent estimate (April 1992), puts Kitsap's population at 205,600. The Kitsap Regional Planning Council projects the number of inhabitants to reach 280,985 by the year 2010, an increase of 48.10% over the 1990 figure.

Kitsap County's economy is largely affected by the federal government. Government is Kitsap County's largest employment sector, with the federal government having the greatest impact. As of 1993, Puget Sound Naval Shipyard was the largest employer in the county, employing about 10,200 civilian personnel. In 1990, the government sector's share of county employment was approximately 45 percent. The retail trade and services sectors are the county's next highest employers. Many of the service industries, such as the growing number of engineering and management firms, directly or indirectly support the military. By 1989, the services sector accounted for 21 percent of employment in the county and the retail trade sector accounted for 20.5 percent (Navy 1991a).

The majority of the labor force that would be employed at the shipyard for construction and operation of the naval spent nuclear fuel area would be expected to reside within about 20 miles from the shipyard. The calculated total population, labor force, and employment within this region for the base year (1995) are presented in Table 4.1.1-1. Projections of employment and population for the years beyond 1995 have not been presented because, as discussed in Section 5, the number of additional jobs that might be created at the shipyard under any alternative could be small.

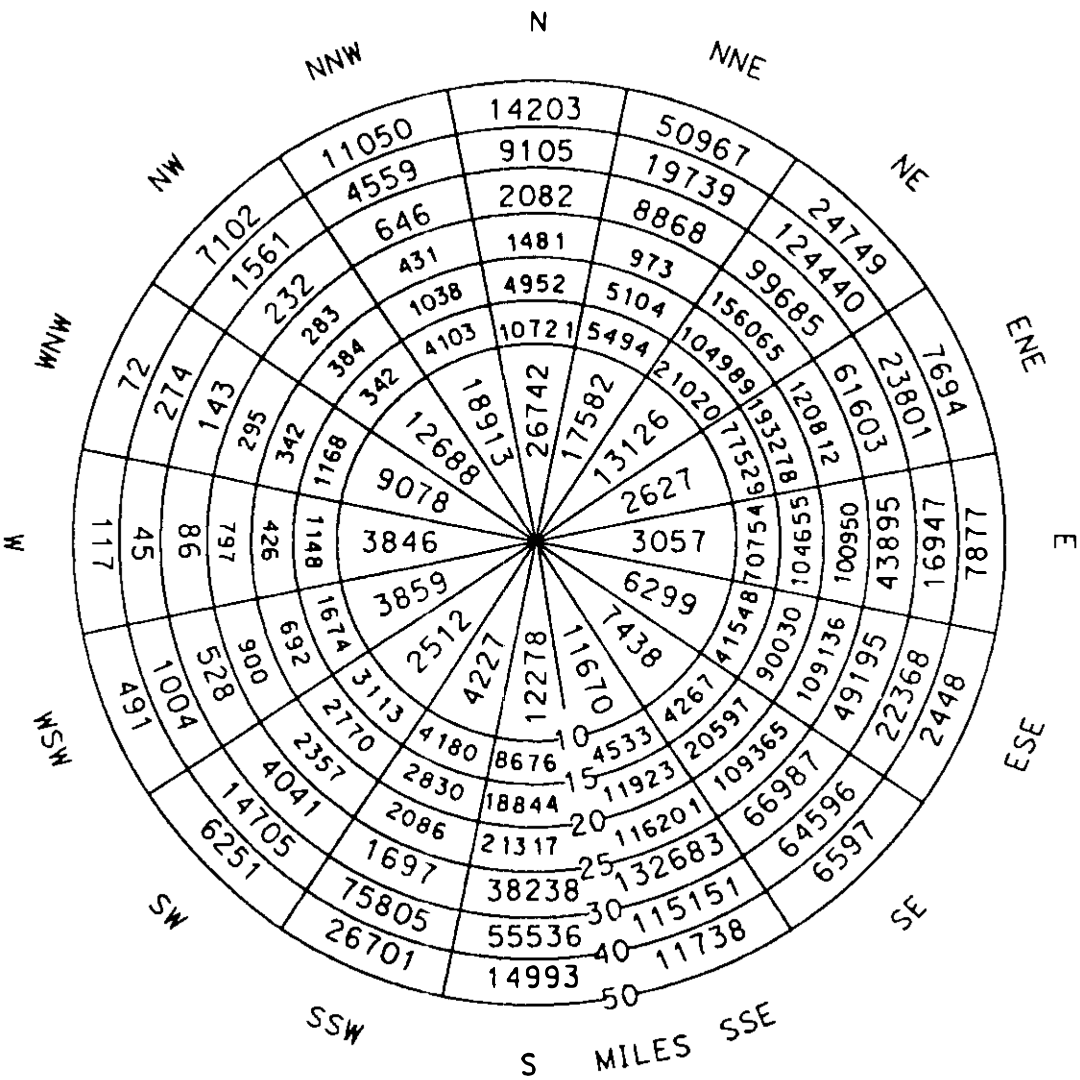
Table 4.1.1-1. Regional employment factors at Puget Sound Naval Shipyard.

Regional Employment	Regional Labor Force	Regional Population
492,900	527,000	979,070

There are seven port districts in the county. The Port of Bremerton is the largest, with Bremerton and Port Orchard within its boundaries. The Port of Bremerton owns Bremerton National Airport, Olympic View Industrial Park, marinas in downtown Bremerton and Port Orchard, and the First Street Dock in Bremerton. Kitsap County is governed by a Board of Commissioners and is divided into three districts. Bremerton is split between the three districts. Regional planning is the responsibility of the Kitsap Regional Planning Council, and the Puget Sound Regional Planning Council, which is made up of elected officials from King, Kitsap, Pierce, and Snohomish counties and cities, and from the Indian tribal councils. Land use outside the shipyard is regulated by the city of Bremerton Comprehensive Plan and Zoning Ordinance. The Bremerton Area Council of Neighborhoods is made up of nine neighborhoods. The group was established to encourage citizen participation in Bremerton city planning (Navy 1991a).

Agencies responsible for environmental protection are the U.S. Army Corps of Engineers, U.S. Coast Guard, the Environmental Protection Agency (EPA), and the United States Fish and Wildlife Service (USFWS). The Washington State Department of Ecology and the city of Bremerton are responsible for the Coastal Zone Management Plan. The Department of Natural Resources has jurisdiction over marine lands management, and the Department of Fisheries and Department of Game protect wildlife resources. Washington's system of freeways, highways, and ferries is the responsibility of the Washington State Department of Transportation. Historic preservation programs for the state are administered by the Office of Archaeology and Historic Preservation.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the Puget Sound Naval Shipyard, consistent with the population data provided in Figure 4.1.1-4.



Miles	People	Cumulative People
0-5	90,353	90,353
5-10	65,589	155,942
10-20	823,124	979,066
20-30	1,254,058	2,233,124
30-40	549,636	2,782,760
40-50	193,050	2,975,810

Based on 1990 Census

Figure 4.1.1-4. 50-mile population distribution around Puget Sound Naval Shipyard.

Figure 4.1.1-5 shows the locations of populations in which minority membership exceeds the average within the 50-mile radius by more than 20 percentage points and populations which have more than 50 percent minority members. These populations have been identified following an approach developed by the Environmental Protection Agency which, for purposes of environmental justice evaluation, defines minority communities as those which have percentages of minorities greater than the average in the region analyzed (EPA 1994).

Figure 4.1.1-6 shows the locations of populations which have more than 25 percent of their members living in poverty, reflecting a common definition of low-income communities (EPA 1993). The U. S. Census Bureau characterizes persons in poverty as those whose income is less than a "statistical poverty threshold." For the 1990 census, this threshold was based on a 1989 income of $12,500 per household.

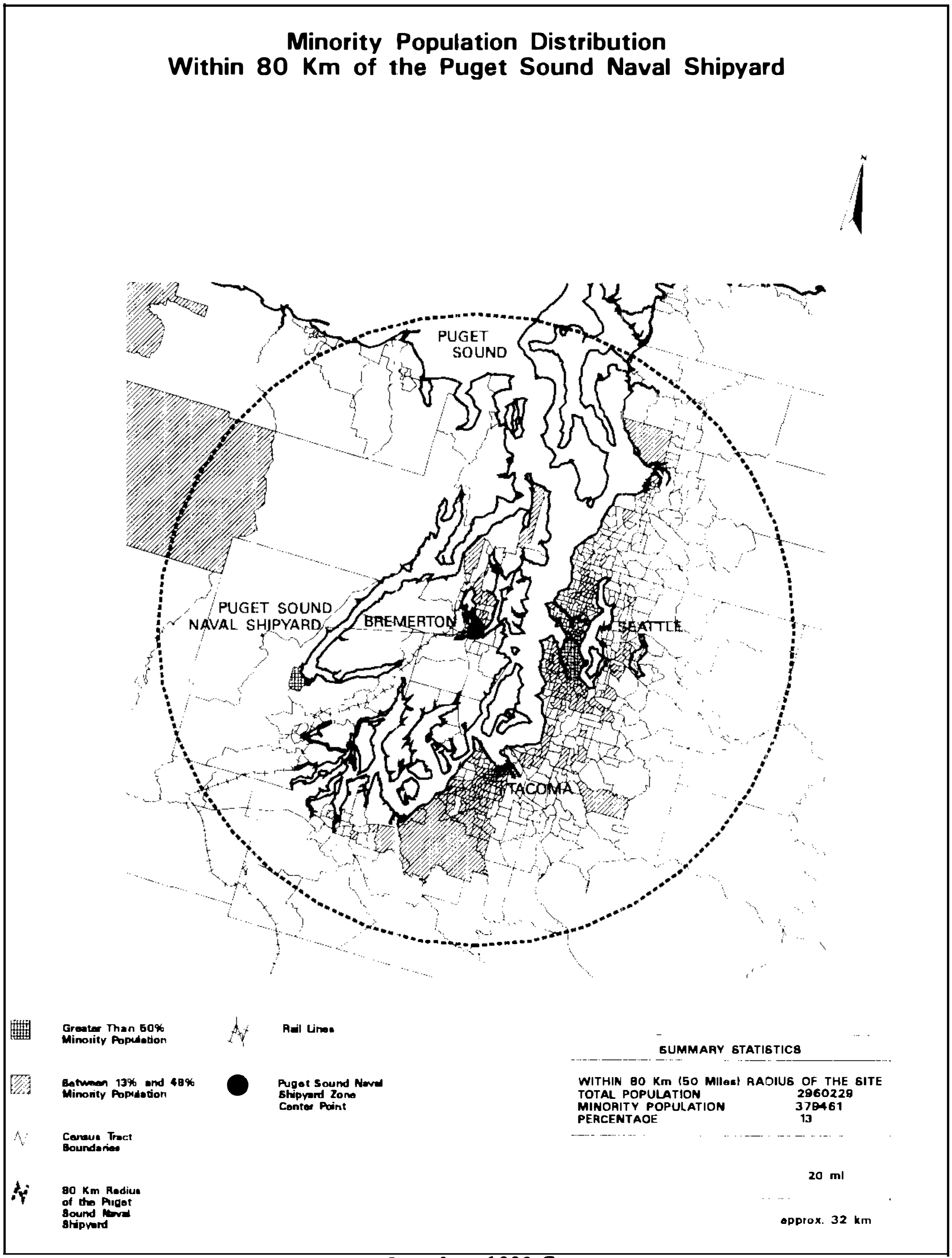
4.1.1.4 Cultural Resources

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 100 years, the principal settlement of the Suquamish Tribe lay along the west shore of Agate Passage.

Congressional funding in 1891 led to the purchase of 190 acres of land on Sinclair Inlet for the construction of a dry dock, repair, and overhaul base for the U.S. Navy. This base was called the Puget Sound Naval Station.

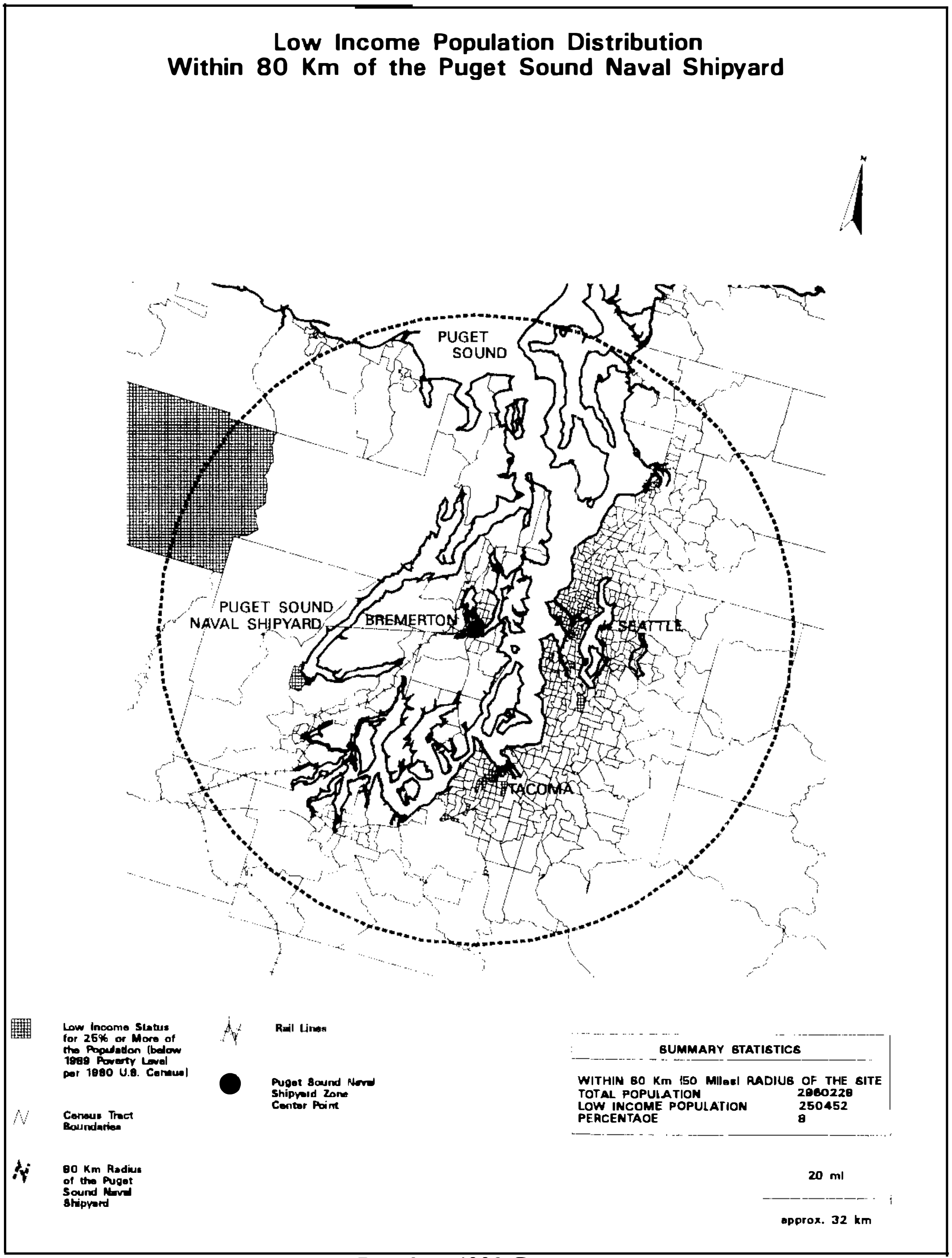
No prehistoric archaeological sites have been identified at the Puget Sound Naval Shipyard. In addition, no submerged cultural resources have been recorded in the immediate vicinity of the shipyard. There are no Native American properties or ceremonial sites in the areas where spent nuclear fuel would be stored.

There is one National Historic Landmark and four National Registered Historic Districts within the shipyard. The east industrial portion of the shipyard was designated as a National Historic Landmark in 1992 as a part of the "World War II in the Pacific" group and contains buildings, piers, dry docks, and equipment that were used in World War II warship repairs. The four Historic



Based on 1990 Census

Figure 4.1.1-5. Minority population distribution within 50 miles of the Puget Sound Naval Shipyard.



Based on 1990 Census

Figure 4.1.1-6. Low-income population distribution within 50 miles of the Puget Sound Naval Shipyard.

Districts are: Officer's Row, Old Puget Sound Radio Station, Old Naval Hospital, and the Old Marine Reservation.

4.1.1.5 Aesthetic and Scenic Resources

The Puget Sound region offers a striking contrast in terrain, with mountains; low, rolling hills; flat-topped ridges; and plateaus. These areas are separated by numerous channels, bays, inlets, lakes, and valleys. The shoreline along the county is characterized by moderate to steep irregular cliffs. The county has large areas of farmlands and forest.

The city of Bremerton and the Puget Sound Naval Shipyard are urbanized areas. The shipyard has an industrialized character along the shoreline, with parking areas, dry docks, warehouses, and ship traffic along Sinclair Inlet. The upland section of the shipyard contains housing, recreational facilities, and retail businesses. Chainlink fences mark the shipyard boundaries. The area within the shipyard where the naval spent nuclear fuel would be stored has low visual sensitivity since the area is an industrial site.

4.1.1.6 Geology

4.1.1.6.1 General Geology. The Kitsap Peninsula consists of several geological phenomena which have occurred over the past 60 million years. The upper layers of rock are generally underlain by hard, dense, fine-grained lava with an accumulation of several thousand feet (in most places) of marine sedimentary rocks above the lava flows. Uplifting of the Cascade and Olympic Mountain ranges caused the Kitsap Peninsula and other Puget Trough lowlands to become sites of deposition for sedimentary materials washed down from the surrounding ranges. More recently, glaciation, as well as erosion, have been responsible for carving the low, hilly, rolling topography of the area (Navy 1991a). The following geological discussion was obtained from "Site Inspection Report Puget Sound Naval Shipyard" (URS 1992).

Puget Sound Naval Shipyard is within the Puget Sound Lowland between the Olympic Mountains and the older Cascade Mountains to the east. Before the glaciation which occurred up to 1.7 to 2.2 million years ago, the Puget Sound Lowland probably contained a large river valley draining to the north and west into what is now the Strait of Juan de Fuca. Glaciation of the Puget Sound Lowland produced the arms and embayments of Puget Sound.

4.1.1.6.2 Geologic Resources. Geological materials found in Puget Sound include hard, dense volcanic rock formed up to 63 to 65 million years ago, and fragmented sedimentary rocks, as well as unconsolidated sediments deposited by glaciers up to 1.7 to 2.2 million years ago. At least four separate glacial advances and accompanying periods between glaciers have been hypothesized for the Puget Sound Lowland. Soil layers deposited by glaciers are generally coarse sand and gravel, sand, silt from lakes, and low-permeability deposits left by glaciers. The soils from the periods between glaciers are generally fine-grained silts and sands deposited by rivers or lakes, interbedded with lenses of sand and gravel.

Most of the geologic material in Kitsap County is glacial deposits. The Kitsap Peninsula is the remnant of a plain formed from the debris deposited by glaciers. Volcanic bedrock outcrops near the south end of Sinclair Inlet and at Gold Mountain south and west of Bremerton. Sedimentary bedrock outcrops on the south end of Bainbridge Island and at the adjacent tip of the peninsula east of Bremerton.

Kitsap County has four basic soil types: soils underlain by cemented hard-packed subsoil or bedrock substrate; soils with permeable, distinctly stratified sublayers which are coarse and have good internal drainage; the organic soils represented by small, widely scattered areas of peat and muck; and soils having little or no agricultural or building potential. Typical landforms include rough mountainous land, steep broken land, coastal beaches, and tidal marshes.

The natural topography of the shipyard has been altered substantially 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 surface of the filled areas is a solid layer of earth. The remaining areas of natural soils vary from dense deposits from glaciers to soft bay mud and peat. The upland soil is a stiff hard-packed clay soil with low permeability. (URS 1992)

There are no economic geologic resources at the shipyard.

4.1.1.6.3 Seismic and Volcanic Hazards. Seismic risk related to structural damage may be represented in the United States by a relative scale of 0 through 4, with Zone 0 not expected to encounter damage and Zone 4 expected to encounter the greatest seismic risk. The Puget Sound Naval Shipyard is located in Zone 3. (UBC 1991) The Uniform Building Code seismic classification provides a means for a comparable assessment of the seismic hazard between the alternate sites. If the Record of Decision identifies this site for the interim storage of naval spent fuel, then a detailed seismic evaluation would be conducted. More detailed information regarding the design basis considerations for storage of naval spent nuclear fuel at the shipyard is provided in Attachment D.

There have been approximately 200 earthquakes in the Pacific Northwest since 1840, most of which caused little or no damage. The most recent earthquakes of high magnitude in the region were near Olympia (approximately 40 miles from Bremerton) in 1949 (moment magnitude 7.1) and near Seattle in 1965 (moment magnitude 6.5). There has recently been speculation by some seismologists that earthquakes in the Puget Sound area might produce moment magnitudes as high as 8.2 to 8.8. On the other hand, some seismologists believe that earthquakes with moment magnitudes exceeding 7.0 are unlikely in this region. There is also some disagreement at present on the nature of fault movements that might occur in this area.

There is no known fault line within 3000 feet of the Bremerton Naval Complex; however, two known fault traces have been identified in Kitsap County. The Kingston-Bothell trace, in the northern portion of the county, and the Seattle-Bremerton trace, located a few miles north of Bremerton. There has been no known surface faulting in conjunction with earthquakes in the shipyard region.

Potential hazards from volcanism are minimal and limited to wind-borne volcanic ash. Both the distance of the shipyard from the Cascade vents and the configuration of the intervening topography exclude other volcanic hazards. Only ash from a "large" or "very large" eruption would reach the shipyard. The 1980 eruption of Mount St. Helens, Washington, approximately 120 miles south of the shipyard, resulted in a very slight coating of ash at the shipyard.

The potential hazard from large waves generated by volcanoes or earthquakes is minimal. The system of straits and inlets surrounding Puget Sound provides a natural barrier for the Puget Sound Area, which effectively dampens the propagation of distantly generated large waves. The risk of a local large wave generated by seismic events occurring that would affect the shipyard is small;

however, seismologists have found evidence of a large, shallow focus earthquake near Seattle about 1300 years ago. This earthquake was most likely in excess of moment magnitude 7. In the event that a shallow focus earthquake such as this were to occur beneath Puget Sound, a tsunami could result which might cause flooding in the Puget Sound area. Because the largest earthquakes of record in the area are deep seated (more than 60 kilometers (37 miles)), and no major surface rupture is known to have occurred, the hazard of generation of a large wave by a local earthquake is minimal. The potential for landslide-generated waves is controlled by the geologic conditions; however, development of an earthquake-induced landslide of sufficient size to create a large wave is not expected.

A more detailed description of the regional geology and seismicity is documented in "Seismic Design Study - Water Pit Facility, Puget Sound Naval Shipyard, Bremerton, Washington" (Navy 1978).

4.1.1.7 Air Resources

4.1.1.7.1 Climate and Meteorology. The general meteorological conditions of the Puget Sound area are typical of a marine climate, since the prevailing air currents at all elevations are from the Pacific Ocean. The relatively cool summers, mild winters, and wetness characteristic of a marine climate are enhanced by the presence of Puget Sound. The area tends toward damp, cloudy conditions much of the year. The Cascade Range to the east serves as a partial barrier to the temperature extremes of the continental climate of eastern Washington.

The normal annual precipitation near Bremerton is 38.33 inches. The rainy season extends from October to March and accounts for more than 75 percent of the yearly precipitation.

The mean annual temperature is 51.4°F. Normally, January is the month with the lowest average temperature of 39°F and July is the month with the highest average temperature of 64.5°F.

The average annual mean wind speed at the Seattle-Tacoma Airport is 9.0 miles per hour (mph), with a recorded maximum speed of 1-minute duration of 49 mph. Prevailing winds are from the southwest.

The mean annual relative humidity at the Seattle-Tacoma Airport at 4:00 a.m. (PST) is 83 percent, decreasing to 62 percent by 4:00 p.m. There is an average of 43.4 days per year that fog reduces visibility to 0.25 mile or less. The mean annual percent of possible sunshine is 46 percent. The month with the greatest mean percent of possible sunshine is July with 65 percent and the month with the least is December with 21 percent (Navy 1991a).

4.1.1.7.2 Air Quality. An area can be designated by the Environmental Protection Agency as having air quality that is better than defined by the National Ambient Air Quality Standards (attainment) or as exceeding one or more of those standards (nonattainment for one or more pollutants). The Code of Federal Regulations, Title 40, Part 81, states that the Air Quality Control Region for the shipyard is better than national standards for total suspended particulate matter and SO_2. The area has no specific classification for ozone, carbon monoxide, and NO_2. The nearest Class I Area is the Olympic National Park, approximately 24 kilometers (15 miles) from the shipyard.

4.1.1.7.3 Existing Radiological Conditions. Radiological facilities at all naval shipyards are designed to ensure that there are no uncontrolled discharges of radioactivity in airborne exhausts. Radiological controls are exercised to preclude exposure of working personnel to airborne radioactivity exceeding federal limits. Air exhausted from radiological work facilities is passed through high-efficiency particulate air filters and monitored during discharges. The annual airborne radioactivity emissions from the shipyards do not result in any measurable radiation exposure to the general public. Calculations of site radioactive airborne emissions for 1992 have been performed as described in Attachment F. These calculations have shown that emissions of radionuclides from each shipyard result in an effective dose equivalent of less than 0.1 mrem per year to any member of the general public.

4.1.1.8 Water Resources

4.1.1.8.1 Surfaca Water. Numerous freshwater sources are found in Kitsap County, with numerous lakes dotting the county's landscape. Kitsap Lake, in west Bremerton, is one of the largest at 238 acres. Lakes and reservoirs are used for recreation and other public uses. Water for the city of Bremerton comes from surface and groundwater supplies.

Freshwaters in the Bremerton area are monitored by the Washington State Department of Ecology. Puget Sound Naval Shipyard has no important surface freshwaters.

Sinclair Inlet is located in Puget Sound. It is a narrow body of marine water approximately 1.1 miles wide at its widest point and approximately 3.5 miles long. A majority of the shoreline of Sinclair Inlet has been developed. The dominant feature is the shipyard, lying on the northern shore. The city of Port Orchard borders the southern shore. Localized areas of Sinclair Inlet contain toxic chemicals as a result of historic urban and industrial activities. Contaminants of concern include polychlorinated biphenyls (PCBs); polycyclic aromatic hydrocarbons (PAH); and toxic metals, such as chromium and mercury (PTI 1990). Fish taken from these localized areas show elevated concentrations of PCBs, mercury, and chromium.

Puget Sound tides are of the twice-daily, mixed type with two unequal highs and two unequal lows per day. Tides in the inlet are similar to those in Seattle, the primary reference station. The principal forces that produce currents in Sinclair Inlet are tidal. Generally, weak currents oscillate in direction moving water in and out of the inlet. The flushing capacity of the inlet is low due to low freshwater input (Navy 1991a).

Based on Flood Insurance Rate Map (FIRM) COMMUNITY-PANEL No. 530093 0015 and topographical maps, the Puget Sound Naval Shipyard is not in the 100 or 500 year floodplain.

4.1.1.8.2 Groundwater. Groundwater is generally found within 100 feet of the ground surface in sand and gravel layers caused by material from receding glaciers. The rate of groundwater recharge in Kitsap County is estimated to be approximately 12 inches annually, equating to approximately 0.5 million gallons per day per square mile. The nature of the geology in the area is such that a well in almost any location can tap a number of aquifers at different depths. The quality of most groundwater near Bremerton is good. Groundwater is used for approximately 35 percent of the public water supply for Bremerton. Groundwater at Puget Sound Naval Shipyard is poor due to salinity caused by intrusion from Sinclair Inlet. (Navy 1991a).

4.1.1.8.3 Existing Radiological Conditions. The normal activities associated with current naval nuclear operations at all naval shipyards do not result in the intentional discharge of any radioactive liquid effluent. However, there were occasions, primarily in the early 1960's, when measurable levels of radioactivity were discharged with liquid effluent. In all cases, effluent releases were less than permitted under the then current limits imposed by state and federal agencies.

The United States Environmental Protection Agency Office of Radiation Programs has performed monitoring of the water, plant life, aquatic life, and sediment in the vicinity of Puget Sound Naval Shipyard. The purpose of the survey was to determine if operations related to U.S. Navy nuclear warship activities resulted in releases of radionuclides which could contribute to significant population exposure or contamination of the environment. "Radiological Surveys of Naval Facilities on Puget Sound" (Lloyd and Blanchard 1989) discusses the most recent Environmental Protection Agency monitoring data. Pertinent conclusions are as follows:

1. "A trace amount of cobalt-60 (0.04 pCi/g+/-0.01 pCi/g) was detected in one sediment sample at PSNS. All other radioactivity detected in the 80 sediment samples is attributed to naturally occurring radionuclides or fallout from past nuclear weapons tests and the Chernobyl reactor accident in 1986."

2. "Results of core sampling did not indicate any previous deposit of cobalt-60 in the sediment."

3. "Water samples contained no detectable levels of radioactivity other than those occurring naturally."

4. "External gamma-ray measurements did not detect any increased radiation exposure to the public above natural background levels."

5. "Based on the current radiological surveys, shipyard and nuclear-powered warship operations have resulted in no increases in radioactivity that would result in major population exposure or contamination of the environment."

Environmental monitoring is conducted by the shipyard. The results of this monitoring program corroborate the Environmental Protection Agency's conclusions.

4.1.1.9 Ecological Resources

4.1.1.9.1 Terrestrial Ecology. Vegetation and wildlife on Puget Sound Naval Shipyard are limited to "open spaces," noncontiguous, undeveloped areas which comprise approximately 46 acres of the entire Bremerton Naval Complex (Navy 1991a). Most of these areas have been previously disturbed and are currently landscaped with native and ornamental trees and shrubs.

Tree species include Douglas fir (Pseudotsuga menziesii), vine maple (Acer circinatum), big leaf maple (Acer macrophyllum), western red cedar (Thuja plicata), madrone (Arbutus menziesii), and western hemlock (Tsuga heterophylla). There are various types of thick underbrush present such as salal (Gaultheria shallon), sword fern (Polystichum sp.), Oregon grape (Berberis nervosa), and rhododendron (Rhododendron spp.) (Navy 1986).

Because of its location on the Pacific flyway, Puget Sound exhibits a diverse avifauana from an influx of seasonal migrants. Many of the migrants, particularly waterfowl, remain and overwinter in the sound because of the mild climate, abundance of bays and coves, and the availability of food. Due to the extensive industrial nature of the shipyard, its resident bird community is characterized by "urban species." Resident bird species include Stellar's jay (Cyanocitta stelleri), starling (Sturnus vulgaris), flicker (Colaptes spp.), American crow (Corvus brachyrhynchos), black-capped chickadee (Parus atricapillus), goldfinch (Spinus tristis), pigeon (Columba fasciata), robin (Turdus migratorius), golden-crowned kinglet (Regulus satrapa), evening grosbeak (Hesperiphona vespertina), and ring-necked pheasant (Phasianus colchicus) (Navy 1986). In addition, numerous glaucous-winged gulls (Larus glaucescens) inhabit the waterfront areas.

Although abundant mammal populations originally existed in the Puget Sound area, the current populations of mammals at the shipyard are extremely limited. The only mammals currently reported at the shipyard are gray squirrels (Sciurus griseus), mice, and shrews (Navy 1990a).

With few exceptions, reptiles and amphibians are not particularly abundant in the Puget Sound area. The lack of suitable habitat restricts the population of reptiles and amphibians at the shipyard to garter snakes, salamanders, newts, and frogs (Navy 1990a).

No environmental concerns associated with vegetation or wildlife have been identified at the shipyard.

4.1.1.9.2 Wetlands. There are no freshwater wetlands on the shipyard. There are no streams, rivers, ponds, or lakes located on the shipyard (Navy 1986). The majority of the shipyard is developed and covered with an impervious surface. The shipyard does own 338 acres of water area (deep-water tidal property) along the waterfront.

4.1.1.9.3 Aquatic Ecology. Salt marsh and brackish marsh communities formerly existed along much of the shoreline of Puget Sound. For a number of years, these areas were perceived as swampy wastelands and thousands of acres were diked, drained, and reclaimed.

The original landform of the shipyard has been greatly altered to accommodate its continuing development. Projects have increased the usable land by filling in the marsh area in the northwest corner and by extending the shoreline with quaywalls and landfill. The shoreside of the shipyard consists primarily of riprap, concrete bulkheads, and old wooden piers. Marine vegetation along the shipyard shoreline consists primarily of sea lettuce (Ulva lactuca), rockweed (Fuchus distichus), and debris of algae that have been dislodged from their subtidal moorings and carried inshore. There are no waterfront areas at the shipyard that have clam beds, eelgrass, kelp beds, or similar habitat (Navy 1986).

Resident fish populations inhabiting the shipyard intertidal shoreline include sculpins (Cottidae), surf perch (Embiotocidae), and flatfish (Pleuronectidae). Migratory fish species include Pacific salmon (Oncorhynchus spp.), sea-run cutthroat trout (Oncorhynchus clarki), Pacific tomcod (Microgadus proximus), Pacific cod (Gadus macrocephalus), Pacific herring (Clupea harengus pallasii), rockfish (Sebastes spp.), and two or three species of migratory smelt (Osmeridae) (Navy 1986). There is near-shore migration of juvenile salmon and other fish species annually, from March 15 to June 15. Herring mill in the vicinity of the shipyard from January 20 through April 15 (Navy 1991a). No recreational or commercial fishing is allowed within the confines of the shipyard.

4.1.1.9.4 Endangered and Threatened Species. As required under Section 7 of the Endangered Species Act of 1973, the responsible agency of a major federal action must conduct a biological assessment to identify any endangered or threatened species which are likely to be affected by such action. The United States Fish and Wildlife Service had previously provided a list of endangered and threatened species that may be in the Bremerton area (Navy 1991a). The list included one species, the bald eagle (Haliaeetus leucocephalus). Wintering bald eagles may occur in the Bremerton area from about October 31 through March 31.

Bald eagles are regularly seen along most of the inland waters of Puget Sound. Eagles are active during the day and feed on a variety of animals (preferring fish or waterfowl) and carrion. They nest and rest most often in conifers, choosing large, open-crowned trees near water (Navy 1991a). Eagles are capable of tolerating a certain amount of intrusion and change; however, they tend to seek privacy for rearing their young.

Although no eagles have been reported nesting on the shipyard, there are several active nests within 1 mile of the shipyard (Navy 1991a). Trees suitable for perching and roosting are found in the non-industrialized area at the shipyard, but not near the waterfront. Bald eagles may feed within Sinclair Inlet anywhere and at any time. It is not likely that eagles feed on fish near the shipyard on a regular basis because of the high level of human activity and the variability of fish populations. Eagles in this area feed primarily on seagulls and other birds (Navy 1991a).

Marine mammals are afforded full federal protection under the Marine Mammal Protection Act of 1972. Pinnipeds (seals and sea lions) and cetaceans (whales, dolphins, and porpoises) that regularly or occasionally are found in central Puget Sound include the Pacific harbor seal (Phoca vitulina), California sea lion (Zalophus californianus), killer whale (Ordinus orca), Dall porpoise (Phocoenoides dalli), and harbor porpoise (Phocoena phocoena) (Navy 1991a).

The National Marine Fisheries Service had previously provided a list of endangered and/or threatened species under its jurisdiction that may occur in Puget Sound waters in support of the "Final Programmatic Environmental Impact Statement Fast Combat Support Ship (AOE-6 Class) U.S. West Coast Homeporting Program" (Navy 1991a). The list included two endangered mammals, the gray whale (Eschrichtius robustus) and the humpback whale (Megaptera novaeangliae); one threatened mammal, the Steller sea lion (Eumetopias jubatus); and one endangered turtle, the leatherback sea turtle (Dermochelys coriacea).

None of the sensitive, threatened, or endangered species are represented in the aquatic life of the shipyard (Navy 1991a).

4.1.1.10 Noise

Puget Sound Naval Shipyard is an existing industrial-type environment characterized by noise from truck and auto traffic; ship loading cranes and related diesel-powered equipment; and continuously operating transmission lines for steam, fuel, water, and related compressors for those and other liquids. In addition, new construction of buildings, reconstruction and rehabilitation activities for streets, buildings, parking lots, and ships all contribute to an industrial environment. Primary noise sources are located along the naval shore support facilities (piers and associated land-side facilities) and are dampened to the residential areas by the hills adjacent to the industrial area.

4.1.1.11 Traffic and Transportation

Primary regional land access to the Seattle/Tacoma/Bremerton area is achieved via two interstate highways, I-90 and I-5. Major transportation corridors in Kitsap County are based upon a network of state routes. The county's municipalities and population centers are accessed by State Routes (SR) 104, 303, 304, 305, and 308. The major thoroughfare in south Kitsap County is SR 16, which runs south from Bremerton to Tacoma and connects with I-5 in Tacoma.

Bremerton's primary access routes include SR 3, which is a major north-south thoroughfare that travels through western Bremerton; SR 303, which originates within Bremerton as Warren Avenue and continues through eastern Bremerton to Silverdale; SR 304, which travels through Bremerton as Callow Avenue, Burwell Street, and Washington Avenue; Kitsap Way, which turns into 6th Street within the city; 11th Street, which provides local east-west circulation; and Wycoff, Montgomery, and Naval avenues, which provide local north-south circulation. The proposed Gorst to Bremerton Connector is a road-widening project that will improve accessibility to downtown Bremerton from SR 3 and SR 16.

Kitsap Transit provides transportation service to various areas of Kitsap County including population centers, ferry docks, and other activity centers, through a Public Transit Benefit Authority. In addition, tours and charters are available locally through Cascade Trailways which also offers a twice daily scheduled run to Tacoma. Taxi service is also available throughout the Kitsap County area.

Bremerton National Airport, used for general aviation, is the largest of three airfields located in Kitsap County and is located near SR 3 south of Bremerton. The other two airfields in the county are Port Orchard Airport and Apex Airpark near Silverdale.

Two ferry systems provide services to the Bremerton area. The Washington State Ferry System provides numerous daily runs from Bremerton, Kingston, Bainbridge Island, and Southworth to the Seattle area. There is also a state ferry run in the northern part of the county connecting Kingston to Edmonds, Washington, north of Seattle. In addition to the cross sound service provided by the Washington State Ferry System, Horluck Transportation Company runs a passenger-only service connecting downtown Port Orchard to Bremerton.

Burlington Northern Railroad provides scheduled and on-demand freight rail service to a number of locations in the southern and central portions of Kitsap County. A Navy-owned spur line from Shelton, Washington, provides additional rail service to the shipyard and Bangor Naval Submarine Base.

Naval spent nuclear fuel has been removed from Navy nuclear-powered ships and transported to the Idaho National Engineering Laboratory Expended Core Facility (ECF) for examination and evaluation as a routine part of their operating cycle. Starting in 1962, the naval spent nuclear fuel originating at Pearl Harbor Naval Shipyard was transported by ocean vessel to Puget Sound Naval Shipyard for subsequent rail shipment to ECF. From 1962 to the present, a total of 20 naval spent nuclear fuel shipments have been made from Pearl Harbor Naval Shipyard to Puget Sound Naval Shipyard, then on to ECF. In 1966, Puget Sound Naval Shipyard began removing naval spent nuclear fuel from Navy nuclear-powered ships and transporting it by rail to ECF. From 1966 to the present, a total of 115 shipments of naval spent nuclear fuel originating at Puget Sound Naval Shipyard have been made to ECF. Attachment A provides a list of the spent nuclear fuel shipments made to date by year and by originating shipyard. Attachment A also contains detailed descriptions of the shipping containers used for naval spent nuclear fuel shipments from shipyards.

Puget Sound Naval Shipyard has 23 miles of railroad tracks, 8 piers, 4 mooring sites, and 6 large dry docks.

4.1.1.12 Occupational and Public Health and Safety

4.1.1.12.1 Occupational Radiological Health and Safety. The Navy has well established and effective Occupational Safety, Health, and Occupational Medicine programs at all of its shipyards. In regard to radiological aspects of these programs, the Naval Nuclear Propulsion Program policy is to reduce to as low as reasonably achievable the external exposure to personnel from ionizing radiation associated with naval nuclear propulsion plants. These stringent controls on minimizing occupational radiation exposure have been successful. No civilian or military personnel at Navy sites have ever exceeded the federal accumulated radiation exposure limit which allows 5 rem exposure for each year of age beyond age 18. Since 1967, no person has exceeded the federal limit which allows up to 3 rem per quarter year and since 1980, no one has received more than 2 rem per year from radiation associated with naval nuclear propulsion plants. The average occupational exposure of each person monitored at all shipyards is 0.26 rem per year. The average lifetime accumulated radiation exposure from radiation associated with naval nuclear propulsion plants for all shipyard personnel who were monitored is 1.2 rem. (NNPP 1994a) This corresponds to the likelihood of a cancer fatality of 1 in 2083.

The Navy's policy on occupational exposure from internal radioactivity is to prevent radiation exposure to personnel from internal radioactivity. The limits invoked to achieve this objective are one-tenth of the levels allowed by federal regulations for radiation workers. As a result of this policy, no civilian or military personnel at shipyards have ever received more than one-tenth the federal annual occupational exposure limit from internal radiation exposure caused by radioactivity associated with naval nuclear propulsion plants.

For work operations involving the potential for spreading radioactive contamination, containments are used to prevent personnel contamination or generation of airborne radioactivity. The controls for contamination are so strict that precautions sometimes have had to be taken to prevent tracking contamination from fallout and natural sources into radiological areas because the contamination control limits used in these areas were well below the levels of fallout and natural contamination occurring outside in the general public areas. A basic requirement of contamination control is monitoring all personnel leaving any area where radioactive contamination could possibly occur. Workers are trained to survey themselves (i.e., frisk), and their performance is checked by radiological control personnel. Frisking of the entire body is required, normally using sensitive hand-held survey instruments. Major work facilities are equipped with portable monitors, which are used in lieu of hand-held friskers. These stringent controls to protect the workers and the public from contamination have proven effective in the past.

In 1991, researchers from Johns Hopkins University, Baltimore, Maryland, completed a very comprehensive epidemiological study of the health of workers at the six naval shipyards and two private shipyards that service the Navy's nuclear-powered ships (Matanoski 1991). This independent study evaluated a population of 70,730 civilian workers over a period from 1957, beginning with the first overhaul of the first nuclear-powered submarine, USS NAUTILUS, through 1981, to determine whether there was an excess risk of leukemia or other cancers associated with exposure to low levels of gamma radiation.

The Johns Hopkins study found no evidence to conclude that the health of people involved in work on U.S. naval nuclear-powered ships has been adversely affected by exposure to low levels of radiation incidental to this work. Additional studies are planned to investigate the observations and update the shipyard study with data beyond 1981.

The radiation exposure during normal operations at each shipyard for workers who have their radiation levels monitored is determined based on the annual radiation exposure of 0.26 mrem per worker for all shipyards based on Naval Nuclear Propulsion Program Report NT-94-2 (NNPP 1994a). The total number of shipyard personnel monitored for radiation exposure associated with the Naval Nuclear Propulsion Program has been about 164,000.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to transportation workers for all historical shipments is 16.6 person-rem, which statistically corresponds to 0.0066 cancer fatalities. The maximum exposed individual (MEI) is a transportation worker, since the workers are closer to the shipment for a longer time than any member of the general population. Under the limiting assumption that the same worker is associated with every shipment for the entire historical period, this person would receive a total exposure of 7.5 rem over the approximately 40-year period, or about 0.19 rem per year, which is within DOE standards for occupationally exposed individuals. The radiation exposures to workers correspond to much less than one incident cancer, which means that it is unlikely that there have been any past health impacts due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.1.12.2 Occupational Non-radiological Health and Safety. The shipyard has an occupational health/preventive medicine unit and a branch clinic (industrial dispensary) which are run by Naval Hospital Bremerton. Personnel may also be taken to Harrison Memorial Hospital as needed.

The shipyard maintains two fire stations with approximately 50 personnel. The shipyard has a fire department that is fully equipped for structural and industrial firefighting and hazardous material spill response.

The shipyard has a security force of approximately 177 personnel providing law enforcement services, emergency services, security clearances, and parking and traffic control for the Bremerton Naval Complex.

In the non-radiological Occupational Safety, Health, and Occupational Medicine area, the Navy complies with the Occupational Safety and Health Administration regulations. The Navy policy is to maintain a safe and healthful work environment at all naval facilities. Due to the varied nature of work at these facilities, there is a potential for certain employees to be exposed to physical and chemical hazards. These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to high noise levels or heat stress. In addition, employees are monitored for their exposure to chemical hazards such as organic solvents, lead, asbestos, etc., and where appropriate are placed into medical surveillance programs for these chemical hazards.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact due to the historical shipment of naval spent nuclear fuel over the entire history of such shipments.

4.1.1.12.3 Public Radiological Health and Safety. In order to quantify the exposures resulting from normal shipyard radiological releases to the general public, detailed analyses were performed based on very conservative estimates of radioisotopic releases since releases began. Attachment F provides detailed annual release values used in the analyses.

The GENII computer code (Napier et al. 1988) was used to calculate exposures to human beings due to the estimated radionuclide releases from normal operations at the shipyards.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from stored fuel. The population data used to calculate population exposures were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F.

The hypothetical exposures calculated in Attachment F for the period 1995 through 2035 were adjusted from an annual basis (1995) to the historical basis by multiplying by 38 years and by a factor of 1.7 to take into consideration variations in the number of ships and operations.

The calculated accumulated exposures through 1995 to the general population within 50 miles of the site (about 3 million people) are 1.3 person-rem. To provide perspective, the exposures received due to natural radiation sources through 1995 are approximately 34 million person-rem, based on 0.3 rem per person per year.

The results of environmental monitoring as described in Naval Nuclear Propulsion Program Report NT-94-1 show that Naval Nuclear Propulsion Program activities had no distinguishable effect on normal background radiation levels at site perimeters (NNPP 1994b).

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to the general population for all historical shipments is 1.95 person-rem, which statistically corresponds to 0.00098 cancer fatalities.

All of the radiation exposures to the general population correspond to much less than one incident cancer, which means that it is unlikely that there has been any past health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.1.12.4 Public Non-radiological Health and Safety. Kitsap County has two hospitals, Harrison Memorial Hospital in East Bremerton and the Naval Hospital Bremerton.

Fire protection in Kitsap County is administered by local fire departments and fire districts. The Bremerton Fire Department has three stations. Police protection services in Kitsap County are provided by the County Sheriff's Office, the city of Bremerton, and other local jurisdictions providing mutual aid.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.1.13 Utilities and Energy

Public water systems supply the majority of Kitsap County's water requirements. Wells are the primary source of water for outlying areas. The Bremerton watershed, located in the Gold Mountain area, is the largest single source for the city of Bremerton. A dam on the Union River provides the water storage reservoir. Freshwater is received at the shipyard from the city of Bremerton public water supply. A saltwater system is used at the piers and dry docks for firefighting, flushing, and cooling of ship systems. Refer to Section 4.1.1.8 for further discussion of water resources.

The Bonneville Power Administration and the Puget Sound Power and Light Company provide electrical service to Kitsap County. Rates for electrical power are relatively low due to the close proximity of hydroelectric facilities. The shipyard steam plant provides emergency electrical service, as well as steam.

A limited industrial natural gas distribution system exists in the east end of the complex. A majority of the military support area in the west end of the shipyard has been converted to natural gas. Natural gas is used industrially, since most of the buildings are heated by steam. The forge shop, foundry, and pipe shops are the largest users of gas. The only natural gas space heating in the industrial area is in the foundry (Navy 1991a).

Shipyard freshwater usage is approximately 676 million gallons annually.

Electricity usage is about 247,000 megawatt hours annually.

4.1.1.14 Materials and Waste Management

All of Bremerton's sewage is treated by the Bremerton Wastewater Utility at the Charleston Water Treatment Plant, located at the intersection of State Routes 3 and 304. This plant was completed in 1985 to provide secondary treatment. Navy ships produce sewage which is transferred to the city of Bremerton's Water Treatment Plant. Berthed ships generally have on-board pumps to discharge their sewage into the piers' sewage lines. In some cases, portable pumps are utilized to lift and pressurize.

Most of the solid waste produced by the shipyard is hauled by a private contractor to the privately owned Olympic View landfill. Miscellaneous acid and alkaline cleaning solution (concentrated liquid) is collected, stored on base, and eventually shipped to hazardous waste treatment storage and disposal facilities. Solid and liquid chemical wastes are collected, characterized, packaged, and labeled at the shipyard, then turned over to a contractor for disposal. A facility at the Manchester Fuel Department provides for the collection and recycling of oily wastes, sludges, and bilge waters (Navy 1991a).

Solid radioactive waste materials are packaged in strong, tight containers, shielded as necessary, and shipped to burial sites licensed by the U.S. Nuclear Regulatory Commission or a State under agreement with the U.S. Nuclear Regulatory Commission. Shipyards and other shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. During 1992, approximately 851 cubic yards of routine low-level radioactive waste containing 59 curies were shipped from the shipyard for burial.

Waste which is both radioactive and chemically hazardous is regulated under both the Atomic Energy Act and the Resource Conservation and Recovery Act (RCRA) as "mixed waste." Within the Naval Nuclear Propulsion Program, concerted efforts are taken to avoid commingling radioactive and chemically hazardous substances so as to minimize the potential for generation of mixed waste. For example, these efforts include avoiding the use of acetone solvents, lead-based paints, lead shielding in disposal containers, and chemical paint removers. Radioactive wastes, including those containing chemically hazardous substances, are handled in accordance with long-standing Program radiological requirements. Such handling includes solidification to immobilize the radioactivity, separation of the radioactive and chemically hazardous substances, removal of liquids from solids, and other simple techniques. A determination is then made as to whether the resulting waste is hazardous. As a result of Program efforts to avoid the use of chemically hazardous substances in radiological work, Program activities typically generate only a few hundred cubic feet of mixed waste each year. This small amount of mixed waste, along with limited amounts of mixed waste from Program work conducted prior to 1987, will be stored pending the licensing of commercial treatment and disposal facilities.

Since the complex contains so much pavement, surface drainage is required. An extensive storm sewer system exists, which is separate from the sanitary sewer system. The storm sewer discharges runoff into Sinclair Inlet through 15 outfalls (Navy 1991a).

4.1.2 NORFOLK NAVAL SHIPYARD: PORTSMOUTH, VIRGINIA

4.1.2.1 Overview

Norfolk Naval Shipyard is located in the Tidewater region of Virginia as shown on Figure 4.1.2-1. The shipyard is contiguous with the city of Portsmouth at 36° 49' 5" north latitude and 76° 17' 38" west longitude. The shipyard consists of over 1,200 acres and includes over 500 administrative, industrial, and support structures and 4 miles of shoreline. Figure 4.1.2-2 provides a vicinity map, and Figure 4.1.2-3 provides the site map for the Norfolk Naval Shipyard. For information, Figures 4.1.2-4 and 4.1.2-5 show the location and vicinity of Newport News Shipbuilding. Six city areas are within 15 miles of the shipyard: Portsmouth, Chesapeake, Norfolk, Virginia Beach, Hampton and Newport News, and Suffolk. The cities of Portsmouth to the immediate west, Chesapeake to the south, and Norfolk to the north and east surround the shipyard. The land area of Norfolk is separated from the shipyard proper by the Southern Branch of the Elizabeth River to the east and by the confluence of the Southern, Eastern, and Western Branches of the Elizabeth River to the north.

4.1.2.2 Land Use

Over 95 percent of the land area within the boundaries of the shipyard is covered by structures or paved with concrete and asphalt. The shipyard is divided internally into a controlled industrial area and a non-industrial area. All of the piers, dry docks, and work facilities accomplishing naval nuclear propulsion plant work are within the controlled industrial area.

The surrounding six city areas are a mix of urban, suburban, light industrial, and rural areas with the land areas dissected by the numerous rivers, creeks, bays, and wetlands.

Portsmouth is predominantly urban and suburban. The two main industries are the shipyard and the Portsmouth Marine Terminals, which are cargo shipping terminals operated by Virginia International Terminals. There are few undeveloped tracts of land in Portsmouth.

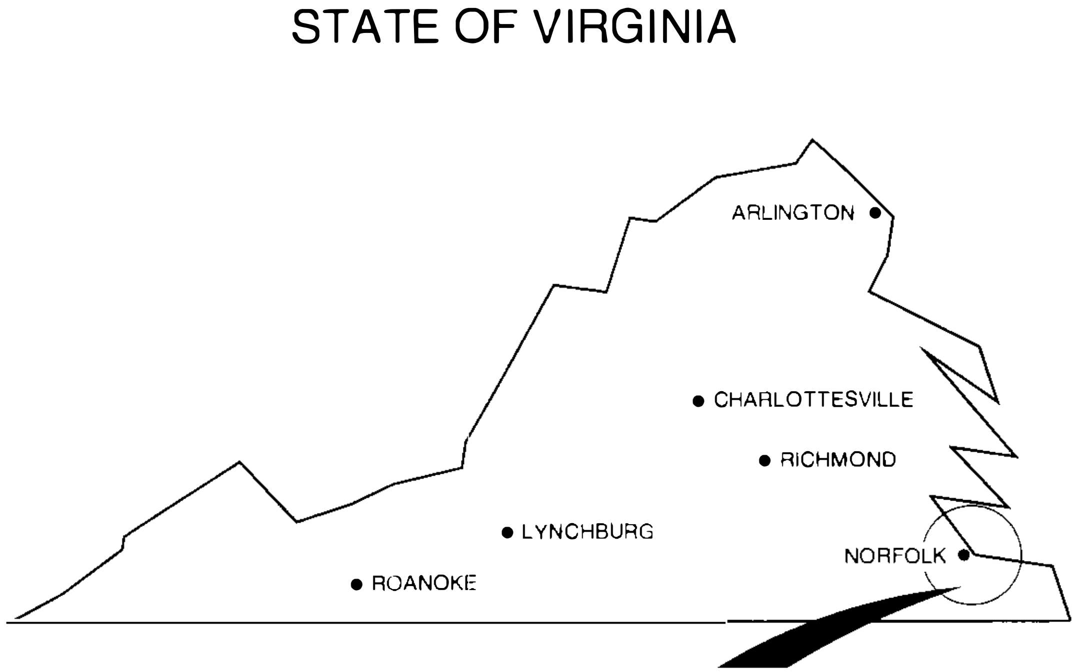


Figure 4.1.2-1. Location of Norfolk Naval Shipyard within Virginia.

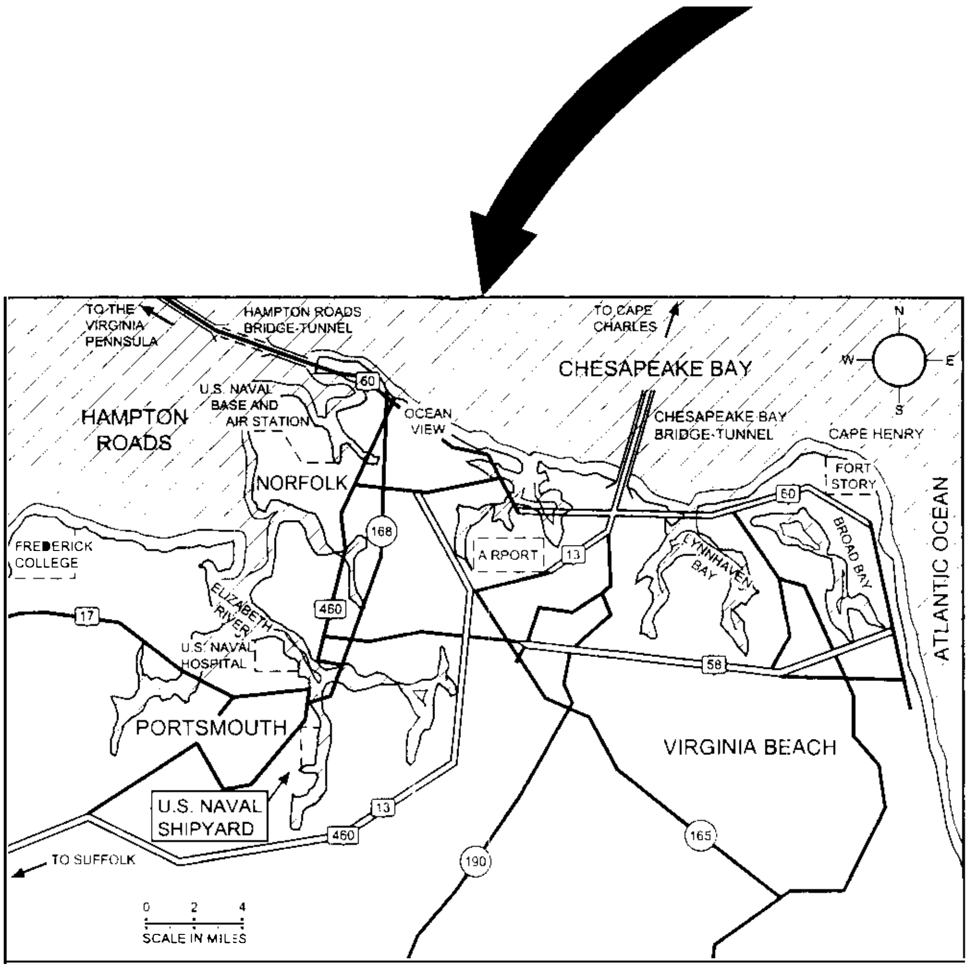


Figure 4.1.2-2. Norfolk Naval Shipyard vicinity map.

Figure 4.1.2-3. Norfolk Naval Shipyard site map.

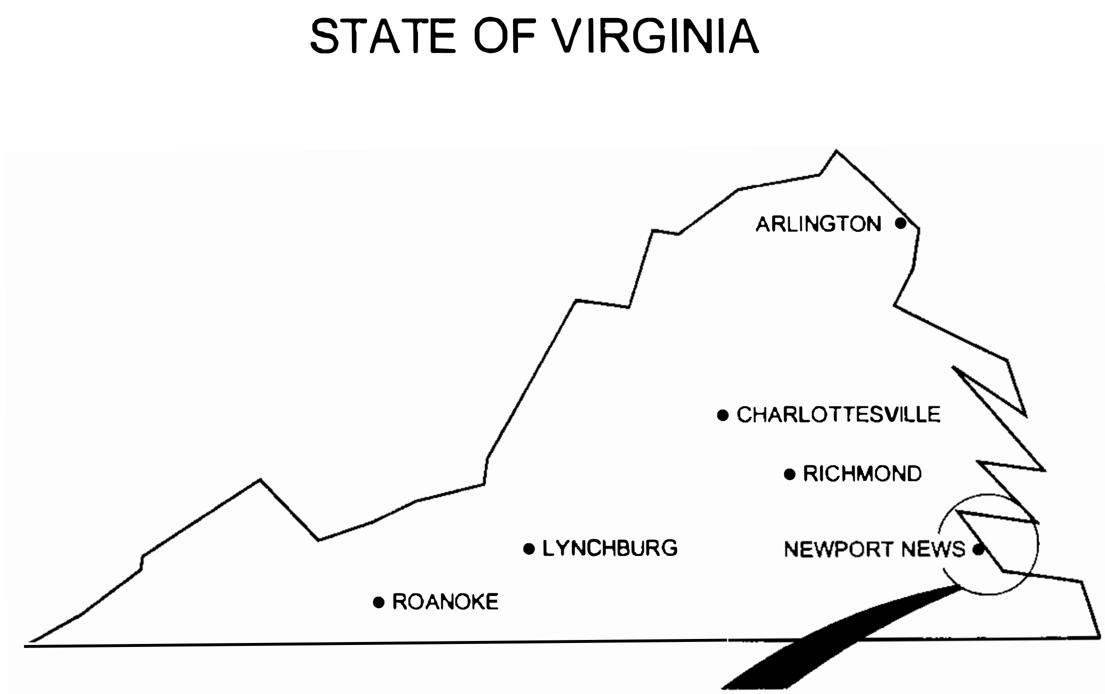


Figure 4.1.2-4. Location of Newport News Shipbuilding within Virginia.

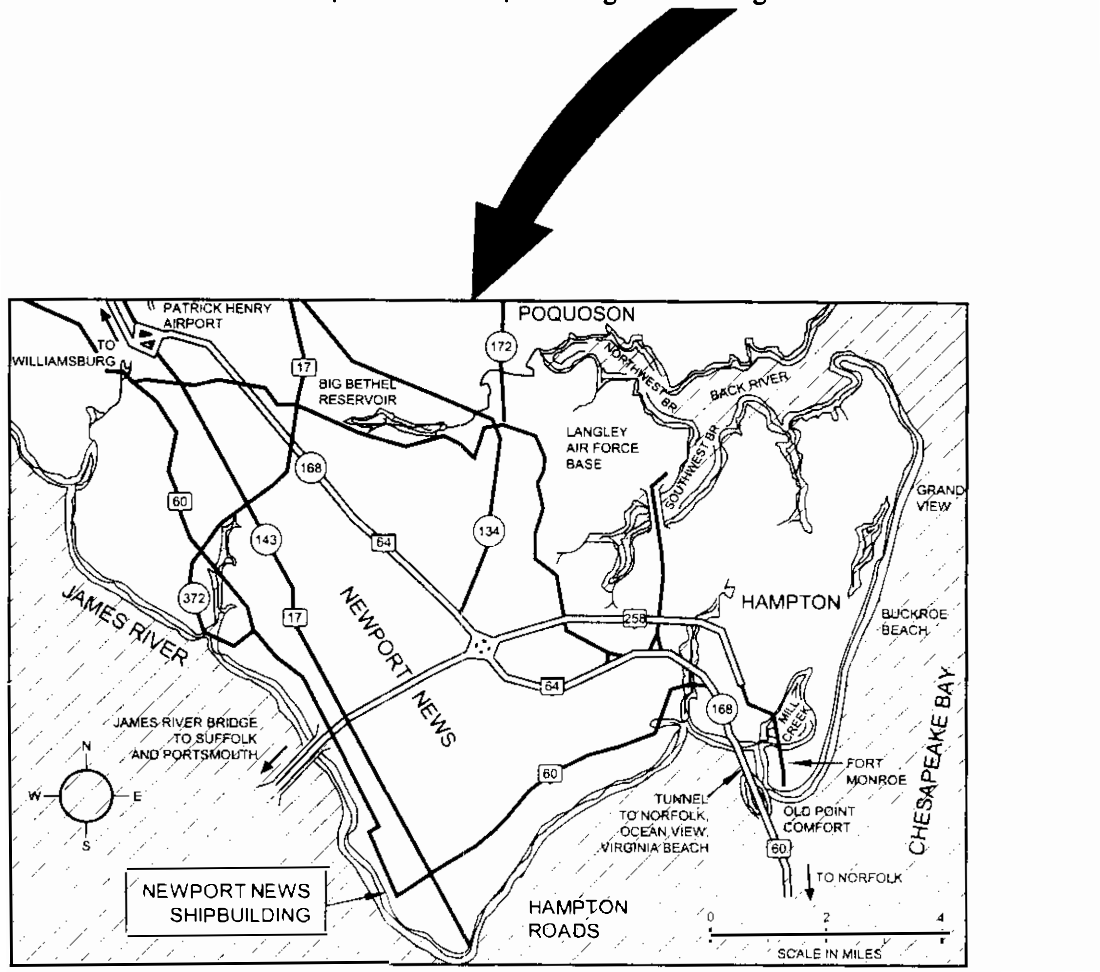


Figure 4.1.2-5. Newport News Shipbuilding vicinity map.

Norfolk is north and east of the shipyard and separated from the Portsmouth land mass by the Elizabeth River. Downtown Norfolk is about 2.5 miles north-northeast of the shipyard and is the financial, cultural, and educational hub of the Southside area. Norfolk is primarily urban and suburban with light industrial centers scattered throughout the city. The Norfolk waterfront has commercial shipyards, coal terminals, various piers for bulk cargo such as gypsum and phosphate, and the Norfolk Naval Base. Like Portsmouth, Norfolk has few undeveloped tracts of land.

The Chesapeake corporate limit adjoins the Norfolk corporate limit just south of the St. Helena Annex and the Portsmouth corporate limit mid-stream of the Southern Branch of the Elizabeth River due east of the shipyard. The majority of the shipyard industrial area is across the river from Chesapeake. The land area immediately along the riverfront is industrial, bulk cargo terminals, and manufacturing. Chesapeake is a mixture of suburban and rural areas. The Western Branch Area adjoins Portsmouth and is primarily suburban with large tracts of undeveloped land currently used for crops to the south and west. Greenbriar adjoins Norfolk and is the central commercial hub of Chesapeake. Great Bridge adjoins Virginia Beach and is primarily residential with commercial corridors and regional shopping areas. The southern part of Chesapeake partially contains the Great Dismal Swamp and is rural with isolated residential areas scattered throughout the region.

Virginia Beach is not contiguous with any shipyard property but is within 15 miles. Virginia Beach adjoins Norfolk and Chesapeake on their eastern borders and fronts the Atlantic Ocean from Cape Henry to the North Carolina state line. The area between the ocean front resort strip and the Norfolk city line has undergone explosive growth over the past 20 years. The area is primarily residential with several commercial corridors connecting various parts of the city. A so-called "Green Line" divides the southern agricultural rural area from the developed areas in the northern part of Virginia Beach. This line has moved south in steps over the years in response to increasing pressure for further development.

Hampton and Newport News are adjoining cities lying on a peninsula formed by the James and York rivers. Newport News Shipbuilding and port facilities for coal and containerized cargo are the major industries. Although within 15 miles, the peninsula cities have historically been isolated from the southside cities economically and demographically as well as politically. This is slowly changing with the opening of the bridge-tunnel connecting western Tidewater with the peninsula. Inclusion of the peninsula cities into the Regional Standard Metropolitan Statistical Area joined the regions demographically. Land use is primarily suburban with several major commercial corridors dissecting and connecting the two cities. A downtown area of Newport News sits at the tip of the peninsula separated from the James River waterfront by coal terminals and the Newport News Shipbuilding facilities. The limited agricultural land is being rapidly supplanted by expanding residential and commercial development.

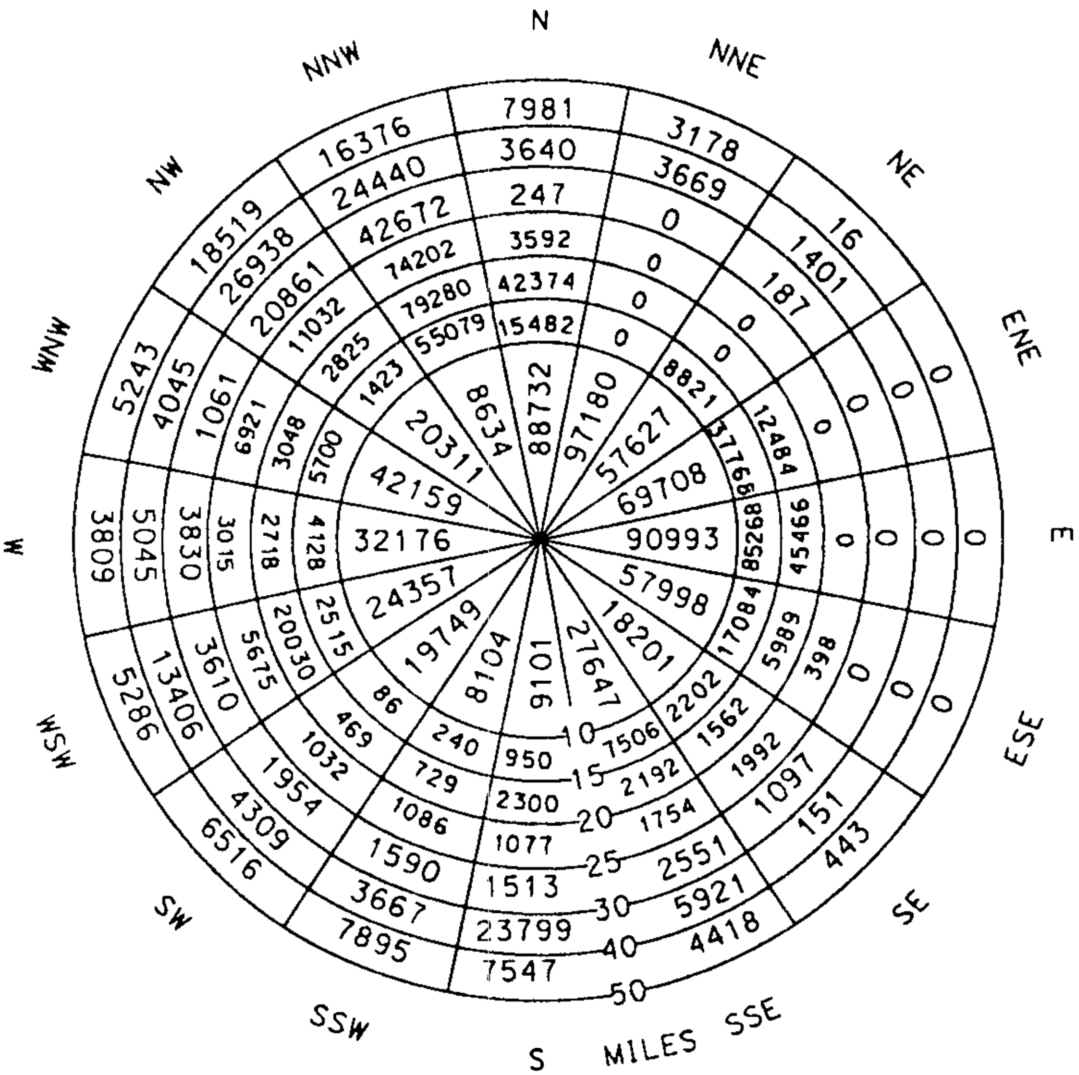
Suffolk is the westernmost of the southside cities. Suffolk is predominantly rural and has substantial land area under cultivation with peanuts, soybeans, and produce vegetables being the major crops. Residential areas are scattered but are becoming more numerous as land in Portsmouth and the Western Branch Area of Chesapeake is developed.

4.1.2.3 Socioeconomics

The shipyard is centrally located in relation to the six city population centers that comprise the Tidewater region. At the time of the 1990 census, approximately 1.5 million persons resided within a 50-mile radius of the shipyard. The six-city metropolitan area houses most of this population. Figure 4.1.2-6 provides a population distribution rose showing the population density and population for principal centers within 50 miles of the shipyard. Population data are based on the 1990 census.

As of 1993, Norfolk Naval Shipyard employed approximately 8,500 civilian personnel. The number of military personnel at the shipyard is typically between 2,000 and 3,000 and can vary at times up to approximately 15,000.

The majority of the labor force that would be employed at the shipyard for construction and operation of the naval spent nuclear fuel area would be expected to reside within about 20 miles from the shipyard. The total calculated population, labor force, and employment within this region for the base year (1995) are presented in Table 4.1.2-1. Projections of employment and population for the years beyond 1995 have not been presented because, as discussed in Section 5, the number of additional jobs that might be created at the shipyard under any alternative could be small.



Miles	People	Cumulative People
0-5	247,051	247,051
5-10	425,626	672,677
10-20	465,718	1,138,395
20-30	192,949	1,331,344
30-40	120,431	1,451,775
40-50	87,227	1,539,002

Based on 1990 Census

Figure 4.1.2-6. 50-mile population distribution around Norfolk Naval Shipyard.

Table 4.1.2-1. Regional employment factors at Norfolk Naval Shipyard.

Regional Employment	Regional Labor Force	Regional Population
498,000	533,000	1,138,400

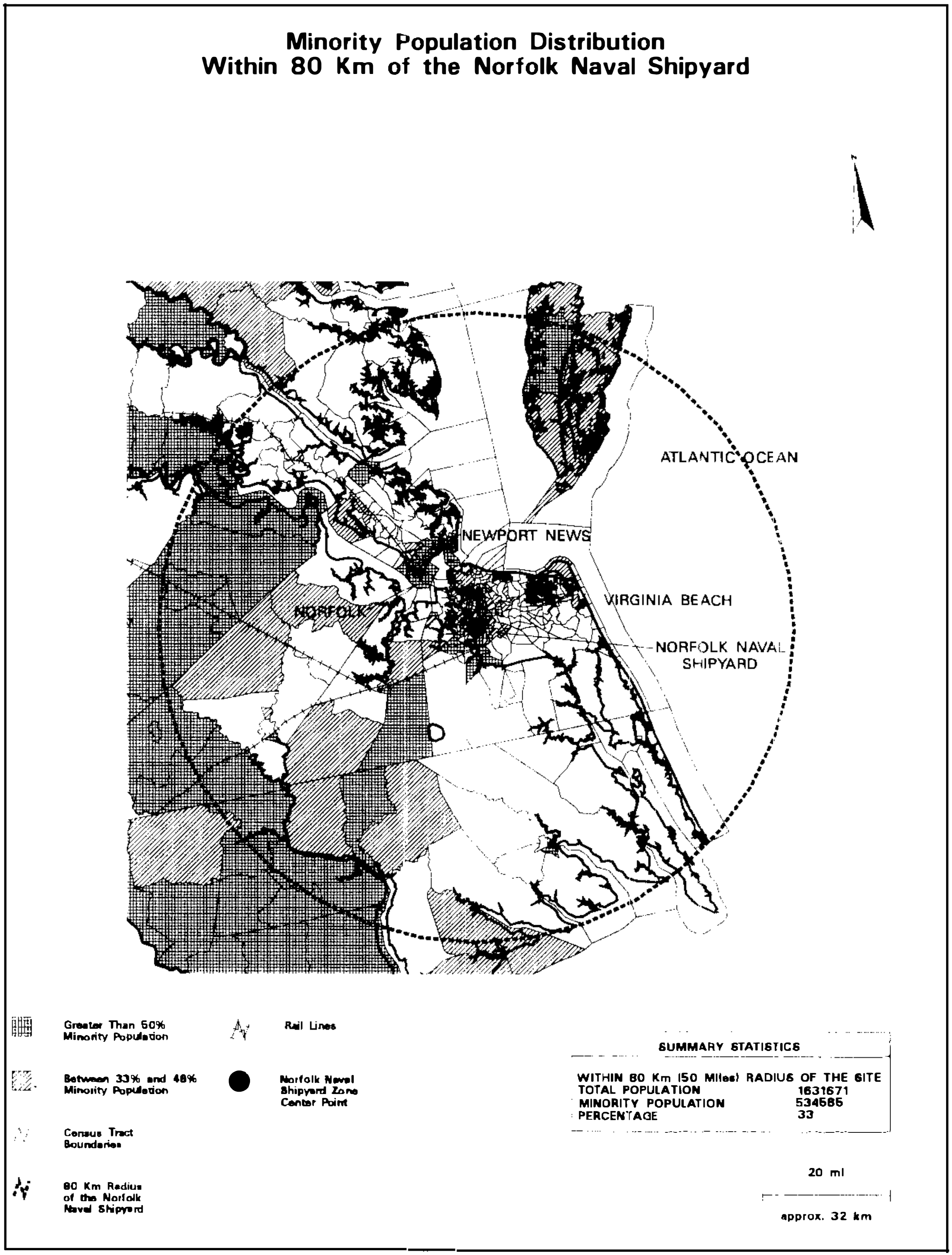
Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the Norfolk Naval Shipyard, consistent with the population data provided in Figure 4.1.2-6.

Figure 4.1.2-7 shows the locations of populations which have more than 50 percent minority members within the 50-mile radius. Minorities make up approximately 33 percent of the total population in this area. These populations have been identified following an approach developed by the Environmental Protection Agency which, for purposes of environmental justice evaluation, defines minority communities as those which have percentages of minorities greater than the average in the region analyzed (EPA 1994).

Figure 4.1.2-8 shows the locations of populations which have more than 25 percent of their members living in poverty, reflecting a common definition of low-income communities (EPA 1993). The U. S. Census Bureau characterizes persons in poverty as those whose income is less than a "statistical poverty threshold." For the 1990 census, this threshold was based on a 1989 income of $12,500 per household.

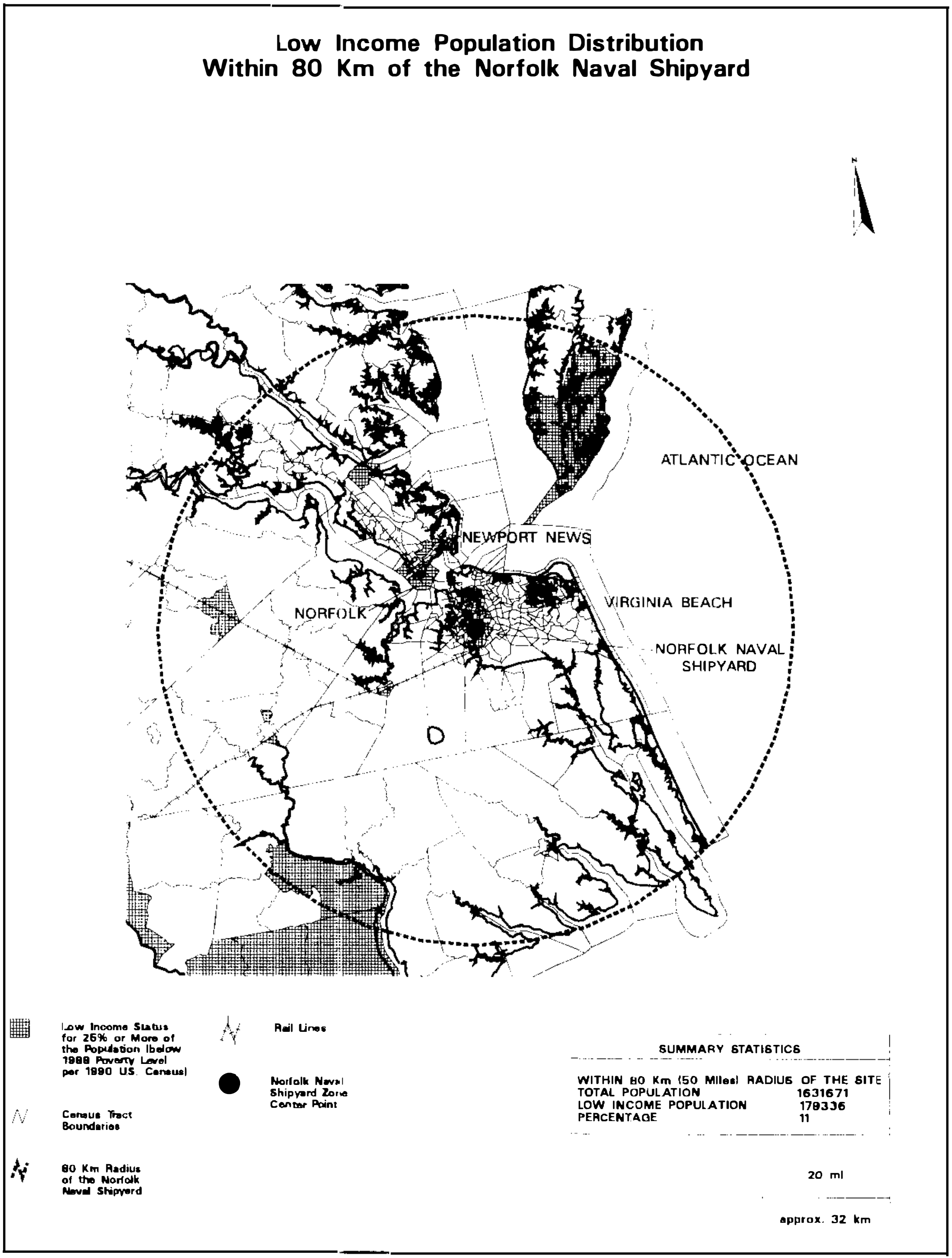
4.1.2.4 Cultural Resources

Founded November 1, 1767 under the British flag, the shipyard pre-dates the United States Navy Department by 30 years. The first drydocking in the western hemisphere occurred at the



Based on 1990 Census

Figure 4.1.2-7. Minority population distribution within 50 miles of the Norfolk Naval Shipyard.



Based on 1990 Census

Figure 4.1.2-8. Low-income population distribution within 50 miles of the Norfolk Naval Shipyard.

shipyard on June 17, 1833. Dry dock 1 is a National Historic Landmark. Over the years, the shipyard has been greatly expanded. Beginning in 1963, the yard was authorized to perform Naval Nuclear Propulsion Program work.

The Naval Shipyard Museum located at the foot of High Street in downtown Portsmouth contains many historical photographs and drawings, valuable artifacts, and archives of records tracing the 226-year history of the shipyard and its close ties to the city of Portsmouth. This museum is open to the public and to researchers.

No prehistoric archaeological sites have been identified at the Norfolk Naval Shipyard. In addition, no submerged cultural resources have been recorded in the immediate vicinity of the shipyard. There are no Native American properties or ceremonial sites in the areas where spent nuclear fuel would be stored. In the area where naval spent nuclear fuel would be stored, there are no historic sites that are potentially eligible or listed on the National Register of Historic Places (NPS 1991). Due to the historic nature of the shipyard, there might be areas of archaeological interest. In the past, artifacts from the early shipbuilding era have been uncovered during construction excavation.

4.1.2.5 Aesthetic and Scenic Resources

The lower Chesapeake Bay - Hampton Roads region is a flat coastal plain with minimal topographic relief. The numerous bays, rivers, and creeks that dissect the region provide access to various wetlands consisting of saltwater marshes, bogs, and swamps. The unique ecology of these wetlands provides habitat for numerous indigenous and migratory species of aquatic and avian wildlife. Area beaches fronting the Atlantic Ocean from Cape Henry southward and along the Chesapeake Bay westward from Cape Henry provide both scenic and recreational opportunities to area residents and visitors.

The shipyard is centrally located in a highly developed urban area and has an industrialized character. The area within the shipyard where the naval spent nuclear fuel would be stored has low visual sensitivity since the area is an industrial site. The original character of the area has been extensively modified in the 300 years that western man has occupied the area.

4.1.2.6 Geology

4.1.2.6.1 General Geology (Coch 1971). The coastal plain is characterized by a series of marine transgressions with extended periods of non-marine erosion and deposition of river sediment. From the surface down to a depth of about 120 feet, the most recent sediments of the Columbia Group occur. Underlying the Columbia Group is the Yorktown Formation (deposits of fine silt, sand, and shells), which, at the location of the shipyard, is about 100 feet thick. The Calvert Formation, with a thickness of about 345 feet, underlays the Yorktown Formation.

The Calvert Formation consists of usually consolidated greenish-brown clays, silty clays, and silicon-based clays over a basic layer of coarse sand. The Calvert clays form an impermeable hard-packed barrier which limits the vertical migration of shallow groundwater. This barrier also isolates the Columbia and Yorktown regional aquifers from deeper lying aquifers contained in permeable formations underlying the Calvert. Extensive studies of the Coastal Plain of Virginia sponsored by the Virginia Division of Mineral Resources have been conducted and published in various bulletins and reports (Teifke and Onuschak 1973; Coch 1971).

4.1.2.6.2 Geologic Resources. There are no unique or economic geological resources in the shipyard region. (Teifke and Onuschak 1973; Coch 1971)

4.1.2.6.3 Seismic and Volcanic Hazards. Seismic risk related to structural damage may be represented in the United States by a relative scale of 0 through 4, with Zone 0 not expected to encounter damage and Zone 4 expected to encounter the greatest seismic risk. The Norfolk Naval Shipyard is located in Zone 1. (UBC 1991) No volcanic hazards exist. The Uniform Building Code seismic classification provides a means for a comparable assessment of the seismic hazard between the alternate sites. If the Record of Decision identifies this site for the interim storage of naval spent fuel, then a detailed seismic evaluation would be conducted. More detailed information regarding the design basis considerations for storage of naval spent nuclear fuel at the shipyard is presented in Attachment D.

4.1.2.7 Air Resources

4.1.2.7.1 Climate and Meteorology. The Tidewater area is nearly surrounded by water with Chesapeake Bay to the north, Hampton Roads to the west, and the Atlantic Ocean to the east. The area contains numerous bays and is traversed by several rivers and creeks. The climate of the region is essentially marine. The land is level and low with an average elevation of 13 feet above sea level.

Based on the 1951 through 1980 period, the average first occurrence of 32 degrees Fahrenheit is November 17 and the average last occurrence is March 23. Temperatures of above 100 degrees are infrequent and below zero temperatures are almost nonexistent. The proximity to the surrounding water modifies the invading air masses. Summer winds are predominantly from the south and southwest, pulling large amounts of moisture up from the Gulf of Mexico. During the summer months, afternoon thunderstorms due to daytime heating of the near surface air are very common. Large areas of high pressure frequently stall just east of the southern coast. These "Bermuda Highs" can lead to extended periods of hot, humid weather with very little precipitation other than scattered thunderstorms. Thunderstorms occasionally spawn isolated tornadic activity throughout the region. Although locally destructive, the tornados move through the area rapidly along with storm centers.

Precipitation is distributed fairly evenly throughout the year and totals about 43 inches on the average. Snowfall is usually light and is frequently gone within 24 hours. Large accumulations do occur but are infrequent. July and August are generally the wettest months due to thunderstorms while November and December are the dryest. Average monthly precipitation is 3.5 inches. Spring weather can begin as early as March but more frequently occurs in April. This is a transitional period between winter and summer weather patterns. During the spring, summer-like days, rain, snow, and cold-humid weather can and frequently do occur during the same week. Mild weather in the fall usually extends through Thanksgiving.

Winter climate is primarily determined by the latitude of the upper level jet stream which steers eastwardly moving arctic air masses. Usually, winters are mild with alternating periods of cold and warm weather. Winter rains are frequent due to the frontal boundaries formed from low-pressure storm cells to the north and moisture-laden Gulf air moved into the area by a high-pressure area to the south. North to northeast winds predominate during the winter months. Northeast winds can affect the Atlantic Coast from the Carolinas northward. Strong northeast winds and heavy rains can cause localized flooding of low-lying areas. Since the Chesapeake Bay is shallow, a strong northeast wind can move large amounts of water from the north end of the bay southward. When this elevated water level is combined with a high tide, flooding occurs. Added to this is the heavy rainfall and poor drainage due to the low elevation. High tide levels 6 to 8 feet above normal are experienced during major northeast winds along with major beach erosion from Cape Henry to Cape Hatteras.

4.1.2.7.2 Air Quality. An area can be designated by the Environmental Protection Agency as having air quality that is better than defined by the National Ambient Air Quality Standards (attainment) or as exceeding one or more of those standards (nonattainment for one or more pollutants). The Code of Federal Regulations, Title 40, Part 81, states that the Air Quality Control Region, in which the shipyard is located, is in marginal nonattainment for ozone and is better than national standards for total suspended particulate matter and SO_2. The area has no specific classification for carbon monoxide and NO_2. The nearest Class I Area is the Swanquarter National Wilderness Area, approximately 161 kilometers (100 miles) from the shipyard.

4.1.2.7.3 Existing Radiological Conditions. Radiological facilities at all naval shipyards are designed to ensure that there are no uncontrolled discharges of radioactivity in airborne exhausts. Radiological controls are exercised to preclude exposure of working personnel to airborne radioactivity exceeding federal limits. Air exhausted from radiological work facilities is passed through high-efficiency particulate air filters and monitored during discharges. The annual airborne radioactivity emissions from the shipyards do not result in any measurable radiation exposure to the general public. Calculations of site radioactive airborne emissions for 1992 have been performed as described in Attachment F. These calculations have shown that emissions of radionuclides from each shipyard result in an effective dose equivalent of less than 0.1 mrem per year to any member of the general public.

4.1.2.8 Water Resources

4.1.2.8.1 Surface Water. Hampton Roads is a relatively wide body of water formed by the confluence of the James, Elizabeth, and Nansemond Rivers. It connects on the east with the Chesapeake Bay. The natural depth of the main part of Hampton Roads ranges from 20 to 80 feet; however, the harbor shoals to less than 10 feet toward shore. Two channels are maintained at a depth of 40 feet by dredging. The currents in Hampton Roads are influenced considerably by the winds and have a velocity of 0.5 m/sec.

The Elizabeth River is the most downriver tributary of the James River. The Elizabeth River system is comprised of a main stem, running from Sewell's Point and Craney Island to Town and Pinner Points, plus four tributary arms: the Lafayette River and the Eastern, Western, and Southern Branches.

Deep navigation channels are maintained from Hampton Roads up the main stem and Southern Branch of the Elizabeth River. Project depths decrease from 45 feet at the mouth to 35 feet between the Norfolk Naval Shipyard and Newton Creek. The channels in the Eastern and Western Branch and Lafayette River are maintained at 25 feet, 14 feet, and 8 feet, respectively.

The Southern Branch of the Elizabeth River is an estuarine body of water in which tidal action brings about a mixing of salt and fresh water. This portion of the river is a slow-moving, heavily sediment-laden body of water. The movement of the water is affected by the narrowness of the channel and the influence of tidal action.

Located along the river banks and in the surrounding territory are extensive and important naval bases and docking facilities, pleasant exurbs and yacht clubs, dry docks and international shipping terminals, the commercial centers of Norfolk and Portsmouth, relatively quiet rural areas, and the Great Dismal Swamp.

Neither the Southern Branch of the Elizabeth River, nor the Hampton Roads Harbor, is fished commercially. Within these waterbodies, it has been established by the Virginia Department of Health that it shall be unlawful for any person, firm, or corporation to take shellfish from the condemned areas for any reason.

Norfolk Naval Shipyard is located on the Southern Branch of the Elizabeth River in a highly industrialized area of the city of Portsmouth, Virginia, 8 miles upstream from the confluence of the James and Elizabeth Rivers. The Southern Branch is a deep-water river which provides access to heavy industry (i.e., ship repairs, gas and oil distribution, etc.) in the vicinity of the shipyard. In addition, the Southern Branch is a major north-south part of the Army Corp of Engineers Intercoastal Waterway System.

The Southern Branch is brackish and is not a source of drinking water. The Southern Branch of the Elizabeth River-Naval Shipyard waterbody extends from Jones and Paradise Creeks to the Downtown Tunnel (Route 264). Shellfish condemnations impact 429 acres. This condemnation is due to historical sediment toxic contamination, and the potential for pollutants of fecal coliform bacteria (Virginia WCB 1992a). Sixteen industrial facilities discharge to the Southern Branch Elizabeth River main stem and tributaries. Surveys of finfish in the Elizabeth River (primarily in the Southern Branch) show obvious signs of stress and/or disease, especially among those species exposed to the contaminated bottom sediments. Many fish have external lesions, fin erosion, inflamed fins, and cataracts.

The bottom sediments of the Elizabeth River are highly contaminated with a variety of organic and inorganic compounds at several locations (Virginia WCB 1992a). The majority of the contamination problems occur in the highly industrialized Southern Branch. Of particular concern among the synthetic organic compounds found in the Southern Branch of the Elizabeth are polynuclear aromatic hydrocarbons (PAH's). They are long-lived, and many are mutagenic and carcinogenic. PAH's are found in a variety of sources including creosote, coal tar, coal pile runoff, fly and bottom ash from coal-fired boilers, roofing tar, asphalt oil, petroleum oil, bilge discharge, diesel soot, and wood stove soot. One source of this class of compounds in the Elizabeth River has been attributed to the wood-preserving facilities, which have been in operation along the Southern Branch since the early 1900's.

The James River-Hampton Roads waterbody encompasses the James River mainstem and tributaries from Old Point Comfort to Willoughby Spit (northern border) to the west side of Craney Island (eastern border), west to Barrel Point (southern border), and north to Boat Harbor, Hampton River, and Mill Creek. Shellfish condemnations impact 17,281 acres (Virginia WCB 1992a). This condemnation is due to historical toxic contamination, and the potential for fecal coliform bacteria pollution. This portion of the James River mainstem receives additional discharges from 14 facilities, at least half of which are seafood preparation waste discharges.

Surrounding the Nansemond River watershed are seven lakes (Lake Kilby, Lake Cahoon, Lake Meade, Speights Run Lake, Lake Prince, Lake Burnt Mills, and Western Branch Reservoir) which are used as public water supply sources for the surrounding cities. Lake Taylor, located in the city of Norfolk, is the closest lake and is approximately 7 miles from Norfolk Naval Shipyard. The other lakes are approximately 20 miles to the west of the shipyard.

The Flood Insurance Rate Map (FIRM COMMUNITY-PANEL No. 515529 0060 B) shows that most of the Norfolk Naval Shipyard, including the location considered for the interim storage of naval spent nuclear fuel, is in the 100-year floodplain. However, the location considered for naval spent nuclear fuel is not in a high-hazard area (as defined by Title 10, Part 1022 of The Code of Federal Regulations for floodplains) which is an area where frequent flooding occurs.

4.1.2.8.2 Groundwater. Shallow groundwater underlies the whole region. Designated as the Columbia aquifer, it is composed primarily of sediments that were deposited up to 1.7 to 2.2 million years ago as channel fill and river or ocean terraces. The aquifer is composed of interbedded gravel, sand, silt, and clay and is unconfined throughout the region. The saturated thickness of the Columbia aquifer is about 80 feet in the Tidewater area.

A consolidated layer of silty clay underlies the water table and separates it from the Yorktown Formation. In general, water flow within the Columbia aquifer is from the topographic highs to topographic lows. This flow distribution is modified locally by the pumping of wells, dewatering of borrow pits, and by the upper contours of the Yorktown Formation. As a result, the depth of shallow wells can vary drastically in only a few hundred yards.

Underlying the Columbia aquifer are seven distinct aquifers that originate east of the Fall Line and progressively deepen as they proceed eastward. The names of the aquifers and their approximate depths at the location of the shipyard are shown in Table 4.1.2-2.

The material confining the individual aquifers thickens from west to east so that the vertical leakage between aquifers due to gravity or artesian pressure differentials decreases eastward. The Yorktown-Eastover aquifer is both confined and unconfined, depending on location, and consists of fine to coarse sand interbedded with clay, shell, and sandy clay. The formation thickness is about 100 feet in the vicinity of the shipyard. Where the aquifer is unconfined, it is a major source of recharge to both the water table aquifer and to underlying confined flow systems.

Table 4.1.2-2. Aquifers that underlie the Columbia aquifer.

Aquifer	Depth Below Sea Level (ft)
Yorktown - Eastover	Sea Level
Chickahominy - Piney Point	200
Aquia	400
Brightseat	500
Upper Potomac	750
Middle Potomac	900
Lower Potomac	> 1500

Artesian pressure existing in the confined portions of the Yorktown aquifer causes an upward vertical leakage from the Yorktown aquifer into the water table aquifer. In the vicinity of the shipyard, the thickness of the confining layer is about 80 feet. The confining layer consists of blue-gray to green-gray clay interbedded with massive silty clay, fine sand, and chalky shell fragments.

The Yorktown aquifer is a major source of domestic, commercial, and light industrial water. Yields are reported to range from 20 to 250 gallons per minute. 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 groundwater aquifers have been extensively monitored and results published in numerous papers, bulletins, and reports (Siudyla et al. 1981; USGS 1990). Groundwater quality is monitored by several state agencies and boards with annual reports submitted to the EPA and Congress (Virginia WCB 1992b).

Since the underlying layers slope downward from west to east, the flow of groundwater in the vicinity of the shipyard generally trends from west to east, with localized modifications as previously described.

Rivers and creeks bound the shipyard on the immediate east and south. The confluence of the Southern, Eastern, and Western Branches of the Elizabeth River occurs about 1.5 miles north of the shipyard. These stream beds are below sea level and thus intercept the water table aquifer.

Where an aquifer is interfaced with surface streams or impoundments, the net flow within the aquifer is toward the surface water. In the case of the shipyard, the water table aquifer is intercepted on three sides (N, E, S) by a surface stream. This confines any contaminant infiltrating into the aquifer to the area of and immediately adjacent to the shipyard property. With a net easterly flow due to gravity, any contaminant infiltrating from the shipyard area would percolate through the soil zone into the water table under the shipyard and be intercepted by bounding surface waters.

4.1.2.8.3 Existing Radiological Conditions. The normal activities associated with current naval nuclear operations at all naval shipyards do not result in the intentional discharge of any radioactive liquid effluent. However, there were occasions, primarily in the early 1960's, when measurable levels of radioactivity were discharged with liquid effluent. In all cases, effluent releases were less than permitted under the then current limits imposed by state and federal agencies.

The United States Environmental Protection Agency Office of Radiation Programs has performed monitoring of the water, plant life, aquatic life, and sediment in the vicinity of Norfolk Naval Shipyard. The purpose of the survey was to determine if operations related to U.S. Navy nuclear warship activities resulted in releases of radionuclides which could contribute to significant population exposure or contamination of the environment. "Radiological Surveys of the Norfolk Naval Station, the Norfolk Naval Shipyard, and Newport News Shipbuilding" (Sensintaffar and Blanchard 1988) discusses the most recent Environmental Protection Agency monitoring data. Pertinent conclusions are as follows:

1. "The trace amounts of cobalt-60 measured in the harbor sediments are significantly less than observed during the 1968 survey and exist about 5 inches beneath the surface of the sediment, indicating that no detectable cobalt-60 has been deposited in the sediments since the 1968 survey.

2. In addition to cobalt-60, only radionuclides of natural origin plus trace amounts of cesium-137 from previous nuclear weapons testing were detected in any of the harbor sediment samples.

3. No tritium or gamma-ray emitters, other than those occurring naturally, were detected in harbor water, or samples of sediment, water, and vegetation collected from public areas.

4. Drinking water samples contained no detectable levels of radioactivity other than those occurring naturally.

5. The shoreline gamma-ray surveys failed to detect any elevated exposure levels except at one location where the levels are attributed to the naturally occurring radionuclides that exist in granite rock.

6. The levels and locations of radioactivity identified and the limited media in which it was found show that operations related to nuclear-powered warship activities resulted in no discernible adverse effects on public health or the environment."

Environmental monitoring is conducted by the shipyard. The results of this monitoring program corroborate the Environmental Protection Agency's conclusions.

4.1.2.9 Ecological Resources

4.1.2.9.1 Terrestrial Ecology. The shipyard area is highly developed and its surface is about 95% covered with impervious materials. The few green areas are outside the controlled industrial area and have been extensively graded. Landscaping consists primarily of turf grasses and native trees. The oldest growth areas are in the vicinity of the Shipyard Commander's residence and Trophy Park. Appendix B of the "Land Management Plan for Norfolk Naval Shipyard" (NFEC 1991) lists those plants known to or likely to occur on the shipyard or its annexes.

The shipyard bird population consists of urban species commonly found in southeastern Virginia. These species include pigeons, jays, robins, finches, chickadees, starlings, flickers, blackbirds, grackles, cowbirds, chimney swifts, martins, mocking birds, cardinals, herons, egrets, terns, and several species of gulls. There are few mammals that inhabit the shipyard and their populations are limited. Squirrels and other rodents common to developed areas are observed.

The shipyard offers little refuge for reptiles and amphibians. Non-poisonous garter snakes and the occasional black snake are found in vegetated areas and in warehouse structures. Toads, newts, salamanders, and other semi-aquatic reptiles can be found in wet areas where suitable forage and habitat exists. Sightings are infrequent due to the dispersed habitat locations and the limited number of suitable sites.

The Tidewater area is part of the Mid-Atlantic flyway. Migratory species pass through the area or over-winter in the numerous bays, sounds, creeks, and wetlands that occur in the region. During migratory periods and over the winter, more than a hundred species of water fowl have been observed in the region. Since there is no suitable habitat or forage areas on the shipyard, the appearance of migrating species is rare.

4.1.2.9.2 Wetlands. There are no freshwater wetlands on the main shipyard site where naval spent nuclear fuel would be stored. The majority of the shipyard is developed and covered with an impervious surface. National Wetlands Inventory Maps (DOI 1986) show a number of estuarine wetlands along the banks of Paradise, Blows, and St. Juliens Creeks. There are no remaining tidal wetlands along the western shoreline of the Southern Branch from its mouth to Paradise Creek (Silberhorn and Dewing 1989). The total wetland area along Paradise Creek is, according to this reference, about 422 acres.

Blows Creek wetlands occur along the Southern Branch and encompass about 2.54 acres. St. Juliens Creek tidal marshes are subdivided into eight locations and total about 52 acres (Silberhorn and Dewing 1991).

4.1.2.9.3 Aquatic Ecology. The majority of the shipyard property is located on land that has been filled to raise its elevation above the level of the river. The shipyard shoreline consists of concrete bulkheads and finger piers built on concrete pilings. Wooden wharfs and quays have been replaced over the years with concrete structures. Marine vegetation along the shipyard waterfront is limited to red and green algae. As reported in Section 4.1.2.8.1, the marine life in the Southern Branch is limited due to the pollution in the river from sewage treatment plants and riverfront industries. There is no commercial fishing and only limited sport fishing in the Southern Branch. In the contiguous shipyard waters, there is no fishing due to a security buffer zone and because of the heavy traffic along the river.

Estuarine wetland ecology is principally vegetative and consists of Saltmarsh Cord grass and Reed grass. The abundance of Reed grass in these areas is indicative of disturbed wetlands that have been filled or are impacted by overloads of upland sediment.

Herring gulls, several species of terns, brown pelicans, egrets, herons, cormorants, and migratory bird species common along the Atlantic flyway take refuge in or feed on riverine or marshland environments and biota.

The waters adjoining the shipyard are frequently dredged to maintain the depth along the piers, at the entrance to dry docks, and in the turning basin. The periodic removal of silt and detritus limits the habitat of benthic organisms common in other parts of the lower bay and tributaries.

4.1.2.9.4 Endangered and Threatened Species. There are no critical habitats as defined in 50CFR424.02 within the 15-mile tidal influence area. Several federally designated threatened (T) or endangered (E) species have been identified as existing in the vicinity. The exact locations of specific habitats could not be located; however, surveys of the area have not identified any habitat on shipyard property. The U.S. Fish and Wildlife Service lists the following species as endangered or threatened in the South Hampton Roads area from Suffolk eastward (DOI 1990).

1. Loggerhead turtle (T)
2. Bald eagle (E)
3. Peregrine falcon (E)
4. Piping plover (T)
5. Red-cockaded woodpecker (E)
6. Eastern cougar (E)
7. Dismal Swamp southeastern shrew (T)
8. Northeastern beach tiger beetle (T)

No state rare, threatened, or endangered species exist within the 15-mile tidal influence zone (Buhlmann and Ludwig 1992).

There are no marine mammals that are routinely found within the lower Chesapeake Bay or its tributaries. Manatees and Atlantic Bottlenose dolphins occasionally appear in the bay and Hampton Roads; however, their presence is transient. Stranding and grounding of pods of migratory whales and dolphins as well as carcasses of dead animals occasionally appear along Atlantic beaches from Virginia's Eastern Shore to the North Carolina Outer Banks but sightings of whales in the bay or near the ocean shore are rare.

Various oceanic turtles may nest along the sandy beaches surrounding the Chesapeake Bay and Outer Banks. The highly developed regions along the Elizabeth River do not provide suitable nesting sites for these marine reptiles.

4.1.2.10 Noise

Norfolk Naval Shipyard is an existing industrial-type environment characterized by noise from truck and auto traffic; yard cranes and related internal combustion engine powered equipment; and operating transmission lines for steam, air, and water along with associated pumps and compressors. The eastern shoreline of the Southern Branch contains private shipyards, manufacturing plants, and bulk material handling and storage terminals. These activities, along with Norfolk Naval Shipyard, add to the ambient noise levels of the river corridor.

Intervening structures and distance separate adjacent residential areas to the south and immediately west of the shipyard from the waterfront ship repair activities and thus attenuate the noise generated by those activities.

4.1.2.11 Traffic and Transportation

Within the city of Portsmouth, three main corridors, High Street, Portsmouth Boulevard, and George Washington Highway serve as access to suburban commercial and residential areas. The Downtown and Midtown tunnels link Portsmouth and Norfolk and join via connecting arteries the regional interstate highway network consisting of 1-64, 1-262, 1-464, and I-664. 1-64 crosses Hampton Roads while I-664 crosses the lower James River linking the southside cities to Newport News and Hampton on the peninsula. The bridge-tunnels allow the unimpeded flow of the largest commercial ships and warships through Hampton Roads.

Tidewater Regional Transit provides bus services throughout Portsmouth and Norfolk. Only limited public transportation is available in Chesapeake and Virginia Beach.

The Norfolk International Airport provides commercial scheduled passenger and cargo air service to major connecting hubs. Most private and general aviation not operating from Norfolk International operate from airports in Chesapeake, Suffolk, and Virginia Beach.

A passenger ferry across the Elizabeth River connects the Portsmouth downtown area with the Waterside Berths on the Norfolk side. This ferry service is primarily designed for tourist and recreational passengers rather than commuter service.

Norfolk Southern and CSX corporations operate extensive networks of rail transportation 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, Southgate, and St. Juliens Creek annexes.

Naval spent nuclear fuel has been removed from Navy nuclear-powered ships and transported to the Idaho National Engineering Laboratory Expended Core Facility (ECF) for examination and evaluation as a routine part of their operating cycle. Naval spent nuclear fuel shipments from Norfolk Naval Shipyard to ECF were initiated in 1965. Since that time, 10 shipments of naval spent nuclear fuel originating at Norfolk Naval Shipyard have been made to ECF. The naval spent nuclear fuel was shipped by rail. Attachment A provides a list of these shipments made to date by year. Attachment A also contains detailed descriptions of the shipping containers used for naval spent nuclear fuel shipments from shipyards.

Norfolk Naval Shipyard has 30 miles of paved roads, 19 miles of railroad tracks, and dry docks.

4.1.2.12 Occupational and Public Health and Safety

4.1.2.12.1 Occupational Radiological Health and Safety. The Navy has well established and effective Occupational Safety, Health, and Occupational Medicine programs at all of its shipyards. In regard to radiological aspects of these programs, the Naval Nuclear Propulsion Program policy is to reduce to as low as reasonably achievable the external exposure to personnel from ionizing radiation associated with naval nuclear propulsion plants. These stringent controls on minimizing occupational radiation exposure have been successful. No civilian or military personnel at Navy sites have ever exceeded the federal accumulated radiation exposure limit which allows 5 rem exposure for each year of age beyond age 18. Since 1967, no person has exceeded the federal limit which allows up to 3 rem per quarter year and since 1980, no one has received more than 2 rem per year from radiation associated with naval nuclear propulsion plants. The average occupational exposure of each person monitored at all shipyards is 0.26 rem per year. The average lifetime accumulated radiation exposure from radiation associated with naval nuclear propulsion plants for all shipyard personnel who were monitored is 1.2 rem. (NNPP 1994a) This corresponds to the likelihood of a cancer fatality of 1 in 2083.

The Navy's policy on occupational exposure from internal radioactivity is to prevent radiation exposure to personnel from internal radioactivity. The limits invoked to achieve this objective are one-tenth of the levels allowed by federal regulations for radiation workers. As a result of this policy, no civilian or military personnel at shipyards have ever received more than one-tenth the federal annual occupational exposure limit from internal radiation exposure caused by radioactivity associated with naval nuclear propulsion plants.

For work operations involving the potential for spreading radioactive contamination, containments are used to prevent personnel contamination or generation of airborne radioactivity. The controls for contamination are so strict that precautions sometimes have had to be taken to prevent tracking contamination from fallout and natural sources into radiological areas because the contamination control limits used in these areas were well below the levels of fallout and natural contamination occurring outside in the general public areas. A basic requirement of contamination control is monitoring all personnel leaving any area where radioactive contamination could possibly occur. Workers are trained to survey themselves (i.e., frisk), and their performance is checked by radiological control personnel. Frisking of the entire body is required, normally using sensitive hand-held survey instruments. Major work facilities are equipped with portable monitors, which are used in lieu of hand-held friskers. These stringent controls to protect the workers and the public from contamination have proven effective in the past.

In 1991, researchers from Johns Hopkins University, Baltimore, Maryland, completed a very comprehensive epidemiological study of the health of workers at the six naval shipyards and two private shipyards that service the Navy's nuclear-powered ships (Matanoski 1991). This independent study evaluated a population of 70,730 civilian workers over a period from 1957, beginning with the first overhaul of the first nuclear-powered submarine, USS NAUTILUS, through 1981, to determine whether there was an excess risk of leukemia or other cancers associated with exposure to low levels of gamma radiation.

The Johns Hopkins study found no evidence to conclude that the health of people involved in work on U.S. naval nuclear-powered ships has been adversely affected by exposure to low levels of radiation incidental to this work. Additional studies are planned to investigate the observations and update the shipyard study with data beyond 1981.

The radiation exposure during normal operations at each shipyard for workers who have their radiation levels monitored is determined based on the annual radiation exposure of 0.26 mrem per worker for all shipyards based on Naval Nuclear Propulsion Program Report NT-94-2 (NNPP 1994a). The total number of shipyard personnel monitored for radiation exposure associated with the Naval Nuclear Propulsion Program has been about 164,000.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to transportation workers for all historical shipments is 16.6 person-rem, which statistically corresponds to 0.0066 cancer fatalities. The maximum exposed individual (MEI) is a transportation worker, since the workers are closer to the shipment for a longer time than any member of the general population. Under the limiting assumption that the same worker is associated with every shipment for the entire historical period, this person would receive a total exposure of 7.5 rem over the approximately 40-year period, or about 0.19 rem per year, which is within DOE standards for occupationally exposed individuals. The radiation exposures to workers correspond to much less than one incident cancer, which means that it is unlikely that there have been any past health impacts due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.2.12.2 Occupational Non-radiological Health and Safety. In the non-radiological Occupational Safety, Health, and Occupational Medicine area, the Navy complies with the Occupational Safety and Health Administration Regulations. The Navy policy is to maintain a safe and healthful work environment at all naval facilities. Due to the varied nature of work at these facilities, there is a potential for certain employees to be exposed to physical and chemical hazards. These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to high noise levels or heat stress. In addition, employees are monitored for their exposure to chemical hazards such as organic solvents, lead, asbestos, etc., and where appropriate are placed into medical surveillance programs for these chemical hazards.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact due to the historical shipment of naval spent nuclear fuel over the entire history of such shipments.

The shipyard has an occupational health/preventive medicine unit and a branch clinic (industrial dispensary). Personnel may also be taken to Portsmouth Naval Hospital and Portsmouth General Hospital as needed.

The shipyard maintains two fire stations with approximately 60 personnel. The fire department is fully equipped for structural and industrial firefighting and hazardous material spill response.

The shipyard security force has approximately 100 personnel providing law enforcement services, emergency services, security clearances, and parking and traffic control for the Norfolk Naval Shipyard Complex.

Relative to social services, military personnel receive assistance through various programs at Portsmouth Naval Hospital and the Navy's Morale Welfare and Recreation Department.

4.1.2.12.3 Public Radiological Health and Safety. In order to quantify the exposures resulting from normal shipyard radiological releases to the general public, detailed analyses were performed based on conservative estimates of radioisotopic releases since releases began. Attachment F provides detailed annual release values used in the analyses.

The GENII computer code (Napier et al. 1988) was used to calculate exposures to human beings due to the estimated radionuclide releases from normal operations at the shipyards.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from stored fuel. The population data used to calculate population exposures were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F.

The hypothetical exposures calculated in Attachment F for the period 1995 through 2035 were adjusted from an annual basis (1995) to the historical basis by multiplying by 38 years and by a factor of 1.7 to take into consideration variations in the number of ships and operations.

The calculated accumulated exposures through 1995 to the general population within 50 miles of the site (about 1.5 million people) are 3.9 person-rem. To provide perspective, the exposures received due to natural radiation sources through 1995 are approximately 18 million person-rem, based on 0.3 rem per person per year.

The results of environmental monitoring as described in Naval Nuclear Propulsion Program Report NT-94-1 show that Naval Nuclear Propulsion Program activities had no distinguishable effect on normal background radiation levels at site perimeters (NNPP 1994b).

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to the general population for all historical shipments is 1.95 person-rem, which statistically corresponds to 0.00098 cancer fatalities.

All of the radiation exposures to the general population correspond to much less than one incident cancer, which means that it is unlikely that there has been any past health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.2.12.4 Public Non-radiological Health and Safety. Portsmouth has three hospitals: Portsmouth General Hospital, Maryview Hospital, and Portsmouth Naval Hospital.

Fire protection in Portsmouth is administered by local fire departments and fire districts. The Portsmouth Fire Department has nine stations. Police protection services are provided by the city of Portsmouth.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.2.13 Utilities and Energy

The shipyard purchases all of its water from the city of Portsmouth. Section 4.1.2.8.1 describes the sources of public water supplies for the region. A saltwater system is provided at berths and dry docks for cooling supplies to ship systems and for fire and flushing mains.

Shipyard and ship sewage effluents are discharged to the Hampton Roads sanitation district mains via the Portsmouth sewer system. Sewage treatment plants along the Southern Branch and lower James River receive and treat sewage from surrounding cities.

Electricity is purchased from Virginia Power Company transmission grids and is obtained from the Refuse Derived Fuel Plant located just south of the shipyard and operated by the Southeastern Public Service Authority. During periods of low demand, the Refuse Derived Fuel Plant sells electricity to Virginia Power. The Refuse Derived Fuel Plant also provides yard steam for operations and space heating.

Natural gas serves six buildings within the shipyard. Industrial uses include forging and tempering furnaces, various ovens and torches, laboratory burners, and cooking appliances in the cafeteria. This gas is purchased from Commonwealth Gas Company which serves the Portsmouth area.

Shipyard freshwater usage is approximately 823 million gallons annually.

Electricity usage is about 20,000 megawatt hours annually.

4.1.2.14 Materials and Waste Management

Solid waste generated by tbe shipyard is collected by a private contractor. Metals are segregated on-site in specially marked dumpsters to be recycled by tbe Defense Marketing and Reutilization Office. Solid burnable waste is transferred to tbe Soutbeastern Public Service Autbority where it is eitber compacted into fuel blocks for use in the Refuse Derived Fuel Plant or disposed of at a regional landfill located in Suffolk. Once turned over, tbe Southeastern Public Service Autbority determines tbe final disposition depending on the regional waste volume inventory at tbe fuel plant adjacent to the shipyard.

The Refuse Derived Fuel Plant provides electricity and steam to tbe shipyard and can provide power to the Virginia Power grid when excess capacity exists.

Liquid chemical wastes are collected, characterized, packaged, and labeled by the shipyard then turned over to a licensed contractor for disposal.

Solid radioactive waste materials are packaged in strong, tight containers, shielded as necessary, and shipped to burial sites licensed by the U.S. Nuclear Regulatory Commission or a State under agreement witb tbe U.S. Nuclear Regulatory Commission. Shipyards and other shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. During 1992, approximately 1333 cubic yards of routine low-level radioactive waste containing 15 curies were shipped from tbe shipyard for burial.

Waste which is botb radioactive and chemically hazardous is regulated under botb tbe Atomic Energy Act and the Resource Conservation and Recovery Act (RCRA) as "mixed waste." Witbin the Naval Nuclear Propulsion Program, concerted efforts are taken to avoid commingling radioactive and chemically hazardous substances so as to minimize the potential for generation of mixed waste. For example, these efforts include avoiding the use of acetone solvents, lead-based paints, lead shielding in disposal containers, and chemical paint removers. Radioactive wastes, including those containing chemically hazardous substances, are handled in accordance with long-standing Program radiological requirements. Such handling includes solidification to immobilize the radioactivity, separation of the radioactive and chemically hazardous substances, removal of liquids from solids, and other simple techniques. A determination is tben made as to whether the resulting waste is hazardous. As a result of Program efforts to avoid the use of chemically hazardous substances in radiological work, Program activities typically generate only a few hundred cubic feet of mixed waste each year. This small amount of mixed waste, along with limited amounts of mixed waste from Program work conducted prior to 1987, will be stored pending the licensing of commercial treatment and disposal facilities.

An extensive storm drain system exists on the shipyard to remove the runoff from precipitation. Outfalls empty into the Southern Branch, Paradise Creek, and St. Juliens Creek. About 100 outfalls serving the shipyard property have been mapped and located.

4.1.3 PORTSMOUTH NAVAL SHIPYARD: KITTERY, MAINE

4.1.3.1 Overview

Portsmouth Naval Shipyard is located in York County, in the southeast corner of Maine as shown on Figure 4.1.3-1. The Portsmouth Naval Shipyard is located in Portsmouth Harbor, the estuary of the Piscataqua River. This river flows between the states of Maine and New Hampshire. The shipyard is located on Seavey Island near the mouth of the river and is separated from Portsmouth, New Hampshire, by the main channel of the Piscataqua River and from Kittery, Maine by a back channel. Access to the shipyard is provided by two bridges from the Kittery shore. Figure 4.1.3-2 provides a shipyard site map.

Seavey Island has an area of 278 acres. The center reference point on the island is at 70°44'22" longitude and 43°04'56" latitude. The Portsmouth Harbor and its tributaries are used extensively for fishing, lobstering, and recreational boating. The port of Portsmouth is involved in importing salt and petroleum products, as well as exporting a variety of products, such as raw lumber.

4.1.3.2 Land Use

At the mouth of the Piscataqua River, several creeks and the river converge and mix with the Atlantic Ocean. The shipyard has been developed over time by filling in between five smaller islands and building a rock causeway to the approximately 5-acre undeveloped Clarks Island.

To the north, across the back channel, is the predominantly low-density residential community of Kittery, Maine. Kittery's land along the river and back channel is virtually all designated for residential use. The exceptions are two commercial areas located on Badgers Island and at the intersection of Routes 103 and 236 and several public use areas consisting of playgrounds and parks. The main commercial land use area is located along Route 1 and the Route 1 bypass. Most of Kittery's land further north is undeveloped due to natural constraints. The developable land is primarily designated for low-density residential use.

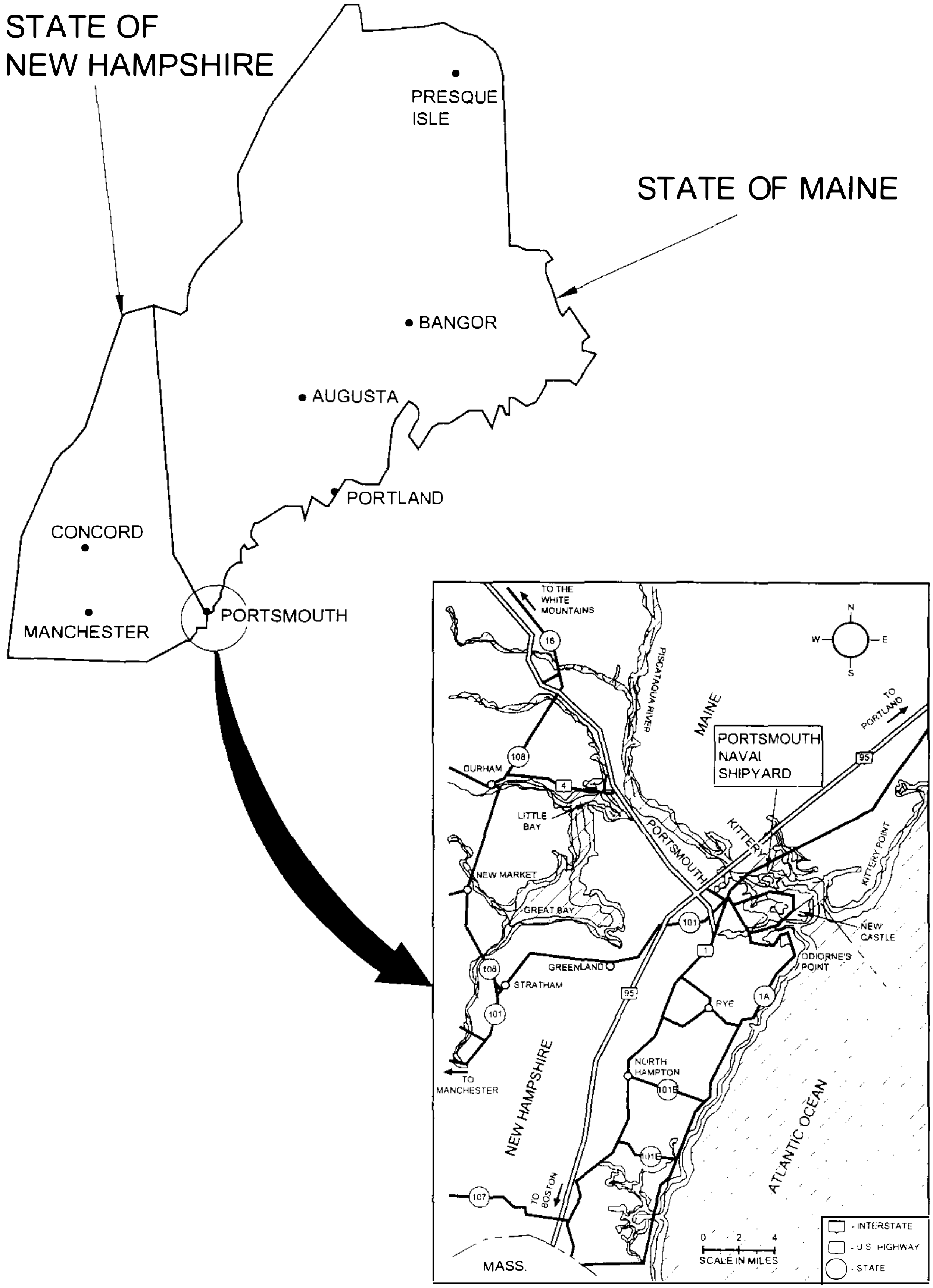


Figure 4.1.3-1. Location of Portsmouth Naval Shipyard within New Hampshire and Maine.

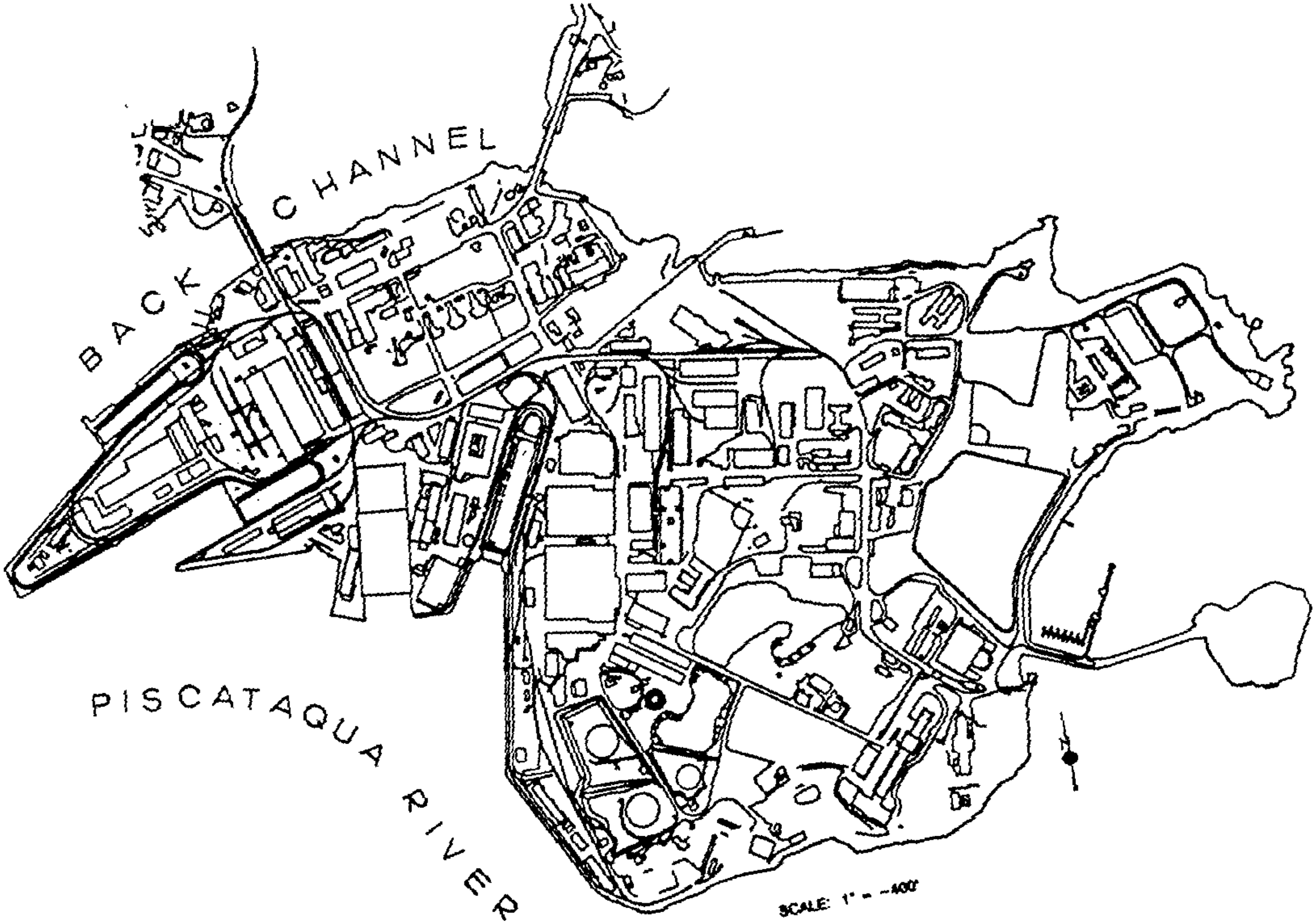


Figure 4.1.3-2. Portsmouth Naval Shipyard site map.

Across the river, south of the shipyard, are the city of Portsmouth and the town of New Castle in the state of New Hampshire. Portsmouth's waterfront is nearly fully developed and has played an important role in the growth and prosperity of Portsmouth since it was settled as Strawberry Banke in 1623. Today there are areas of commercial, industrial, residential, and public/semi-public land use along the river.

Further inland, Portsmouth has large undeveloped land areas. Development on some of this land is constrained by wetlands and other natural factors; however, there still remains much acreage to accommodate future development.

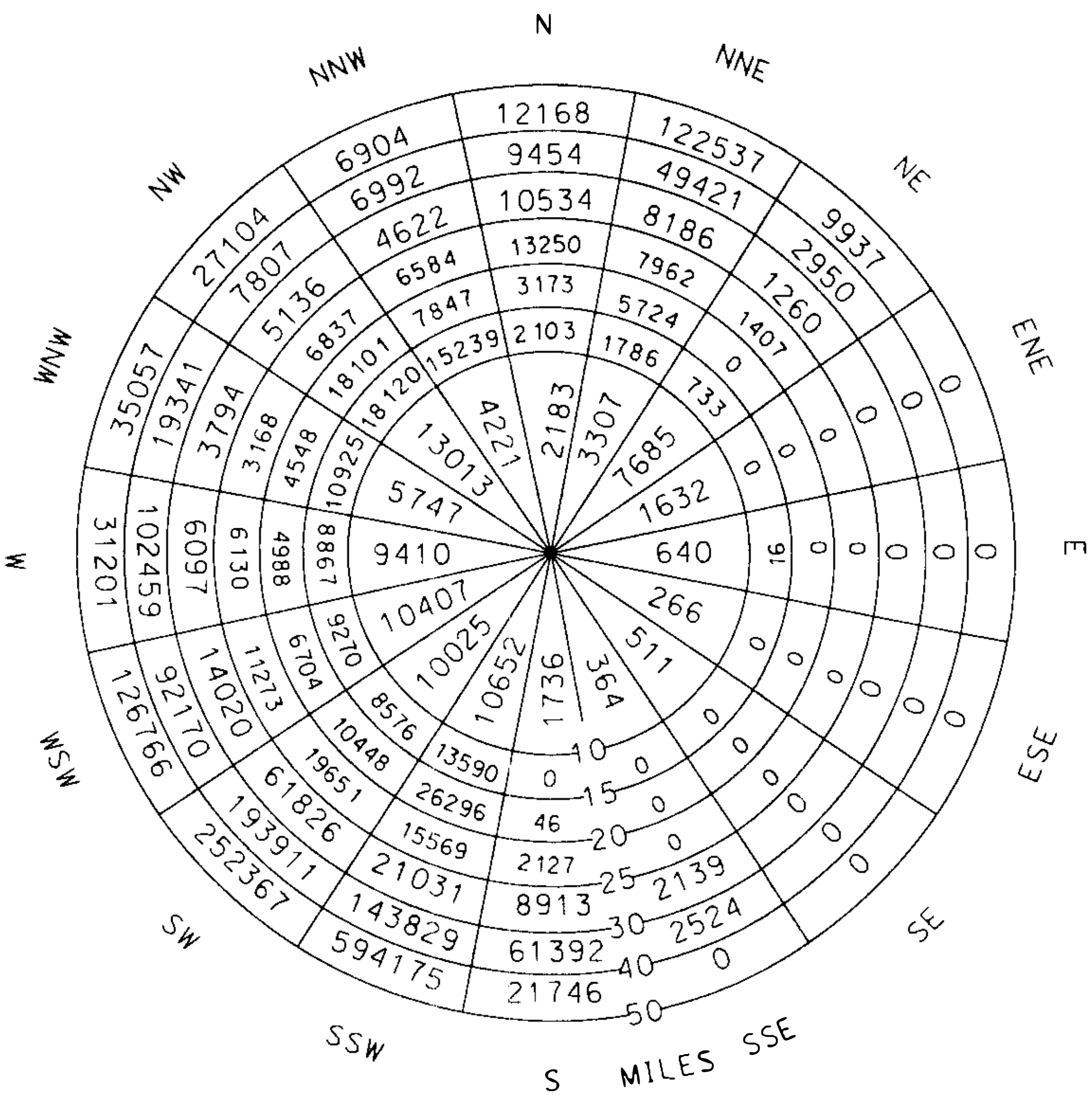
Directly south of the shipyard is a large body of estuarine water containing several small islands. These islands are either undeveloped or have low-density housing.

The town of New Castle is predominantly developed with housing and is the location of a Coast Guard Station. Other land uses on the island town include commercial, public, and semi-public land.

4.1.3.3 Socioeconomics

Portsmouth Naval Shipyard is located in the small town of Kittery, Maine, a region of New England that consists predominantly of small rural towns.

Portsmouth, New Hampshire is the closest urban municipality to the shipyard. With a population of about 22,300, it is also the largest municipality in the area. Other larger municipalities within the area include Sanford and Biddeford in Maine and Rochester and Dover in New Hampshire. They have populations of approximately 20,500, 20,700, 26,600, and 25,000, respectively. Portland, Maine has a population of about 64,400. This major southern Maine urban center is located about 55 miles north of the shipyard. Also, the city of Boston, Massachusetts, with a population of about 574,300, is located approximately 50 miles south of the shipyard. Figure 4.1.3-3 provides a population distribution rose centered on the shipyard and covering a 50-mile radius.



Miles	People	Cumulative People
0-5	42,525	42,525
5-10	39,254	81,799
10-20	177,100	258,899
20-30	241,516	500,415
30-40	692,250	1,192,665
40-50	1,239,962	2,432,627

Based on 1990 Census

Figure 4.1.3-3. 50-mile population distribution around Portsmouth Naval Shipyard.

The overall population of the Portsmouth region has grown through the 1980 to 1990 decade. On the Maine side of the Piscataqua River, the increase in population in York County from 1980 to 1990 was 24,848 which was a 17.8% increase. On the New Hampshire side of the river, the municipalities within Rockingham County gained in population through the 1980 to 1990 decade. There was a gain of 55,500 people or about a 29.2% increase.

Portsmouth Naval Shipyard is located within the "seacoast region" which is defined by seven job centers. Each center includes the smaller communities adjacent to them.

The seacoast region is made up of the Portsmouth, Exeter-Epping, Hampton, Dover-Somersworth, and Rochester centers in New Hampshire and the Kittery and Biddeford centers in Maine.

Historically, the economy of the seacoast region has been based on manufacturing. Textiles, shoes, and marine vessels were for many years the most important products of the region. Shipbuilding and ship repair, primarily at Portsmouth Naval Shipyard, have maintained a dominant role in the economy. Textiles and shoe manufacturing have declined over the past 30 years, but have been supplemented in part by plastics, electronics, and metals industries. The wages paid by these employers are low relative to those paid at the shipyard. On balance, the seacoast region has experienced consistent declines in manufacturing employment in recent years.

Non-manufacturing employment, especially in the trade and service sectors, is increasing. The Hampton, Portsmouth, Kittery, and Biddeford job centers have experienced economic growth as vacation resorts. Communities close to Massachusetts such as Hampton and Exeter-Epping, have grown as part of the Boston metropolitan area.

The city of Portsmouth is the seacoast region's trade and cultural center and a major distribution market for points in northern New England.

The generally healthy state of Portsmouth's economy is reflected by its excellent employment situation. As of July 1993, the unemployment rate was just 3.4% compared to the national average of 6.9%. The civilian labor force in the Portsmouth labor market area numbered 14,600 in July 1993.

The majority of the labor force that would be employed at the shipyard for construction and operation of the naval spent nuclear fuel area would be expected to reside within about 20 miles from the shipyard. The calculated total population, labor force, and employment within this region for the base year (1995) are presented in Table 4.1.3-1. Projections of employment and population for the years beyond 1995 have not been presented because, as discussed in Section 5, the number of additional jobs that might be created at the shipyard under any alternative could be small.

Table 4.1.3-1. Regional employment factors at Portsmouth Naval Shipyard.

Regional Employment	Regional Labor Force	Regional Population
115,230	121,550	258,900

Portsmouth has the distinction of being the only natural deep-water harbor between Boston and Portland, making it a major factor in New England seaborne commerce. Modern year-round port facilities, an established Foreign Trade Zone, and reliable container ship service are all available.

The chief commodities transported through the port are petroleum products which comprise over 90 percent of the marine commerce shipped. Large quantities of limestone (gypsum) and salt are also received. The chief products shipped out of Portsmouth are petroleum products and steel scrap. Commercial fishing in the area represents a multi-million dollar industry.

As of 1994, the region's largest employer, with approximately 4900 employees, was Portsmouth Naval Shipyard. The shipyard is the largest employer in the states of Maine and New Hampshire. The 1993 payroll amounted to $228 million.

Other contributing factors to the region's economic development include Pease Development Authority in Newington, the University of New Hampshire in Durham, and the New Hampshire Vocational/Technical College in Stratham.

The Kittery-York labor market area in York County had 86,165 people in the civilian labor force as of July 1993 and an unemployment rate of 2.3% for July 1993. The majority of the civilian labor force was employed in non-farm related jobs including manufacturing, transportation and utilities, wholesale and retail trade, finances, services, and government.

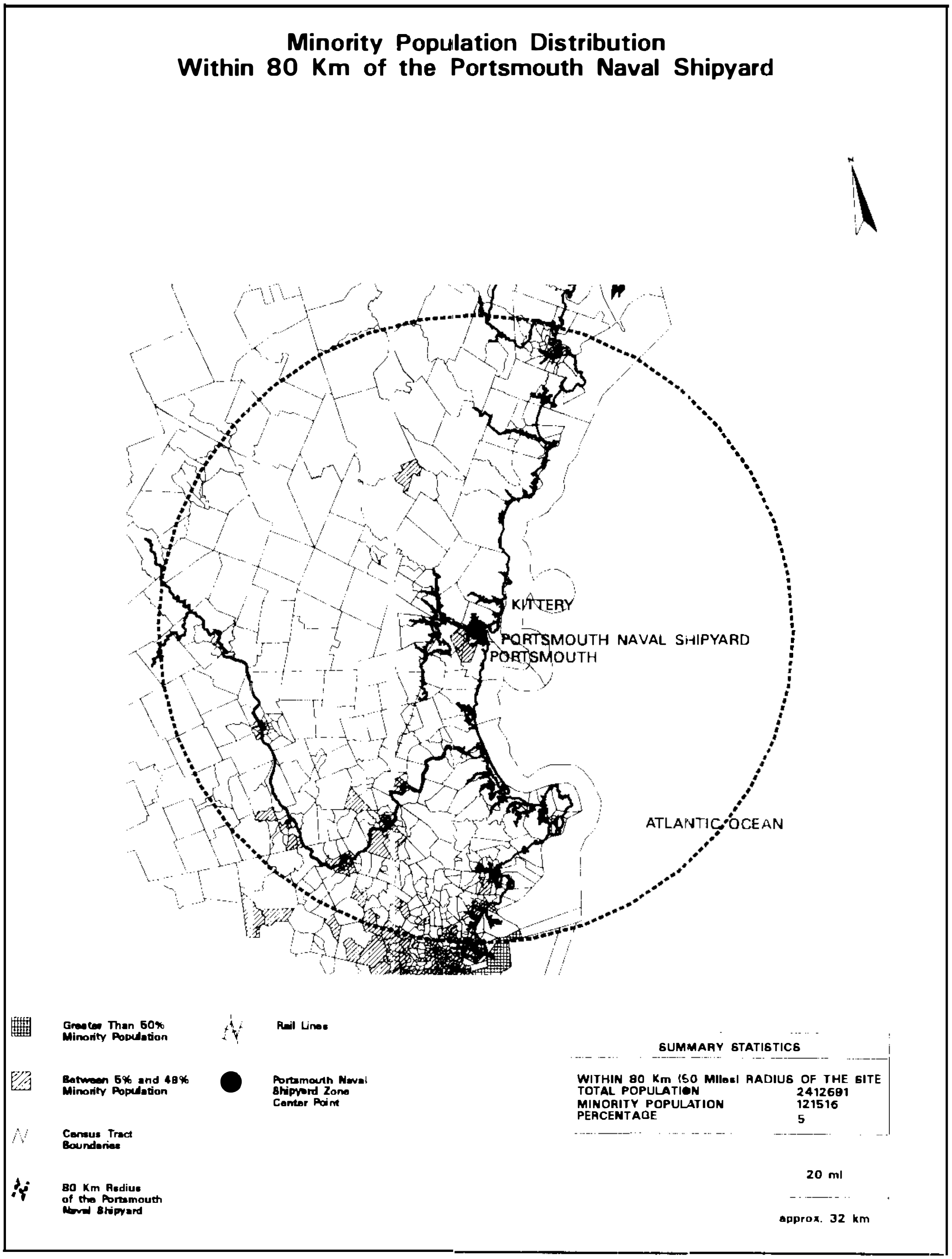
Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the Portsmouth Naval Shipyard, consistent with the population data provided in Figure 4.1.3-3.

Figure 4.1.3-4 shows the locations of populations in which minority membership exceeds the average within the 50-mile radius by more than 20 percentage points and populations which have more than 50 percent minority members. These populations have been identified following an approach developed by the Environmental Protection Agency which, for purposes of environmental justice evaluation, defines minority communities as those which have percentages of minorities greater than the average in the region analyzed (EPA 1994).

Figure 4.1.3-5 shows the locations of populations which have more than 25 percent of their members living in poverty, reflecting a common definition of low-income communities (EPA 1993). The U. S. Census Bureau characterizes persons in poverty as those whose income is less than a "statistical poverty threshold." For the 1990 census, this threshold was based on a 1989 income of $12,500 per household.

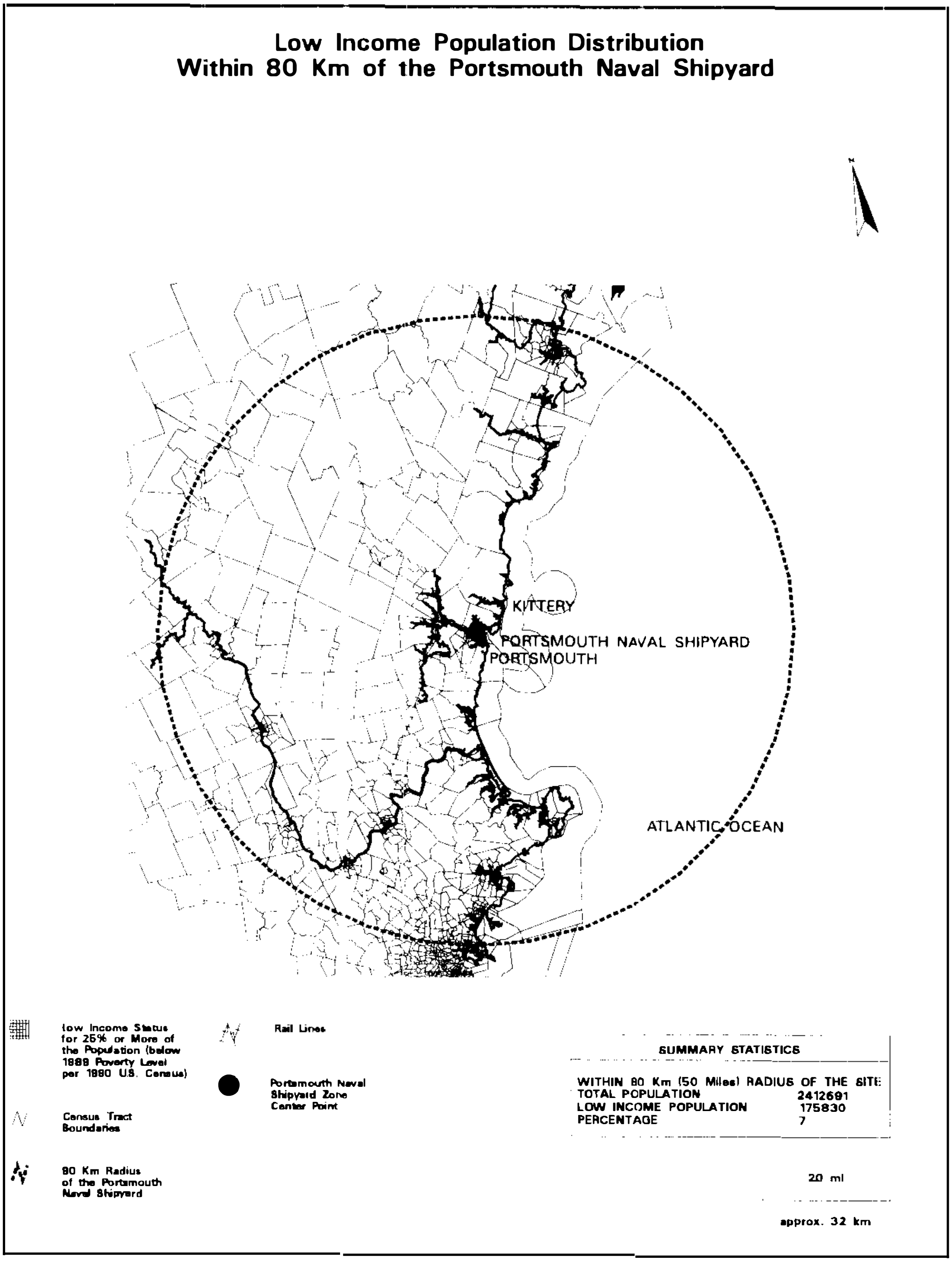
4.1.3.4 Cultural Resources

The Portsmouth-Kittery area has been part of the country's history since its very beginning. Many structures and sites from the late seventeenth, eighteenth, and nineteenth centuries have survived within the framework of new development over the years, especially in the city of Portsmouth. Considered as a group, these preserved structures and sites constitute an aesthetic, cultural, and educational resource, and a heritage with increasing value to future generations in the Portsmouth-Kittery vicinity.



Based on 1990 Census

Figure 4.1.3-4. Minority population distribution within 50 miles of the Portsmouth Naval Shipyard.



Based on 1990 Census

Figure 4.1.3-5. Low-income population distribution within 50 miles of the Portsmouth Naval Shipyard.

On November 17, 1977, the National Park Service, 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. The shipyard qualified for the Historic Status because of its shipbuilding and repair function throughout the history of the United States, its unique industrial site, and its historical and architecturally interesting buildings. From the early colonial period to the present day, this shipbuilding and repair site served first, the British government, later, the revolutionary colonies, and finally, the United States through the eras of sail, steam, and atomic power. Portsmouth Naval Shipyard represents one of the country's earliest complete industrial operations. (Navy 1993a)

There are no known cultural resources in the area of the site where naval spent nuclear fuel would be stored. Due to the historic nature of the shipyard, there might be areas of archaeological interest. In the past, artifacts from the early shipbuilding era have been uncovered during construction excavation.

4.1.3.5 Aesthetic and Scenic Resources

The majority of the 303 acres (278 acres on the shipyard, 25 in Admiralty Village) that make up the Portsmouth Naval Shipyard is considered industrial use land. Although there are no exact figures on the breakdown of land classifications, it is estimated that over 75% of the area is covered by either buildings or pavement. The area within the shipyard where naval spent nuclear fuel would be stored has low visual sensitivity since the area is an industrial site. Improved grounds on the shipyard include the parade grounds, athletic fields and various lawns dispersed throughout. Semi-improved grounds include several small picnic areas on the shipyard, the Jamaica Island Family Recreation area, and the isolated grassy areas on the fringe of the streets and sidewalks. The major areas of unimproved grounds (includes all other unpaved acreage not classified as improved or semi-improved) include the two freshwater ponds and the small beach front on what was once Jamaica Island. Because Admiralty Village is a housing facility, what little open space remained after development was utilized for recreational purposes (e.g., tennis courts) or landscaped to enhance aesthetic value.

4.1.3.6 Geology

4.1.3.6.1 General Geology. Portsmouth Naval Shipyard is located on Seavey Island in the Seaboard Lowland Section of the New England Province. This section has a low, undulating topography with low hills that are either bedrock with a light veneer of rocks or sediment left by glaciers, or marine clay.

The general area near Portsmouth Naval Shipyard is relatively flat, rising gradually to the foothills of the White Mountains and dissected by numerous streams and rivers that have, for example, carved gorges 20 to 100 feet deep in the granite hills of the Mount Agamenticus-Ogunquit area. What remains of the mountain range in the southern and western portions of the area are scattered and isolated, high, smooth, weathered rock hills.

The thickness of the overburden of loose materials varies from 0 to 200 feet over the region, with 80% of the area having less than 50 feet depth to bedrock. A predominant characteristic of the soil in the area is the presence of the groundwater table near or at the surface. (Navy 1984)

4.1.3.6.2 Geologic Resources. The physical geography of the general area near the Portsmouth Naval Shipyard is characterized by bedrock prominences surrounded by and dissected by inlets and stream courses of the Piscataqua River. Seavey Island, itself a rock knob, is one of these prominent bedrock outcrops. The bedrock of Seavey Island is almost entirely the Kittery formation, a fine-grained, lime-silicate material consisting of chalky sandstone formed under heat and pressure, siltstone, and gray sandstone shale from approximately 400 million years ago. (Navy 1984)

There are no economic geologic resources at the shipyard.

4.1.3.6.3 Seismic and Volcanic Hazards. Seismic risk related to structural damage may be represented in the United States by a relative scale of 0 through 4, with Zone 0 not expected to encounter damage and Zone 4 expected to encounter the greatest seismic risk. The shipyard is located in Zone 2A according to the "Uniform Building Code" (UBC 1991). No volcanic hazards exist. The Uniform Building Code seismic classification provides a means for a comparable assessment of the seismic hazard between the alternate sites. If the Record of Decision identifies this site for the interim storage of naval spent fuel, then a detailed seismic evaluation would be conducted.

More detailed information regarding the design basis considerations for storage of naval spent nuclear fuel at the shipyard is provided in Attachment D.

Numerous small faults are to be seen in all rock units of the region. Quantitatively, their abundance appears to be related to the brittleness of the rock containing them. Most involve displacement of a few inches or feet. Only one was deemed to be sufficiently important to show on the geologic map. This is the Portsmouth fault which forms the Rye-Kittery contact for approximately 9 miles. There are so few outcrops of the fault zone, and these are poor, that no attempt was made to calculate the fault displacement. It is not known if the fault continues across the Piscataqua River and into Southeastern Maine. (Navy 1993b)

4.1.3.7 Air Resources

4.1.3.7.1 Climate and Meteorology. The overall climate in the Portsmouth region is characterized as variable. Weather conditions can change dramatically over short intervals. There are alternating frontal systems on a day-to-day basis, widely ranging daily and annual temperatures, and overall differences between the same seasons in different years.

Although this region is situated in the path of the prevailing westerly winds, the coastal area experiences a variety of air changes over the course of a year. These include: cold dry arctic air from the north, warm land air from the Gulf states, and cool, damp air from the Atlantic Ocean. It is the combinations of, or switches between, these conditions that generally cause the area's characteristic weather.

Weather conditions, especially temperature, in the Portsmouth general area are moderated by its maritime setting. The average daily temperature ranges from 80°F in July to 13°F in January and February. Temperatures can fluctuate outside this range, but they are not usually persistent.

Precipitation is fairly evenly distributed over the year, with 2.7 to 4.6 inches falling per month for a 42.6-inch annual total. On the average, there are about 130 days each year having more than a trace of precipitation. Most summer precipitation results from showers and, infrequently, thunderstorms. Winter precipitation is generally associated with stormy conditions caused by air masses moving up along the coast.

The cool Atlantic waters can produce extensive advection fog when warmer moist air is carried over the cool water. With any persistent eastern component in the wind direction, the fog that often lies just offshore during the summer can reach the coastline. This situation is increased during the summer by local sea breezes. All months of the year have a fairly consistent occurrence of fog. Localized and continuous fog was observed at the former Pease Air Force Base an average of 15% of the time and was dense enough to restrict visibility to 1.2 miles (2 kilometers) or less, about 35% of the time.

The predominant direction the wind blows from for the Portsmouth Harbor area is a combination of the western, southwestern, and southern sectors for a combined total of 36% of the time. Differences in wind characteristics occur on a seasonal basis with west-northwest winds dominating in the winter, and southwest-southeast winds increasing in frequency during spring and summer.

The wind speed averages 8.8 miles per hour in the Portsmouth Harbor area. Speeds greater than 40 miles per hour, however, can occur any time of the year. During the winter, increased wind speeds are normally caused by the northeast winds moving down the coast, while during the summer, high winds are more often associated with thunderstorms of squall lines moving through the area. (Navy 1991b)

4.1.3.7.2 Air Quality. A Reasonably Available Control Technology analysis was conducted in response to Maine Department of Environmental Protection (DEP) regulations requiring Reasonably Available Control Technology for Volatile Organic Compound (VOC) emission sources, such as the Portsmouth Naval Shipyard, which are located in ozone nonattainment areas. The Reasonably Available Control Technology analysis was conducted for point and fugitive sources of VOC emissions at the shipyard.

The shipyard is a large industrial complex that emits VOC emissions from a variety of sources located throughout the site. Many of the sources of VOC are small and represent fugitive losses of emissions. VOC emissions from these operations are best controlled through the implementation of good housekeeping practices.

It has been determined that current VOC operations at the shipyard meet Reasonably Available Control Technology. Continuation of current practices will ensure that VOC emissions from the shipyard are maintained at or below Reasonably Available Control Technology levels. (Navy 1991b)

An area can be designated by the Environmental Protection Agency as having air quality that is better than defined by the National Ambient Air Quality Standards (attainment) or as exceeding one or more of those standards (nonattainment for one or more pollutants). The Code of Federal Regulations, Title 40, Part 81, states that the Air Quality Control Region for the shipyard is in moderate nonattainment for ozone and is better than national standards for total suspended particulate matter and SO_2. The area has no specific classification for carbon monoxide and NO_2. The nearest Class I Area to the shipyard is at the Presidential Range - Dry River Wilderness Area, approximately 120 kilometers (75 miles) from the shipyard.

4.1.3.7.3 Existing Radiological Conditions Radiological facilities at all naval shipyards are designed to ensure that there are no uncontrolled discharges of radioactivity in airborne exhausts. Radiological controls are exercised to preclude exposure of working personnel to airborne radioactivity exceeding federal limits. Air exhausted from radiological work facilities is passed through high-efficiency particulate air filters and monitored during discharges. The annual airborne radioactivity emissions from the shipyards do not result in any measurable radiation exposure to the general public. Calculations of site radioactive airborne emissions for 1992 have been performed as described in Attachment F. These calculations have shown that emissions of radionuclides from each shipyard result in an effective dose equivalent of less than 0.1 mrem per year to any member of the general public.

4.1.3.8 Water Resources

4.1.3.8.1 Surface Water. A large portion of York County's surface runoff from precipitation is drained by coastal basins reaching a short distance inland from the coast. The system of water drainage channels used by runoff waters, varying from very small brooks to larger rivers, generally are in a southeasterly direction towards the Atlantic Ocean, but tributaries naturally flow from all directions into the larger channels. The remainder of the area is drained by larger river drainage basins that reach further inland. The Saco River basin and the Piscataqua-Salmon Falls River basins are the largest drainage systems, the Mousam and Kennebunk Rivers being considerably smaller. In each of these drainage basins, surface water is held in swamps, ponds and lakes, both natural and man-made, and by dams for storage, water supply, and development of power.

The largest quantities of surface runoff occur during March, April, and May with the lowest occurring in August and September. On the average, runoff is approximately 22 inches of the 44 inches annual precipitation. The combination of spring rains and snow melt not only serve to greatly increase stream flow, but also tend to replenish groundwater supplies.

The Piscataqua River, formed by the confluence of the Cocheco River and the Salmon Falls River, flows southeasterly for 13 miles until it enters the ocean at Portsmouth Harbor. The entire 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. Due to abrupt channel changes and the strengths of flood and ebb currents, hazardous cross-currents and eddies are found in the main channel passing north and east of Pierce and New Castle Island. The average current velocity at full strength in the main harbor varies from about 2.6 to 4.0 knots, whereas in the back channels, the velocity varies from less than 1 to 2 knots.

The tide at Portsmouth occurs twice daily. The average tidal range from Portsmouth Harbor is 8.4 feet. The average mean spring range is 9.7 feet and the average mean tide level is 4.2 feet.

New Hampshire and Maine have an agreement to maintain acceptable water quality in the Piscataqua River and both states regulate their effluent discharges into the river. The river is designated by the state of New Hampshire as a Class B segment and by the state of Maine as Class SB-1. New Hampshire Class B waters are acceptable for bathing, other recreational purposes, fish habitat, and public water supply after adequate treatment. Maine Class SB-1 waters are suitable for all clean water usages including water contact recreation, fishing, shellfish harvesting and propagation, and fish and wildlife habitat. (Navy 1984)

The Flood Insurance Rate Map (FIRM COMMUNITY-PANEL No. 230171 0008D) shows that the Portsmouth Naval Shipyard is not in a 100 or 500 year floodplain.

4.1.3.8.2 Groundwater. Groundwater reserves constitute an important natural resource and are especially important to the more populated communities in the area. The majority of the public water supply in the area is taken from lakes and rivers, with groundwater providing the remainder of the requirements.

As much as 35% of the total area of York County is underlain by soils which are generally adapted to storage and yield of groundwater, but this figure is based only on surface data. In some localities, marine clays overlie deeper gravels and may represent excellent future sources. When favorable groundwater soils are measured to adequate depths, it is quite probable that the good groundwater yield areas will shrink to a few percent of the total land areas. (Navy 1984)

4.1.3.8.3 Existing Radiological Conditions. The normal activities associated with current naval nuclear operations at all naval shipyards do not result in the intentional discharge of any radioactive liquid effluent. However, there were occasions, primarily in the early 1960's, when measurable levels of radioactivity were discharged with liquid effluent. In all cases, effluent releases were less than permitted under the then current limits imposed by state and federal agencies.

The United States Environmental Protection Agency Office of Radiation Programs has performed monitoring of the water, plant life, aquatic life, and sediment in the vicinity of Portsmouth Naval Shipyard. The purpose of the survey was to determine if operations related to U.S. Navy nuclear warship activities resulted in releases of radionuclides which could contribute to significant population exposure or contamination of the environment. "Radiological Survey of Portsmouth Naval Shipyard, Kittery, Maine and Environs" (Semler 1991) discusses the most recent Environmental Protection Agency monitoring data. Pertinent conclusions are as follows:

1. "No trace of Co-60 was detected in any samples at Portsmouth Naval Shipyard. All radioactivity detected in the 40 sediment samples is attributed to naturally occurring radionuclides or fallout from past nuclear weapons testing.

2. Results of core sampling did not indicate any previous deposit of Co-60 in the sediment.

3. The water samples contained no detectable levels of radioactivity.

4. All radioactivity detected in the biota samples is attributed to naturally occurring radionuclides or fallout.

5. External gamma ray measurements did not detect any increased radiation exposure to the public above natural background levels.

6. Based on the survey, it was concluded that current practices regarding nuclear-powered warship operations have resulted in no increases in radioactivity that would result in major exposure or contamination of the environment."

Environmental monitoring is conducted by the shipyard. The results of this monitoring program corroborate the Environmental Protection Agency's conclusions.

4.1.3.9 Ecological Resources

4.1.3.9.1 Terrestrial Ecology. Portsmouth Naval Shipyard is an isolated land mass that has been highly developed. There is almost no remaining natural habitat in the shipyard area, with the major exception being Clarks Island and the surrounding estuary. Even these areas are not unaffected by activities on the shipyard and nearby industry.

The estuary around the shipyard could be classified as an intertidal river system which supports a subtidal estuary community. The shoreline is characterized by steep, rocky banks and low-lying marshlands. The shipyard mass would probably be classified as a rock outcrop ecosystem, characterized by sparse vegetation of low-lying shrubs and herbs with scattered trees. The community would be classified as an acidic shoreline outcrop.

The vegetation of the shipyard is made up primarily of trees, shrubs, and grasses that have been planted for landscaping purposes. No naturally occurring species remain at this time. Because Clarks Island has remained undeveloped, there is much greater diversity. It supports a variety of herbaceous and shrub species including rushes, skunk cabbage, jewelweed, spike grass, swamp azalea, bittersweet, witch hazel, and dogwood. Several lowland tree species are also growing on the island, including red maple, sycamore, willow, and poplar.

The fringe marshes along the shore of Admiralty Village and along portions of Clarks Island are dominated by two species, cord grass (Spartina alterniflora) and salt hay (Spartina patens). These perennial grasses are year-round producers of vital organic matter that is distributed to the detrital food chain or deposited in the marsh as part of the underlying peat marsh.

Another important plant species present within the Piscataqua River and abundant around the shipyard is Zostera marina, commonly called eel grass. This submerged marine flowering plant is vital to the health and productivity of the estuary. It provides habitat essential to the life cycle of species such as crabs, fin fish, geese, and ducks. Eel grass beds are also preferred nursery habitat for lobsters. Other valuable functions of eel grass beds include: sediment trapping, bottom stabilization, and water filtration. This filtration ability also causes eel grass beds to be susceptible to algal blooms resulting from excessive wastewater and fertilizer nutrients. Thus, eel grass is essential to the health of the estuary and can also serve as an indicator of unhealthy conditions.

The limited amount of vegetation and the highly industrialized nature of the shipyard area severely limit the availability of suitable habitat for most terrestrial species. There are some mammals on the shipyard, primarily those species that tend to live in close association with man, including: mice, squirrels, raccoons, and rabbits. There are white-tailed deer and moose in close vicinity of the shipyard. However, there are no known resident species of deer or moose on the shipyard. The Navy's 1993 "Natural Resources Management Plan for Portsmouth Naval Shipyard" contains a complete listing of all mammals and reptiles found in the southeastern Maine-New Hampshire region (Navy 1993b).

One notable ecological feature of the shipyard is its avian population. Bird species are most abundant in the region during the months of April and September, coinciding with the migratory seasons. The most common species in the area are the herring gull, American black duck, doublecrested commorant, great blue heron, and American crow. The most abundant winter migrant species are Canada geese, greater scaup, bufflehead, and common goldeye. Sea birds in general are the most abundant, and the year-round species include herring gulls and great black-backed gulls. The commom tern can also be found in large numbers during the late spring and summer. Osprey have also been known to frequent the area and there is one known nesting pair in the Great Bay Estuary vicinity. Appendix V.A. of the Navy's Natural Resources Management Plan contains a complete list of bird species common to the coastal region (Navy 1993b).

Clarks Island serves as a safe haven for a multitude of birds. It is an optimum habitat for migratory species in that it has rocky shore, a small beach area, and an inland area of fairly dense wood and low-lying vegetation. It would not be unreasonable to expect that during the early spring and fall, Clarks Island would be utilized by a variety of songbird species along with the typical coastal species mentioned above. (Navy 1993b)

4.1.3.9.2 Wetlands. There are a few isolated marine wetlands in the vicinity of the shipyard and a small freshwater wetland on the shipyard. There are two freshwater ponds on the southern portion of the base, which have been characterized as palustrine, unconsolidated bottom, and permanently flooded. There is a small area on the banks of the larger pond which is characterized as palustrine, scrub shrub, broadleaf deciduous wetland. There are also two very minute areas southwest of the freshwater ponds which have been characterized as palustrine emergent, persistent, seasonally flooded wetlands. Two areas of estuarine wetlands are noted. Along the northeast shoreline, they are classified as intertidal, unconsolidated shore, mud bottom, and regularly flooded. This same classification has been given to the northern shoreline of Clarks Island. Finally, on the western side of Clarks Island and on the southwestern corner of the shipyard, there are areas of estuarine intertidal aquatic bed, algal, regularly flooded wetlands. It should be noted that these determinations were based on stereoscopic analysis of aerial photographs and cannot be considered completely accurate without ground truthing. (Navy 1993b)

Because natural drainage systems are limited, the shipyard has developed an extensive storm water collection system and a drainage system to control flooding of the freshwater ponds. This collection system eventually drains into the Piscataqua River, as does surface runoff. (Navy 1993b)

4.1.3.9.3 Aquatic Ecology. The waters surrounding the Portsmouth Naval Shipyard support a vast amount of marine life, from mammals to benthic organisms. Although the larger mammalian species, like whales and dolphin, are not common to the estuarine waters of the Piscataqua River, harbor seals can be seen throughout the Great Bay region in winter and spring. The estuary also supports a number of commercially and recreationally important fin fish including smelt, winter flounder, Atlantic silversides, alewives, and striped bass. A more complete list can be found in Appendix V.A. of the Navy's Natural Resources Management Plan (Navy 1993b).

These fish species rely heavily on a healthy benthic invertebrate population for survival. Substrate type has a major impact on the number and variety of species that will be found in any particular area. The areas around the shipyard that have a rocky bottom will be populated by epibenthic organisms. Sandy or muddy bottoms can support both epibenthic and infaunal organisms.

Some of the more common shellfish species include lobster, softshell clams, and blue muscles. A more detailed list of benthic infauna can be found in Appendix V.A. of the Navy's Natural Resources Management Plan (Navy 1993b).

The freshwater ponds on the shipyard also serve as a source of aquatic species. There is a healthy benthic community within this ecosystem as well, including a variety of polychaete worms. There is an abundance of vegetation in and around the ponds, which provides habitat for freshwater fish. The most abundant fish species at this time is the smallmouth bass (Micropterus dolomieui), which were stocked at one time. (Navy 1993b)

4.1.3.9.4 Endangered and Threatened Species. In the coastal area from Portland, Maine to Portsmouth, New Hampshire, the threatened or endangered species include the Piping Plover, Roseate Tern, Bald Eagle, Peregrine Falcon, Shortnose Sturgeon, and several species of whales and sea turtles.

Appendix V.A. of the Navy's Natural Resources Management Plan (Navy 1993b) includes a list of the threatened and endangered species of southeastern Maine and New Hampshire. Both Maine and New Hampshire officials were consulted and have determined that there is no evidence to suggest that any threatened or endangered species reside on the Portsmouth Naval Shipyard. Marine mammals are afforded full federal protection under the Marine Mammal Protection Act of 1972 (Navy 1993b).

4.1.3.10 Noise

Portsmouth Naval Shipyard is an existing industrial-type environment characterized by noise from truck and auto traffic; ship loading cranes and related diesel-powered equipment; and continuously operating transmission lines for steam, fuel, water, and related compressors for those and other liquids. In addition, new construction of buildings, reconstruction and rehabilitation activities for streets, buildings, parking lots, and ships all contribute to a pervasively industrial environment.

4.1.3.11 Traffic and Transportation

The Kittery-Portsmouth area is very accessible to vehicular traffic due to the proximity of Interstate 95. The major cities of Boston, Massachusetts and Portland, Maine are approximately one hour away. U.S. Route 1, a primary road, runs parallel to I-95 in a north-south direction and provides good access to the local communities along the seacoast. Because of the shipyard's location on an island in the Piscataqua River, access is restricted to two federally owned bridges. The bridges provide access directly to the shipyard's northern boundary from residential streets in the town of Kittery. The majority of installation oriented traffic traverses five local secondary roadways: Walker Avenue, Wenworth Street, and Shapleigh, Whipple, and Rogers Roads. Walker Avenue is the primary access route to Bridge 1 and Whipple Road provides direct access to Bridge 2. Most shipyard generated traffic is funneled from the two major highways, 1-95 and U.S. Route 1, through the local roadways and over the bridges.

Daily rail service, freight only, is provided to Portsmouth Naval Shipyard by the Boston and Maine Railroad. The railroad connects Portsmouth with Manchester, New Hampshire; Portland, Maine; and Boston, Massachusetts. Rail passenger service is available via AMTRAK connecting to Boston.

Limited air service is provided at small airports at Eliot and Sanford, Maine, and Hampton and Rochester, New Hampshire. Pease Airport provides the opportunity for commuter flights to Logan Airport in Boston, Massachusetts and to other cities. In addition, Portsmouth is within one hour travel time by car from major airports at Boston, Massachusetts and Portland, Maine.

The Portsmouth Harbor, about 3 nautical miles from deep water of the Atlantic Ocean, is accessible year round via the Piscataqua River channel. The river channel is 35 feet deep below mean low water and 400 feet wide. There are about 500 vessel trips each way through the channel each year. About 150 of these trips involve ships with drafts greater than 18 feet, and more than 200 trips are made by tankers. A Coast Guard Station is located at New Castle near the harbor entrance. (Navy 1984)

Naval spent nuclear fuel has been removed from Navy nuclear-powered ships and transported to the Idaho National Engineering Laboratory Expended Core Facility (ECF) for examination and evaluation as a routine part of their operating cycle. Naval spent nuclear fuel shipments from Portsmouth Naval Shipyard to ECF were initiated in 1959. Since that time, 43 shipments of naval spent nuclear fuel originating at Portsmouth Naval Shipyard have been made to ECF. The naval spent nuclear fuel was shipped by rail. Attachment A provides a list of these shipments made to date by year. Attachment A also contains detailed descriptions of the shipping containers used for naval spent nuclear fuel shipments from shipyards.

4.1.3.12 Occupational and Public Health and Safety

4.1.3.12.1 Occupational Radiological Health and Safety. Portsmouth Naval Shipyard and the Admiralty Village housing area are physically located in York County, Kittery, Maine on government-owned land. The U.S. Government provides its own police and fire protection on the shipyard, while Kittery provides police and fire protection for the Admiralty Village Housing Area. (Navy 1984)

The Navy has well established and effective Occupational Safety, Health, and Occupational Medicine programs at all of its shipyards. In regard to radiological aspects of these programs, the Naval Nuclear Propulsion Program policy is to reduce to as low as reasonably achievable the external exposure to personnel from ionizing radiation associated with naval nuclear propulsion plants. These stringent controls on minimizing occupational radiation exposure have been successful. No civilian or military personnel at Navy sites have ever exceeded the federal accumulated radiation exposure limit which allows 5 rem exposure for each year of age beyond age 18. Since 1967, no person has exceeded the federal limit which allows up to 3 rem per quarter year and since 1980, no one has received more than 2 rem per year from radiation associated with naval nuclear propulsion plants. The average occupational exposure of each person monitored at all shipyards is 0.26 rem per year. The average lifetime accumulated radiation exposure from radiation associated with naval nuclear propulsion plants for all shipyard personnel who were monitored is 1.2 rem. (NNPP 1994a) This corresponds to the likelihood of a cancer fatality of 1 in 2083.

The Navy's policy on occupational exposure from internal radioactivity is to prevent radiation exposure to personnel from internal radioactivity. The limits invoked to achieve this objective are one-tenth of the levels allowed by federal regulations for radiation workers. As a result of this policy, no civilian or military personnel at shipyards have ever received more than one-tenth the federal annual occupational exposure limit from internal radiation exposure caused by radioactivity associated with naval nuclear propulsion plants.

For work operations involving the potential for spreading radioactive contamination, containments are used to prevent personnel contamination or generation of airborne radioactivity. The controls for contamination are so strict that precautions sometimes have had to be taken to prevent tracking contamination from fallout and natural sources into radiological areas because the contamination control limits used in these areas were well below the levels of fallout and natural contamination occurring outside in the general public areas. A basic requirement of contamination control is monitoring all personnel leaving any area where radioactive contamination could possibly occur. Workers are trained to survey themselves (i.e., frisk), and their performance is checked by radiological control personnel. Frisking of the entire body is required, normally using sensitive hand-held survey instruments. Major work facilities are equipped with portable monitors, which are used in lieu of hand-held friskers. These stringent controls to protect the workers and the public from contamination have proven effective in the past.

In 1991, researchers from Johns Hopkins University, Baltimore, Maryland, completed a very comprehensive epidemiological study of the health of workers at the six naval shipyards and two private shipyards that service the Navy's nuclear-powered ships (Matanoski 1991). This independent study evaluated a population of 70,730 civilian workers over a period from 1957, beginning with the first overhaul of the first nuclear-powered submarine, USS NAUTILUS, through 1981, to determine whether there was an excess risk of leukemia or other cancers associated with exposure to low levels of gamma radiation.

The Johns Hopkins study found no evidence to conclude that the health of people involved in work on U.S. naval nuclear-powered ships has been adversely affected by exposure to low levels of radiation incidental to this work. Additional studies are planned to investigate the observations and update the shipyard study with data beyond 1981.

The radiation exposure during normal operations at each shipyard for workers who have their radiation levels monitored is determined based on the annual radiation exposure of 0.26 mrem per worker for all shipyards based on Naval Nuclear Propulsion Program Report NT-94-2 (NNPP 1994a). The total number of shipyard personnel monitored for radiation exposure associated with the Naval Nuclear Propulsion Program has been about 164,000.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to transportation workers for all historical shipments is 16.6 person-rem, which statistically corresponds to 0.0066 cancer fatalities. The maximum exposed individual (MEI) is a transportation worker, since the workers are closer to the shipment for a longer time than any member of the general population. Under the limiting assumption that the same worker is associated with every shipment for the entire historical period, this person would receive a total exposure of 7.5 rem over the approximately 40-year period, or about 0.19 rem per year, which is within DOE standards for occupationally exposed individuals. The radiation exposures to workers correspond to much less than one incident cancer, which means that it is unlikely that there have been any past health impacts due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.3.12.2 Occupational Non-radiological Health and Safety. In the non-radiological Occupational Safety, Health, and Occupational Medicine area, the Navy complies with the Occupational Safety and Health Administration Regulations. The Navy policy is to maintain a safe and healthful work environment at all Navy facilities. Due to the varied nature of work at these facilities, there is a potential for certain employees to be exposed to physical and chemical hazards. These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to high noise levels or heat stress. In addition, employees are monitored for their exposure to chemical hazards such as organic solvents, lead, asbestos, etc., and where appropriate are placed into medical surveillance programs for these chemical hazards.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact due to the historical shipment of naval spent nuclear fuel over the entire history of such shipments.

4.1.3.12.3 Public Radiological Health and Safety. In order to quantify the exposures resulting from normal shipyard radiological releases to the general public, detailed analyses were performed based on very conservative estimates of radioisotopic releases since releases began. Attachment F provides detailed annual release values used in the analyses.

The GENII computer code (Napier et al. 1988) was used to calculate exposures to human beings due to the estimated radionuclide releases from normal operations at the shipyards.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from stored fuel. The population data used to calculate population exposures were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F.

The hypothetical exposures calculated in Attachment F for the period 1995 through 2035 were adjusted from an annual basis (1995) to the historical basis by multiplying by 38 years and by a factor of 1.7 to take into consideration variations in the number of ships and operations.

The calculated accumulated exposures through 1995 to the general population within 50 miles of the site (about 2.4 million people) are 0.65 person-rem. To provide perspective, the exposures received due to natural radiation sources through 1995 are approximately 28 million person-rem, based on 0.3 rem per person per year.

The results of environmental monitoring as described in Naval Nuclear Propulsion Program Report NT-94-1 show that Naval Nuclear Propulsion Program activities had no distinguishable effect on normal background radiation levels at site perimeters (NNPP 1994b).

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to the general population for all historical shipments is 1.95 person-rem, which statistically corresponds to 0.00098 cancer fatalities.

All of the radiation exposures to the general population correspond to much less than one incident cancer, which means that it is unlikely that there has been any past health impacts to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.3.12.4 Public Non-radiological Health and Safety. The Naval Medical Clinic located on the shipyard is used by Navy personnel and dependents for their general medical care requirements.

Medical problems that require treatment not available at the clinic are taken care of at hospitals located in York, Maine and Portsmouth, New Hampshire. (Navy 1984)

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.3.13 Utilities and Energy

Portsmouth Naval Shipyard has its own Security, Fire, Public Works, and Supply departments. Portsmouth Naval Shipyard obtains its electricity from Central Maine Power, but has a central power plant capable of producing all of the required steam and electricity. Potable water is furnished by the town of Kittery, Maine. (Navy 1984)

The 1993 electrical power usage at Portsmouth Naval Shipyard was 76,262 megawatt hours. The water usage at the shipyard was approximately 668 million gallons for 1993.

4.1.3.14 Materials and Waste Management

The shipyard's sewage is pumped to the town of Kittery's sewage treatment system. Disposition of solid waste is as follows: 58% is recycled, 38% is burned for energy recovery at the Maine Energy Recovery Incinerator, and 4% is landfilled at licensed off-site facilities. Bulk aqueous waste is collected and shipped for off-site licensed treatment/disposal. Containerized hazardous waste is collected, consolidated, characterized, and labeled at the shipyard's state-licensed Hazardous Waste Storage Facility prior to manifesting to off-site licensed treatment/disposal/energy recovery facilities. Oily waste is presently contracted for off-site disposal; however, an oily waste treatment system has been installed and should be on line in the near future. The effluent from treatment operations will be discharged to the sewer, and the separated waste oil will be sold through the Defense Logistics Agency.

Solid radioactive waste materials are packaged in strong, tight containers, shielded as necessary, and shipped to burial sites licensed by the U.S. Nuclear Regulatory Commission or a State under agreement with the U.S. Nuclear Regulatory Commission. Shipyards and other shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. During 1992, approximately 74 cubic yards of routine low-level radioactive waste containing 2 curies were shipped from Portsmouth Naval Shipyard for burial.

Waste which is both radioactive and chemically hazardous is regulated under both the Atomic Energy Act and the Resource Conservation and Recovery Act (RCRA) as "mixed waste." Within the Naval Nuclear Propulsion Program, concerted efforts are taken to avoid combining radioactive and chemically hazardous substances so as to minimize the potential for generation of mixed waste. For example, these efforts include avoiding the use of acetone solvents, lead-based paints, lead shielding in disposal containers, and chemical paint removers. Radioactive wastes, including those containing chemically hazardous substances, are handled in accordance with long-standing Program radiological requirements. Such handling includes solidification to immobilize the radioactivity, separation of the radioactive and chemically hazardous substances, removal of liquids from solids, and other simple techniques. A determination is then made as to whether the resulting waste is hazardous. As a result of Program efforts to avoid the use of chemically hazardous substances in radiological work, Program activities typically generate only a few hundred cubic feet of mixed waste each year. This small amount of mixed waste, along with limited amounts of mixed waste from Program work conducted prior to 1987, will be stored pending the licensing of commercial treatment and disposal facilities.

4.1.4 PEARL HARBOR NAVAL SHIPYARD: PEARL HARBOR, HAWAII

4.1.4.1 Overview

The Pearl Harbor Naval Shipyard is located in the Southeast Loch of Pearl Harbor, Oahu, Hawaii (Figures 4.1.4-1 and 4.1.4-2). This shipyard consists of approximately 350 acres. The island of Oahu is the third largest (593 square miles) in the State of Hawaii and is the population center of the Hawaiian Islands. The 1990 Oahu population of approximately 820,000 residents comprised over 75% of the state's total, and the City and County of Honolulu are the fastest growing areas in the state, with the highest population densities. Honolulu is the state capital, largest city, and center of business and government.

Pearl Harbor is a principal harbor for U.S. Navy activities and is the base of Navy operations for the mid-Pacific. Figure 4.1.4-3 provides a Pearl Harbor site map. Its water surface area of about 8 square miles and its docks accommodate all classes of Navy vessels up to the largest aircraft carriers. Ship maintenance and repairs are performed for all types of vessels in Pearl Harbor Naval Shipyard's dry docks and docking areas. All of the docks are located in the Southeast Loch area with the exception of Dry Dock 4 which is adjacent to the Pearl Harbor main channel. (Navy 1991c)

4.1.4.2 Land Use

There are six major land use activities at Pearl Harbor. Commander Naval Base Pearl Harbor (NAVBASE) hosts various operational commands that include the Headquarters for the Pacific Fleet and the Headquarters of the Third Fleet.

Pearl Harbor Naval Shipyard provides the maintenance and repair services noted above. The Naval Supply Center provides fuel, ammunition, other supplies, and storage. The other primary land use activities are for: the Submarine Base; the Public Works Center; and the U.S. Naval Inactive Ship Maintenance Detachment.

Land use is designated as urban by the State of Hawaii, and military by the City and County of Honolulu. As can be seen in Figure 4.1.4-2, the Pearl Harbor Naval Shipyard is surrounded by

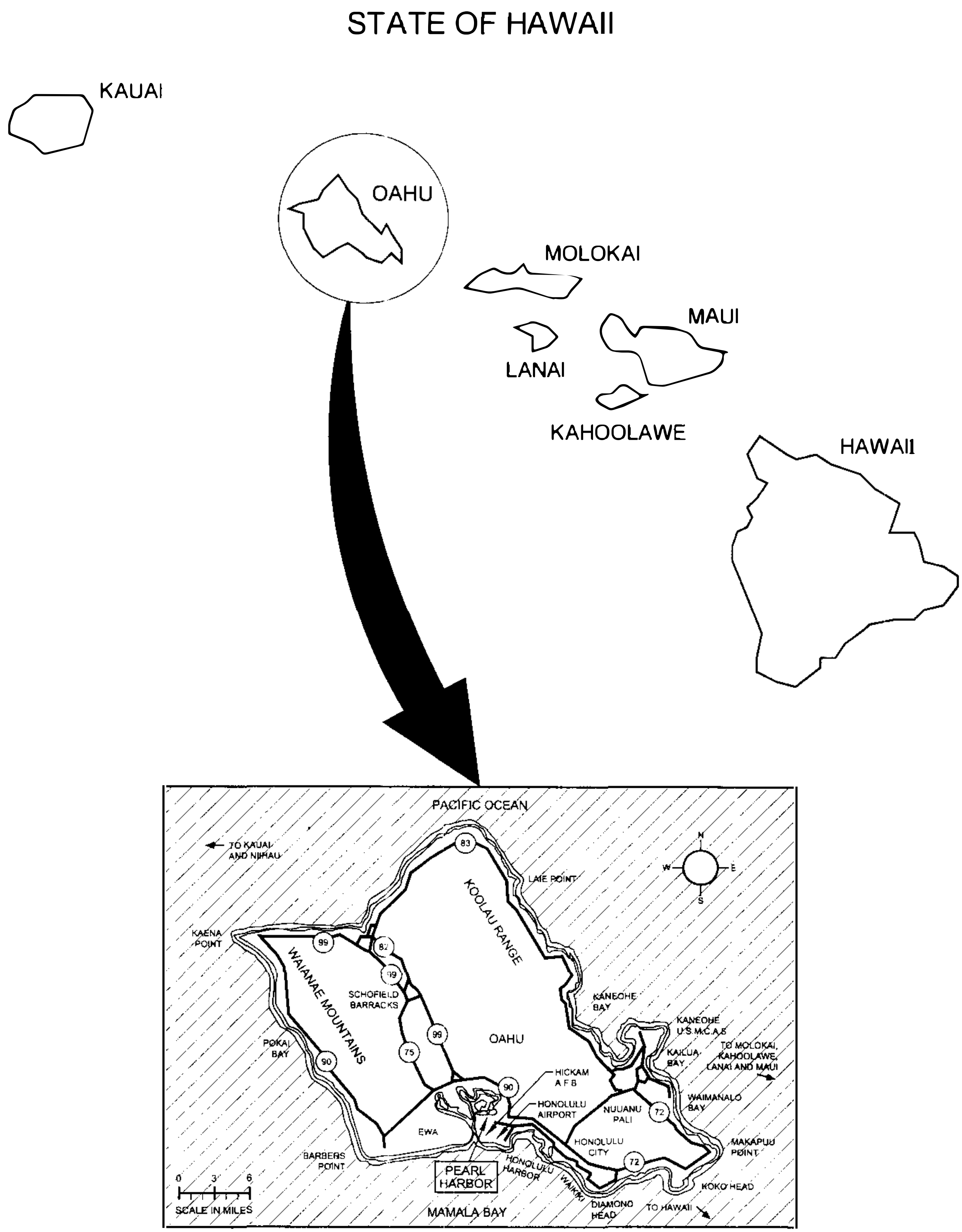


Figure 4.1.4-1. Location of Pearl Harbor Naval Shipyard in Hawaii.

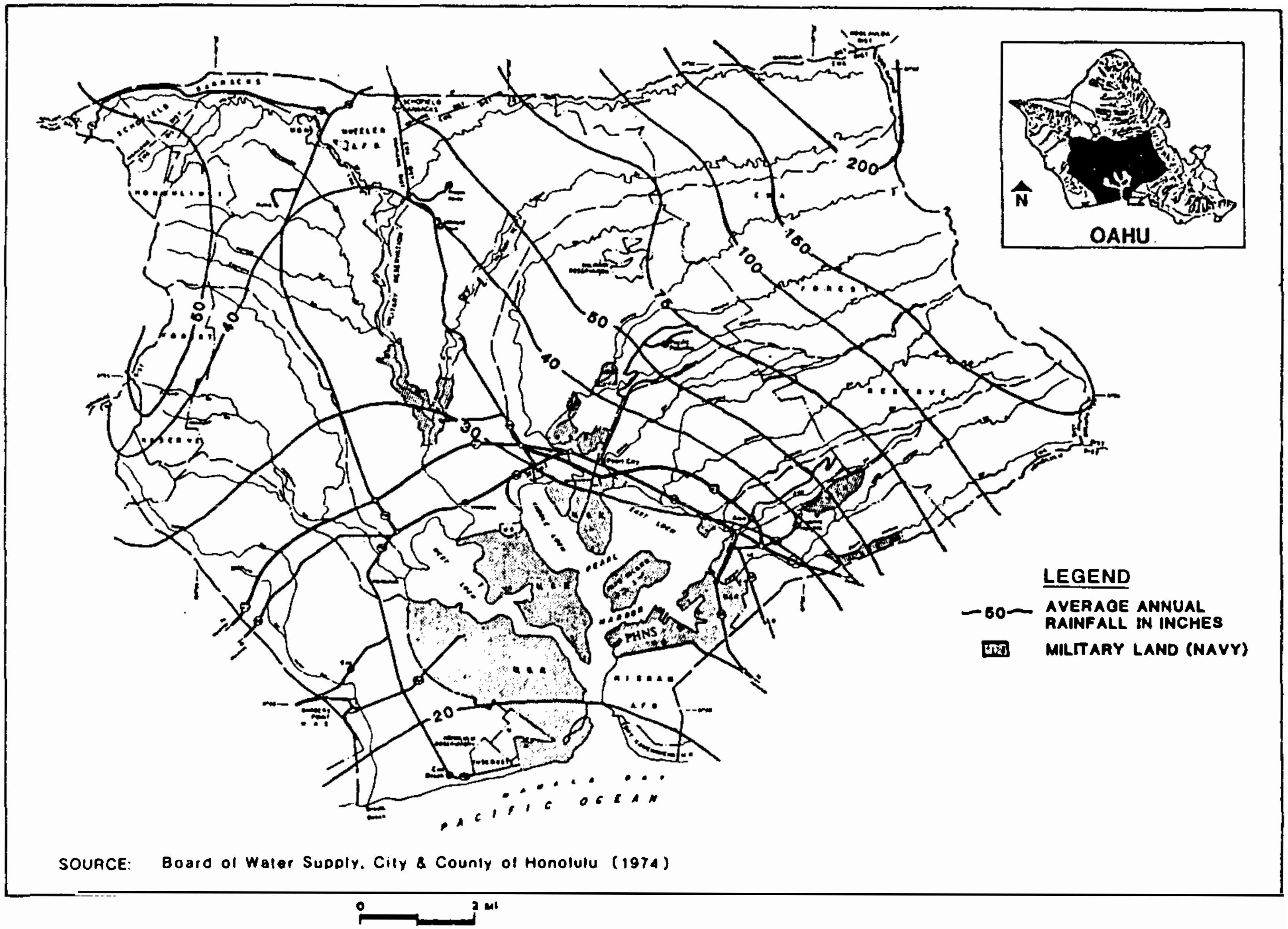


Figure 4.1.4-2. Pearl Harbor vicinity with average annual rainfall gradient.

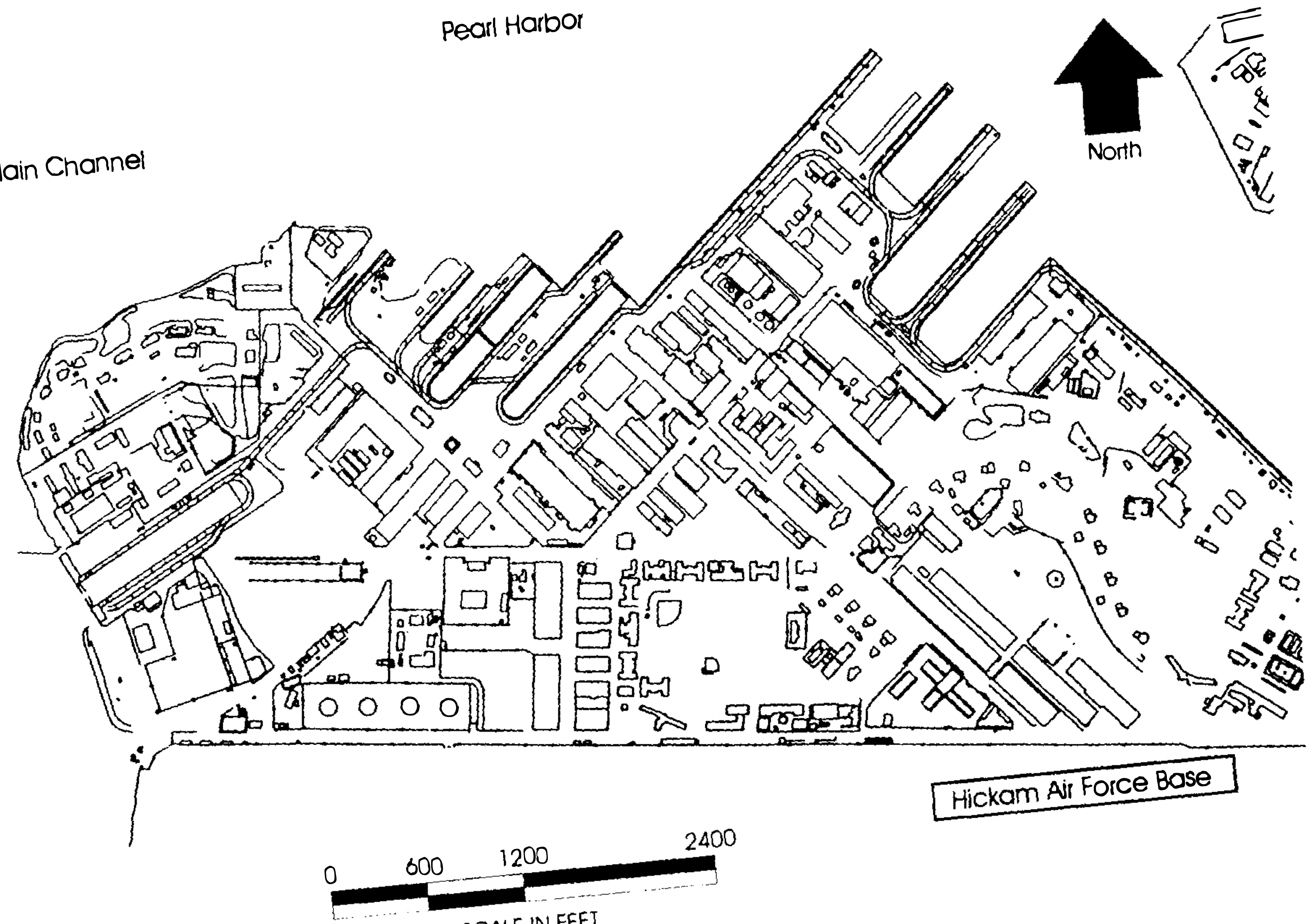


Figure 4.1.4-3. Pearl Harbor Naval Shipyard site map.

military land with Hickam Air Force Base in the southern quadrant and naval installations occupying the remaining three quadrants. Other activities commonly occurring in the Pearl Harbor area are commercial fishing, tourism, and recreational facilities, along with a few retail complexes. (Navy 1990b)

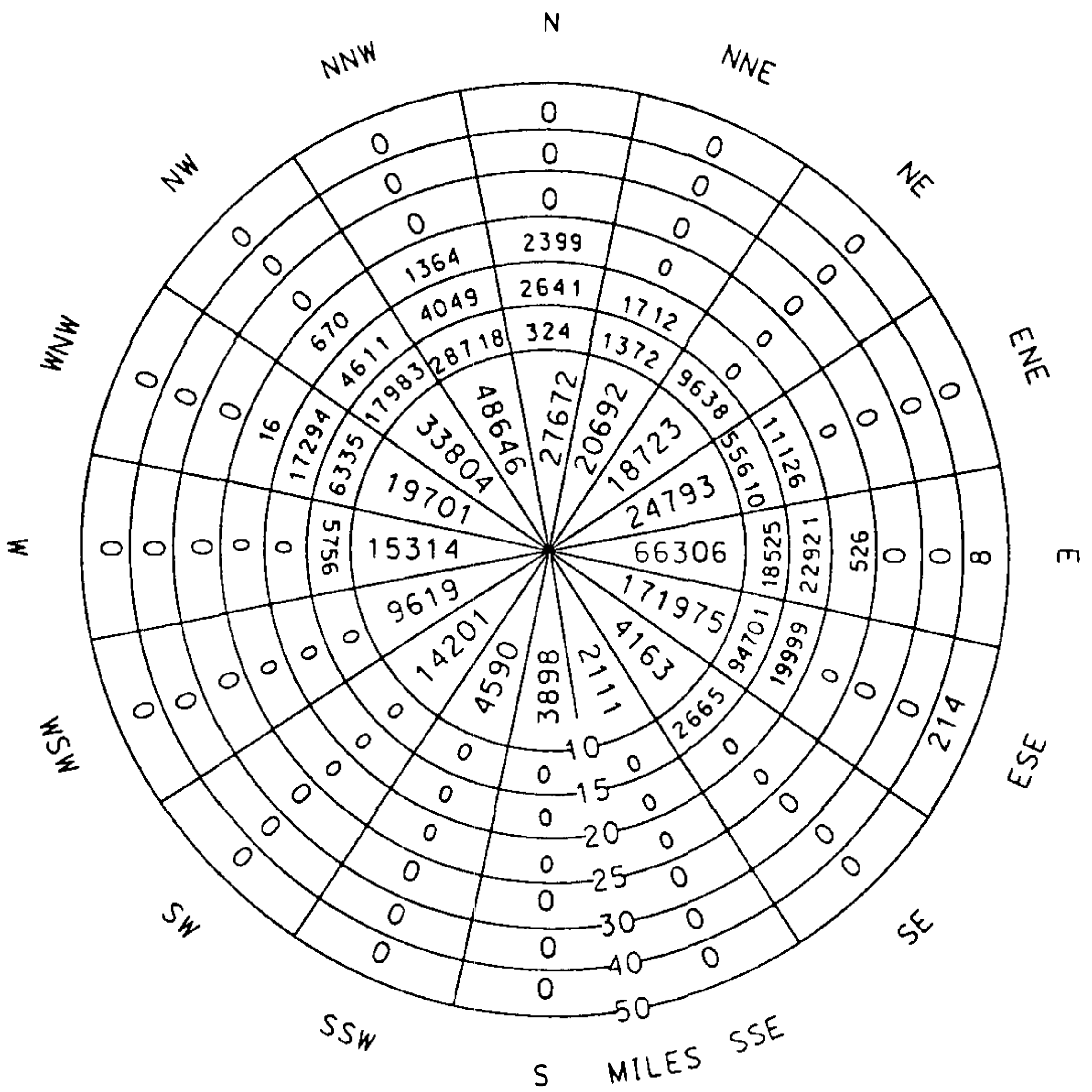
4.1.4.3 Socioeconomics

Oahu has experienced a high rate of economic growth over the past decade due to its location in the Pacific, which benefits both military defense and visitor industries. These two industries have surpassed the two historical bases of the Hawaiian economy, which are pineapple and sugar cultivation and production.

Oahu's visitor industry continues to prosper. Visitor arrivals to the state are projected by the Department of Business and Economic Development to reach 7.8 million visitors by 2000, with Oahu capturing approximately half of the visitors. This would represent a visitor growth rate on Oahu of about 3.4 percent compounded annually.

Defense expenditures cushion Oahu's economy from the seasonal and cyclical fluctuations of tourism. The military is also a primary source of highly skilled employment opportunities for civilians. Pearl Harbor has the largest concentration of Department of Defense employment in the state, with about 7,700 shore-based Navy personnel and 10,900 civilians, for a total of 18,600 at the naval base. In 1993, shipyard employment accounted for about 5,000 of the total. The population distribution within 50 miles of Pearl Harbor Naval Shipyard is shown in Figure 4.1.4-4.

Unemployment figures in the state and for the island of Oahu are among the lowest in the nation. Oahu is at a 2.3 percent unemployment level as of October 1989, reflecting the strong local economy that prevailed in the latter half of the 1980s. With the outlook favorable for continued expansion, job growth is currently expected to equal or better the 2 to 3 percent historical annual increase in Oahu's work force. (Navy 1990b)



Miles	People	Cumulative People
0-5	214,516	214,516
5-10	217,692	486,208
10-20	325,980	812,188
20-30	4,975	817,163
30-40	0	817,163
40-50	222	817,385

Based on 1990 Census

Figure 4.1.4-4. Population distribution within 50 miles of Pearl Harbor Naval Shipyard.

The majority of the labor force that would be employed at the shipyard for construction and operation of the naval spent nuclear fuel area would be expected to reside on the island of Oahu. The calculated total population, labor force, and employment within this region for the base year (1995) are presented in Table 4.1.4-1. Projections of employment and population for the years beyond 1995 have not been presented because, as discussed in Section 5, the number of additional jobs that might be created at the shipyard under any alternative could be small.

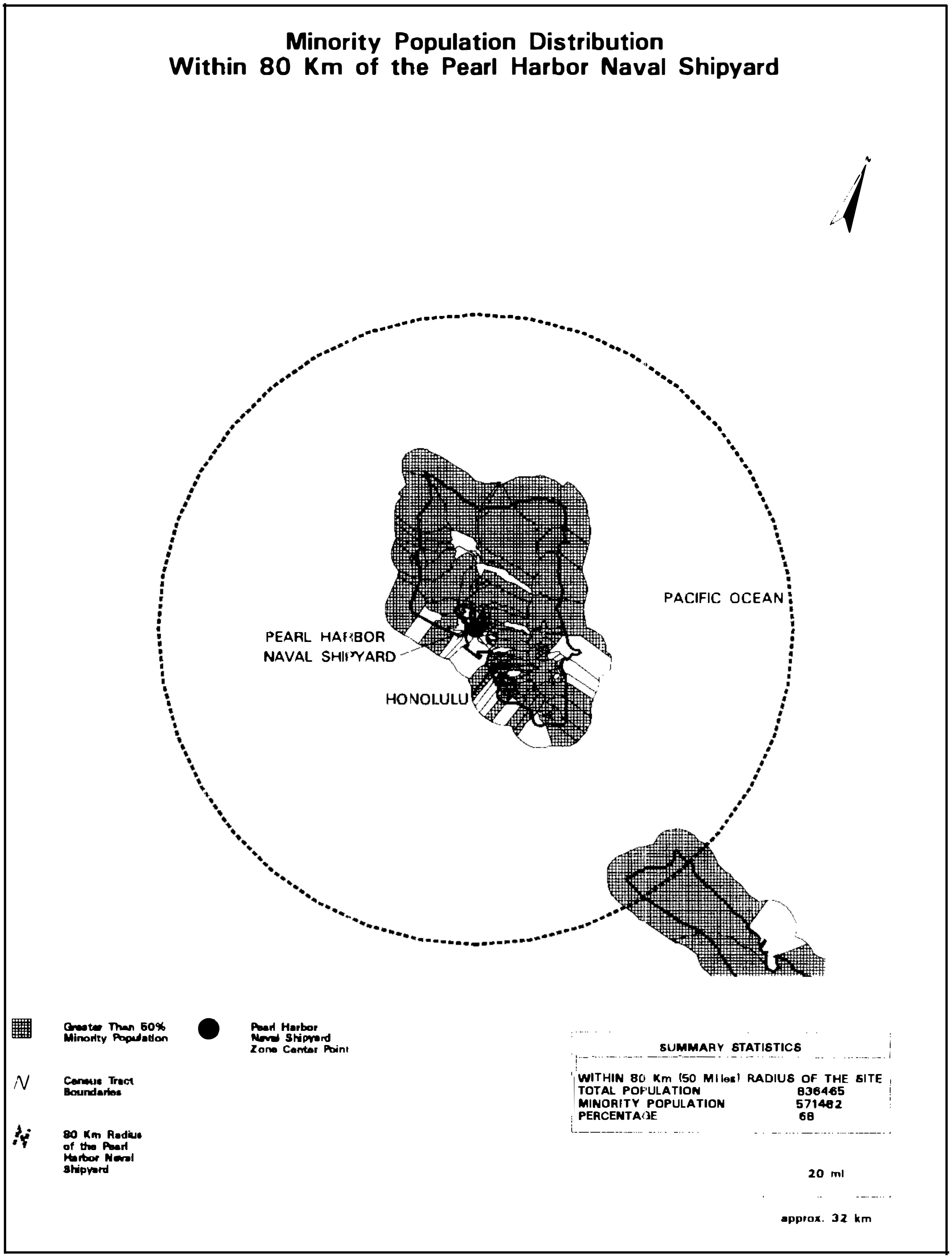
Table 4.1.4-1. Regional employment factors at Pearl Harbor Naval Shipyard.

Regional Employment	Regional Labor Force	Regional Population
393,260	407,530	812,190

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the Pearl Harbor Naval Shipyard, consistent with the population data provided in Figure 4.1.4-4.

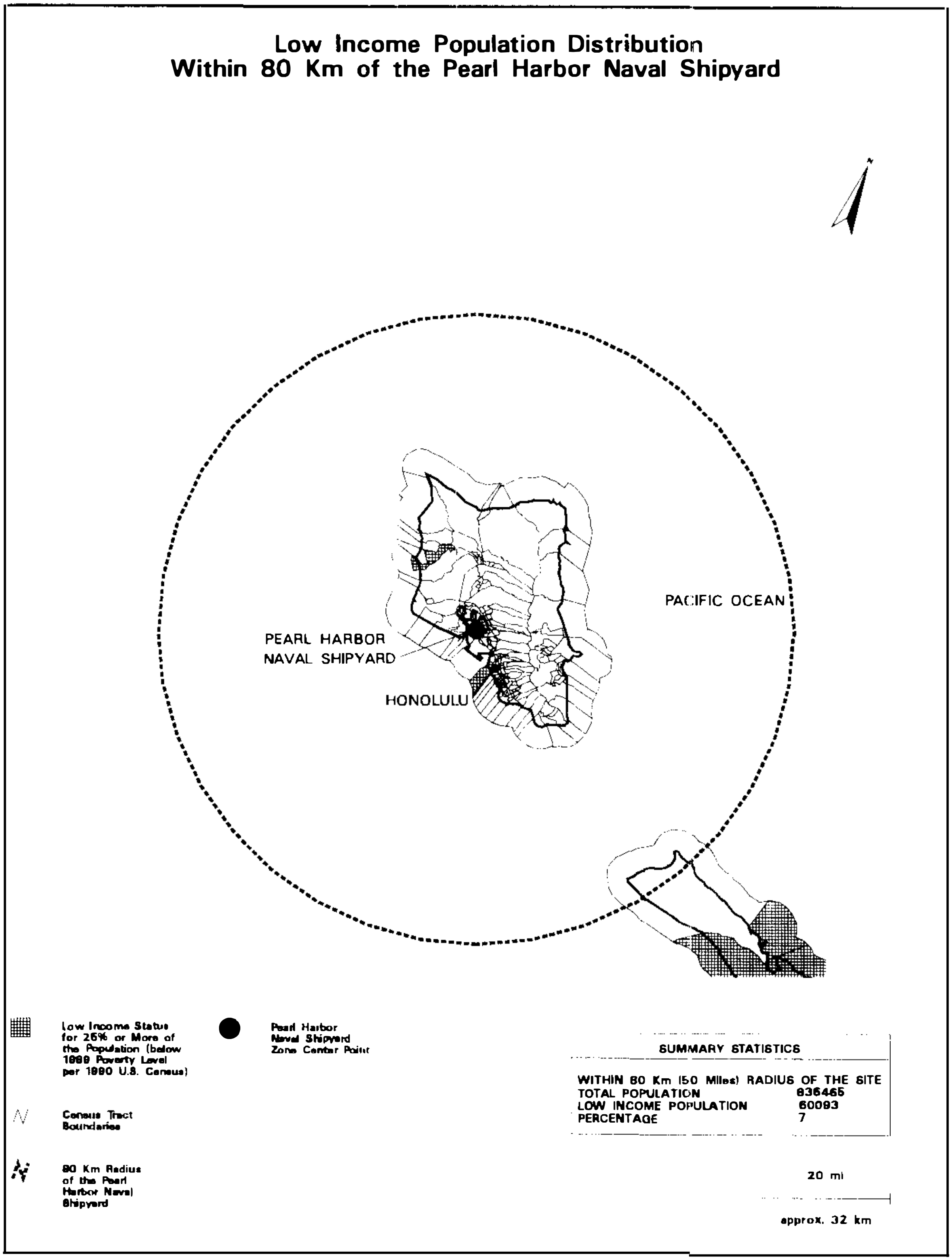
Figure 4.1.4-5 shows the locations of populations which have more than 50 percent minority members within the 50-mile radius. Minorities make up approximately 55 percent of the total population in this area. These populations have been identified following an approach developed by the Environmental Protection Agency which, for purposes of environmental justice evaluation, defines minority communities as those which have percentages of minorities greater than the average in the region analyzed (EPA 1994).

Figure 4.1.4-6 shows the locations of populations which have more than 25 percent of their members living in poverty, reflecting a common definition of low-income communities (EPA 1993). The U. S. Census Bureau characterizes persons in poverty as those whose income is less than a



Based on 1990 Census

Figure 4.1.4-5. Minority population distribution within 50 miles of the Pearl Harbor Naval Shipyard.



Based on 1990 Census

Figure 4.1.4-6. Low-income population distribution within 50 miles of the Pearl Harbor Naval Shipyard.

"statistical poverty threshold." For the 1990 census, this threshold was based on a 1989 income of $12,500 per household.

4.1.4.4 Cultural Resources

Pearl Harbor has been the site of several important historical events and changes, and is most noted for its role in the Pacific Theatre Defense during World War II. Physical sites near and in Pearl Harbor have been designated as historically significant, including several battleships sunk during the December 7, 1941 Japanese bombing of Pearl Harbor, as well as sites where planes were downed. Naval Base Pearl Harbor was designated as a National Historic Landmark in 1964, and in 1974, it was listed on the National Register of Historic Places.

The Pearl Harbor area has been heavily modified over the past 70 years. This includes extensive changes that were intended to stabilize the marshy shorelines. Most surface evidence of any pre-military occupation has long since been obliterated. Due to the historic nature of the shipyard, there might be areas of archaeological interest. However, there are no archaeological sites located within the boundary of the shipyard. Many native Hawaiian cultural resources exist on the Hawaiian Islands. There are three Hawaiian fish ponds located outside the boundary, in West Loch and in East Loch, that have been recommended for preservation. (Navy 1990b)

4.1.4.5 Aesthetic and Scenic Resources

The Pearl Harbor viewshed is dominated by the sweeping mountain to sea vistas characteristic of nearshore areas on Oahu. The City and County of Honolulu's *Coastal View Study* (1987) states that the "flat terrain and the built up military facilities surrounding Pearl Harbor provide very little public viewing opportunities into this bay." (Navy 1990b) The shipyard area, itself, is an industrial setting. The area within the shipyard where naval spent nuclear fuel would be stored has low visual sensitivity since the area is an industrial site.

4.1.4.6 Geology

4.1.4.6.1 General Geology. Oahu's topography consists of two parallel mountain ranges running in a northwest to southeast direction, separated by a plateau. A large, relatively level coastal plain borders the plateau at the south. The Pearl Harbor Naval Complex, for the most part, lies within this coastal plain.

Land near the waterfront areas is very flat, rising slightly inland from Kamehameha Highway. There are moderate slopes which exist around the rim of the Makalapa Crater.

4.1.4.6.2 Geologic Resources. There are several different soil associations within the Pearl Harbor basin. The majority of the U.S. Navy lands surrounding Pearl Harbor are comprised of the Lualualei - Fill Land - Ewa Soil Association. This association consists of well-drained, fine textured, and moderate fine textured soils on fans and in drainage ways on the southern and western coastal plains of Oahu. The soils are formed from sediment deposited by streams, and are nearly level to moderately sloping. This soil association makes up about 14 percent of the island of Oahu.

Pearl Harbor estuary occurs on the coastal sedimentary plain of southern Oahu. The harbor consists of three lochs which join to form a single channel entrance. Streams, springs, and ground-water flow into the harbor; the estuary was formed by freshwater flows that have eroded the coastal plain and retarded coral growth. Since their initial formation, the lochs have been altered by sea-level change, erosion, and silt. The west side of the harbor is composed mostly of limestone reef material known as the Ewa Plain. The east side of the harbor consists mainly of compacted volcanic ash. Hard, dense volcanic rock forms the bulk of the rock material to the north. Marine and terrestrial sediments occur around the perimeter of the harbor. (Navy 1990b)

Much of the land area in Pearl Harbor is fill land created by dredge spoils since 1930. A major dredging effort took place between 1940 and 1943, when dredged material was placed in the Waipio Peninsula and adjacent to Kuahua Island (now Kuahua Peninsula). This landfill resulted in the present shoreline configuration. (Navy 1990b) There are no economic geologic resources at the shipyard.

4.1.4.6.3 Seismic and Volcanic Hazards. Seismic risk related to structural damage may be represented in the United States by a relative scale of 0 through 4, with Zone 0 not expected to encounter damage and Zone 4 expected to encounter the greatest seismic risk. The Pearl Harbor Naval Shipyard is located in Zone 1. (UBC 1991) Except for the island of Hawaii itself, the Hawaiian Islands are not a highly seismic area. Even on Hawaii, most of the earthquakes are of volcanic origin and do little or no damage, although a few have been quite severe. The Uniform Building Code seismic classification provides a means for a comparable assessment of the seismic hazard between the alternate sites. If the Record of Decision identifies this site for the interim storage of naval spent fuel, then a detailed seismic evaluation would be conducted. More detailed information regarding the design basis considerations for storage of naval spent nuclear fuel at the shipyard is provided in Attachment D.

From review of Tsunami Wave Runup Heights in Hawaii by Harold G. Loomis, Hawaii Institute of Geophysics, University of Hawaii, May 1976, past inundation levels from waves produced by seismic events have been about 3 feet above Mean Sea Level (msl). In addition, a memorandum from the U.S. Army Engineering Division, Pacific Ocean, dated 10 January 1986 indicated projected seismically induced wave elevations for the 10-year, 100-year, and 500-year event to be 0.8 feet, 2.0 feet, and 3.8 feet, respectively, for adjacent coastal areas. (Navy 1990b)

Pearl Harbor is fully protected from ocean waves and swells. Waves propagating through the 15,000-foot entrance channel are completely reduced. The normal tides in Hawaii occur twice daily, with pronounced daily inequalities. Maximum high, or spring tides, reach 2.5 feet above msl. Storm water level rise is caused by four components: astronomical tides, rise from atmospheric pressure reduction (pressure setup), wind setup, and wave setup. Based on information obtained from the Naval Western Oceanography Center, maximum hurricane storm water level rise from setup under the worst conditions foreseeable would be approximately 12 feet above the existing tide level. Thus, maximum total storm water level rise would be approximately 14.5 feet above msl. Under the maximum foreseeable conditions, any material stored in the dry dock area of Pearl Harbor Naval Shipyard, which is about 8 feet above msl, could be flooded to a level of about 6.5 feet.

In September 1992, the worst storm in Pacific history, Hurricane Iniki, hit Kauai with sustained 145-mile-per-hour winds and gusts to 175 miles per hour. Oahu, 80 miles to the east, received comparatively minor damage to that experienced on Kauai. The last hurricane to strike the state prior to Iniki was Iwa in 1982 but it did not cause nearly as much damage.

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. (Doell and Dalrymple 1973).

4.1.4.7 Air Resources

4.1.4.7.1 Climate and Meteorology. With the exception of minor differences in temperature and rainfall at Red Hill and Camp Stover, all of the activities at Pearl Harbor lie within the same climatic zone and are subject to the same weather conditions.

The predominant winds are the northeast tradewinds, which prevail most of the year, particularly from February to November. Thus, the predominant winds would carry any airborne contaminant from the shipyard to the unpopulated ocean region adjacent to Pearl Harbor on the south. At certain times of the year, south to southwest winds and mild offshore breezes can be expected. Winds with speeds up to 49 miles per hour may occasionally strike from the north or northeast but rarely reach gale velocities. The south winds are usually accompanied by wet tropical air and frequent heavy showers. During the summer months, periods of no wind occur occasionally but do not persist for more than a day or two. During the winter months, winds tend to be less predictable, with longer periods of light and variable winds, and occurrences of strong southerly or "Kona" winds associated with weather fronts and storms.

The rainfall at Pearl Harbor is light and generally inadequate to sustain lawns and other vegetation for at least nine months of the year. Very heavy precipitation may occasionally fall during times of southerly winds, and this may cause local flooding because of the nature of the soils and the relatively low elevation. The mean annual rainfall for the naval base is between 20 and 30 inches, dependent upon the incidence of the occasional heavy southerly rains mentioned previously. The topography and meteorology of Oahu are responsible for the unusual annual rainfall gradient shown in Figure 4.1.4-2.

Temperatures vary by season as well as daily in the Pearl Harbor region. Highs of 87°F to 89°F are not uncommon during mid-afternoon in summer. Night temperatures during the same season fall between 72°F and 76°F. During the winter and early spring, daytime highs will reach between 76°F and 78°F, and nighttime lows may fall to the low 60's or high 50's. The lows are generally caused by a shallow blanket of cold air that pours down from the mountains and spreads out over the lowlands during periods of low-velocity tradewinds. The low temperatures are almost invariably accompanied by a heavy dewfall which is not normal to the region.

4.1.4.7.2 Air Quality. An area can be designated by the Environmental Protection Agency as having air quality that is better than defined by the National Ambient Air Quality Standards (attainment) or as exceeding one or more of those standards (nonattainment for one or more pollutants). The Code of Federal Regulations, Title 40, Part 81, states that the Air Quality Control Region for the shipyard is better than national standards for total suspended particulate matter and SO_2. The area has no specific classification for ozone, carbon monoxide, and NO_2.

Air quality on Oahu is primarily affected by the prevalence of the northeast tradewinds which prevail approximately 80 percent of the year, particularly from February to November. Air monitoring of the naval base area conducted in 1989 showed that there was no NAAQS violation. Thus, air quality was in attainment with federal standards. The state standards, which are more restrictive in many cases than federal requirements, were exceeded only at intersections having high traffic during peak rush hours. (Navy 1990b) The nearest Class I Area is Haleakala National Park 188 kilometers (117 miles) from the shipyard.

4.1.4.7.3 Existing Radiological Conditions. Radiological facilities at all naval shipyards are designed to ensure that there are no uncontrolled discharges of radioactivity in airborne exhausts. Radiological controls are exercised to preclude exposure of working personnel to airborne radioactivity exceeding federal limits. Air exhausted from radiological work facilities is passed through high-efficiency particulate air filters and monitored during discharges. The annual airborne radioactivity emissions from the shipyards do not result in any measurable radiation exposure to the general public. Calculations of site radioactive airborne emissions for 1992 have been performed as described in Attachment F. These calculations have shown that emissions of radionuclides from each shipyard result in an effective dose equivalent of less than 0.1 mrem per year to any member of the general public.

4.1.4.8 Water Resources

4.1.4.8.1 Surface Water. Pearl Harbor receives surface runoff from seven watersheds. The Waikele Watershed (54 square miles) is the largest of the seven, comprising nearly 40 percent of the Pearl Harbor Basin. It is drained primarily by Waikele Stream, which discharges the heaviest sediment load of any of the Pearl Harbor Basin streams.

The Waiawa Watershed (24.6 square miles) consists of forest, agricultural, and urban land. It is drained by Waiawa Stream and its tributaries into Middle Loch. The Waimalu Watershed (17.7 square miles) is drained by the Waimano, Waimalu, and Kalauao Streams, which discharge into the East Loch of Pearl Harbor. The watershed is primarily undeveloped forest land with established urban areas on the coastal plain and lower slopes. The Aiea and Halawa Watersheds are drained by the Aiea and Halawa Streams, respectively, which discharge into East Loch. They are similar in nature to the Waimalu Watershed. Honouliuli Stream drains the Honouliuli Watershed and discharges intermittently into West Loch. The watershed consists primarily of agricultural and forested land. Only 20 percent of the Ewa Beach Watershed drains into Pearl Harbor. Sediment discharges into Pearl Harbor from the flat lowland area adjacent to West Loch are negligible.

Of the eight streams discharging into Pearl Harbor, two are intermittent: Honouliuli Stream and Aiea Stream. The remaining are perennial streams (Waikele, Waiawa, Waimano, Waimalu, Kalauao, and Halawa), which have their headwaters in the high rainfall area of the Koolau Range. All streams drain the forested and agricultural lands and pass through urban areas before entering Pearl Harbor. Some flooding occurs along the major streams throughout much of the basin but is not a major problem on the Naval Complex, affecting only a narrow strip of land along Aiea stream. (Navy 1990b)

An assessment in 1988 by the State of Hawaii, Department of Health indicated that Pearl Harbor's large drainage basin in central Oahu and the abundant rainfall in headwaters of the eight streams that flow into the harbor are major contributors to the harbor's role as a catchment for nonpoint runoff from agricultural, urban, and military sources. Violations of water quality criteria were noted for nitrogen, phosphorus, turbidity, and fecal coliforms in the harbor water. (Navy 1990b)

The Flood Insurance Rate Map (FIRM) COMMUNITY-PANEL No. 150001 0110 C shows that the floodplain is "undetermined" for the Pearl Harbor Naval Shipyard. Based on FIRM maps and topographical maps of areas approximately 3 miles away, the conceptual interim storage location is in the 100-year floodplain. However, based on experience, the location considered for naval spent nuclear fuel is not in a high-hazard area (as defined by Title 10, Part 1022 of The Code of Federal Regulations for floodplains) which is an area where frequent flooding occurs.

4.1.4.8.2 Groundwater. The major source of potable water on Oahu is dependent on a hydrologic cycle that starts with evaporation of water from the ocean, condensation of that vapor into rain, and the capture of that rain by the Koolau Mountains. A portion of the rainwater percolates down into the porous ground to become groundwater. The groundwater is a limited resource found in three types of groundwater bodies, or aquifers: major basal aquifers, which consist of freshwater floating on heavier seawater sealed from the ocean by layers of dense, hard volcanic rock; perched aquifers in which rainfall is caught behind impermeable dikes at high elevations; and groundwater standing on impermeable beds of volcanic ash, thus creating springs. Naval Base Pearl Harbor receives most of its water from the Koolau Aquifer and a small portion from the Waianae Aquifer, which are basal aquifers located in south central Oahu, partially within the Pearl Harbor Water Management Area (PHWMA). As of 1990, the military had an allocation of 28.125 million gallons per day (mgd) from the PHWMA, of which 22.670 mgd was authorized for the Navy. Over 4 mgd of this allocation was not used in 1988. Approximately 3 mgd of this unused allocation is attributed to the Navy. The quality of groundwater from the above aquifers is good. (Navy 1990b)

4.1.4.8.3 Existing Radiological Conditions. The normal activities associated with current naval nuclear operations at all naval shipyards do not result in the intentional discharge of any radioactive liquid effluent. However, there were occasions, primarily in the early 1960's, when measurable levels of radioactivity were discharged with liquid effluent. In all cases, effluent releases were less than permitted under the then current limits imposed by state and federal agencies.

The United States Environmental Protection Agency Office of Radiation Programs has performed monitoring of the water, plant life, aquatic life, and sediment in the vicinity of Pearl Harbor Naval Shipyard. The purpose of the survey was to determine if operations related to U.S. Navy nuclear warship activities resulted in releases of radionuclides which could contribute to significant population exposure or contamination of the environment. "Radiological Surveys of the Pearl Harbor Naval Shipyard and Environs" (Callis 1987) is the most recent Environmental Protection

Agency report which discusses data taken in 1985. Pertinent conclusions from this report are as follows:

1. "Neither harbor water nor drinking water from surrounding areas contain detectable cobalt-60 or tritium radioactivity.

2. Very small quantities of cobalt-60 were found in sediment and in two aquatic vegetation samples from the harbor. No cobalt-60 was found in any of the aquatic life samples.

3. The levels of cobalt-60 in the harbor sediment have decreased significantly since the surveys of 1966 and 1968 and are consistent with those expected from the radioactive decay of the amounts found in the 1966 and 1968 surveys.

4. The current practice of restricting the release of radioactive material into the harbor to the minimum practical has been effective and should allow the cobalt-60 radioactivity remaining in harbor sediment to continue to decrease.

5. The levels and locations of radioactivity identified and the limited media in which it was found show that operations related to nuclear-powered warship activities resulted in no release of radionuclides having adverse effects on public health or the environment."

Environmental monitoring is conducted by the shipyard. The results of this monitoring program corroborate the Environmental Protection Agency's conclusion.

4.1.4.9 Ecological Resources

4.1.4.9.1 Terrestrial Ecology. Because the Pearl Harbor area has been disturbed extensively and for such a long period of time, the vegetation is dominated by introduced or alien species. Vegetation consists of maintained landscaped specimens or, on unmaintained areas, mangrove thickets and weedy scrub. The few native taxa which occur on these unmaintained areas such as 'uhaloa (Waltheria indica) and 'ilima (Sida fallax) occur throughout the Hawaiian Islands and the Pacific in similar environmental habitats. No plants considered threatened or endangered occur on this location.

Fauna in the Pearl Harbor area is also typically urban. In general, various feral and domestic cats and dogs, rodents, and exotic bird species are found in the area. No endemic land birds were recorded during the course of the field surveys completed in 1989. (Navy 1990b)

4.1.4.9.2 Wetlands. There are several wetland areas at Pearl Harbor identified in the East Loch, Middle Loch, and West Loch, as well as an area on the Waipio Peninsula. There is also a Pearl Harbor National Wildlife Refuge. These are habitats for endangered species of birds, principally the Hawaiian Coot and Hawaiian Stilt. A cooperative agreement established between the U.S. Navy, and the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the State of Hawaii, Department of Land and Natural Resources, protects these wetlands. (Navy 1990b)

4.1.4.9.3 Aquatic Ecology. Most of the Pearl Harbor marine community structure is characterized by four zones: sand-rubble zone, algal-mud zone, channel wall zone, and channel floor mud-silt zone. Sedimentation is the major factor determining the constituents of the Pearl Harbor marine community. Hence, stony corals, which are especially sensitive to high sediment loads, have not been observed. Predominant biota include the sea cucumber (Ophiodesoma spectabilis), a species commonly found in areas of high organic particulate input; benthic (bottom dwelling) algae; sponges; Sabellid (feather duster) worms; Serpulid worm tubes; and various benthic shrimps and crabs. (Navy 1990b)

4.1.4.9.4 Endangered and Threatened Species. Most of the land at Pearl Harbor Naval Shipyard has been urbanized, and the present vegetation consists almost exclusively of introduced plant species. Consequently, no federally or state listed threatened or endangered species or critical habitats are known to exist within the confines of Pearl Harbor Naval Shipyard. Because the area has been greatly disturbed and the native vegetation completely eliminated, there is little remaining terrestrial habitat of any consequence. Small tracts of weedy fields and isolated pockets of disturbed secondary vegetation within the station's boundaries provide limited habitat for introduced species of birds and rodents. Some migratory birds as well as endemic and indigenous waterfowl species may occasionally frequent the shoreline areas of Pearl Harbor Naval Shipyard, but none are considered residents of the activity. The mangrove stands and associated shoreline habitats act as nurseries to a variety of fish and wildlife and aid in shoreline stabilization and erosion control. (Navy 1989)

Marine mammals are afforded full Federal protection under the Marine Mammal Protection Act of 1972. As noted above, there are wetland areas in the Pearl Harbor Complex that include a

National Wildlife Refuge and provide habitats for endangered species of birds, principally the Hawaiian Coot (Fulica americana alai) and Hawaiian Stilt [Himantopus mexicanus (=himantopus) knudseni].

4.1.4.10 Noise

Noise sensitive locations in the Pearl Harbor area have been identified as the U.S.S. Arizona Memorial, U.S.S. Arizona Memorial Visitor Center, U.S.S. Bowfin Park, Marina Restaurant, Richardson Recreation Center, and existing or planned residential areas of Ford Island. Field noise measurements were taken at these locations on December 5, 1989; previous measurements also were taken at some of these locations. All appear to meet state and federal noise standards at present. Pearl Harbor Naval Shipyard is an existing industrial environment characterized by noise from truck and auto traffic, ship loading cranes and related diesel-powered equipment, and continuously operating transmission lines for steam, fuel, water, and related compressors for these and other liquids. In addition, new construction of buildings, reconstruction and rehabilitation activities for streets, buildings, parking lots, and ships all contribute to the noise associated with an industrial environment. (Navy 1990b)

4.1.4.11 Traffic and Transportation

The main portion of traffic into and out of the base is an aggregate of commuting traffic to work, residential related traffic, and service traffic related to the business of the base. 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 the Honolulu direction. (Navy 1990b)

The Honolulu International Airport provides scheduled passenger and cargo air service to major connecting hubs. In addition, Hickam Air Force Base services the military.

Naval spent nuclear fuel has been removed from Navy nuclear-powered ships and transported to the Idaho National Engineering Laboratory Expended Core Facility (ECF) for examination and evaluation as a routine part of their operating cycle. Naval spent nuclear fuel shipments from Pearl Harbor Naval Shipyard to ECF were initiated in 1962. Since that time, 20 shipments of naval spent nuclear fuel originating at Pearl Harbor Naval Shipyard have been made to ECF. The naval spent nuclear fuel containers were transported by ship to the Puget Sound Naval Shipyard where the containers were then transported to ECF by rail. Attachment A provides a list of these shipments made to date by year. Attachment A also contains detailed descriptions of the shipping containers used for naval spent nuclear fuel shipments from shipyards.

Traffic circulation related to Naval Base Pearl Harbor is determined by the working and residential populations of the base, by the geometry of the existing roadways and intersections, and by the access gates into the base.

4.1.4.12 Occupational and Public Health and Safety

4.1.4.12.1 Occupational Radiological Health and Safety. The Navy has well established and effective Occupational Safety, Health, and Occupational Medicine programs at all of its shipyards. In regard to radiological aspects of these programs, the Naval Nuclear Propulsion Program policy is to reduce to as low as reasonably achievable the external exposure to personnel from ionizing radiation associated with naval nuclear propulsion plants. These stringent controls on minimizing occupational radiation exposure have been successful. No civilian or military personnel at Navy sites have ever exceeded the federal accumulated radiation exposure limit which allows 5 rem exposure for each year of age beyond age 18. Since 1967, no person has exceeded the federal limit which allows up to 3 rem per quarter year and since 1980, no one has received more than 2 rem per year from radiation associated with naval nuclear propulsion plants. The average occupational exposure of each person monitored at all shipyards is 0.26 rem per year. The average lifetime accumulated radiation exposure from radiation associated with naval nuclear propulsion plants for all shipyard personnel who were monitored is 1.2 rem. (NNPP 1994a) This corresponds to the likelihood of a cancer fatality of 1 in 2083.

The Navy's policy on occupational exposure from internal radioactivity is to prevent radiation exposure to personnel from internal radioactivity. The limits invoked to achieve this objective are one-tenth of the levels allowed by federal regulations for radiation workers. As a result of this policy, no civilian or military personnel at shipyards have ever received more than one-tenth the federal annual occupational exposure limit from internal radiation exposure caused by radioactivity associated with naval nuclear propulsion plants.

For work operations involving the potential for spreading radioactive contamination, containments are used to prevent personnel contamination or generation of airborne radioactivity. The controls for contamination are so strict that precautions sometimes have had to be taken to prevent tracking contamination from fallout and natural sources into radiological areas because the contamination control limits used in these areas were well below the levels of fallout and natural contamination occurring outside in the general public areas. A basic requirement of contamination control is monitoring all personnel leaving any area where radioactive contamination could possibly occur. Workers are trained to survey themselves (i.e., frisk), and their performance is checked by radiological control personnel. Frisking of the entire body is required, normally using sensitive hand-held survey instruments. Major work facilities are equipped with portable monitors, which are used in lieu of hand-held friskers. These stringent controls to protect the workers and the public from contamination have proven effective in the past.

In 1991, researchers from Johns Hopkins University, Baltimore, Maryland, completed a very comprehensive epidemiological study of the health of workers at the six naval shipyards and two private shipyards that service the Navy's nuclear-powered ships (Matanoski 1991). This independent study evaluated a population of 70,730 civilian workers over a period from 1957, beginning with the first overhaul of the first nuclear-powered submarine, USS NAUTILUS, through 1981, to determine whether there was an excess risk of leukemia or other cancers associated with exposure to low levels of gamma radiation.

The Johns Hopkins study found no evidence to conclude that the health of people involved in work on U.S. naval nuclear-powered ships has been adversely affected by exposure to low levels of radiation incidental to this work. Additional studies are planned to investigate the observations and update the shipyard study with data beyond 1981.

The radiation exposure during normal operations at each shipyard for workers who have their radiation levels monitored is determined based on the annual radiation exposure of 0.26 mrem per worker for all shipyards based on Naval Nuclear Propulsion Program Report NT-94-2 (NNPP 1994a). The total number of shipyard personnel monitored for radiation exposure associated with the Naval Nuclear Propulsion Program has been about 164,000.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to transportation workers for all historical shipments is 16.6 person-rem, which statistically corresponds to 0.0066 cancer fatalities. The maximum exposed individual (MEI) is a transportation worker, since the workers are closer to the shipment for a longer time than any member of the general population. Under the limiting assumption that the same worker is associated with every shipment for the entire historical period, this person would receive a total exposure of 7.5 rem over the approximately 40-year period, or about 0.19 rem per year, which is within DOE standards for occupationally exposed individuals. The radiation exposures to workers correspond to much less than one incident cancer, which means that it is unlikely that there have been any past health impacts due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.4.12.2 Occupational Non-radiological Health and Safety. In the non-radiological Occupational Safety, Health, and Occupational Medicine area, the Navy complies with the Occupational Safety and Health Administration Regulations. The Navy's policy is to maintain a safe and healthful work environment at all naval facilities. Due to the varied nature of work at these facilities, there is a potential for certain employees to be exposed to physical and chemical hazards. These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to high noise levels or heat stress. In addition, employees are monitored for their exposure to chemical hazards such as organic solvents, lead, asbestos, etc., and where appropriate are placed into medical surveillance programs for these chemical hazards.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact due to the historical shipment of naval spent nuclear fuel over the entire history of such shipments.

4.1.4.12.3 Public Radiological Health and Safety. In order to quantify the exposures resulting from normal shipyard radiological releases to the general public, detailed analyses were performed based on very conservative estimates of radioisotopic releases from 1961 through 1992. Attachment F provides detailed annual release values used in the analyses.

The GENII computer code (Napier et al. 1988) was used to calculate exposures to human beings due to the estimated radionuclide releases from normal operations at the shipyards.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from stored fuel. The population data used to calculate population exposures were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F.

The hypothetical exposures calculated in Attachment F for the period 1995 through 2035 were adjusted from an annual basis (1995) to the historical basis by multiplying by 38 years and by a factor of 1.7 to take into consideration variations in the number of ships and operations.

The calculated accumulated exposures through 1995 to the general population within 50 miles of the site (about 0.8 million people) are 1.9 person-rem. To provide perspective, the exposures received due to natural radiation sources through 1995 are approximately 9.3 million person-rem, based on 0.3 rem per person per year.

The results of environmental monitoring as described in Naval Nuclear Propulsion Program Report NT-94-1 show that Naval Nuclear Propulsion Program activities had no distinguishable effect on normal background radiation levels at site perimeters (NNPP 1994b).

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to the general population for all historical shipments is 1.95 person-rem, which statistically corresponds to 0.00098 cancer fatalities.

All of the radiation exposures to the general population correspond to much less than one incident cancer, which means that it is unlikely that there has been any past health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.4.12.4 Public Non-radiological Health and Safety. The military is responsible for providing health care services for its personnel and dependents. Navy families receive both in-patient and out-patient care at Tripler Army Medical Center. Services are also provided at on-base clinics and dispensaries. Active-duty personnel are required to use military health care facilities. In addition, military dependents have the option of going to private providers and being partially reimbursed for the cost.

The Oahu Civil Defense Agency is responsible for developing, preparing, and assisting in the implementation of civil defense plans and programs to protect the safety, health, and welfare of island residents during disasters and emergency situations. However, responsibility for military personnel and dependents on the base rests with the Navy.

Fire protection within Naval Base Pearl Harbor is provided by the Federal Fire Department. A Mutual Aid Pact between the federal (military) fire departments and the Honolulu Fire Department affords dual coverage in times of emergencies.

Naval Base Pearl Harbor is under federal jurisdiction; therefore, federal authorities are normally responsible for providing all needed police service. The City and County of Honolulu Police Department, however, is responsible for traffic control in areas around the base. The closest police station is located in Pearl City. (Navy 1990b)

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.4.13 Utilities and Energy

4.1.4.13.1 Water Consumption. Naval Base Pearl Harbor receives most of its water from the Koolau Aquifer and a small portion from the Waianae Aquifer, which are basal aquifers located in south central Oahu, partially within the Pearl Harbor Water Management Area (PHWMA). In early 1989, a Water Management Plan for the PHWMA was proposed by the Commission on Water and

Resource Management (CWRM) to preserve and manage the Koolau and Waianae basal aquifers and the Schofield high-level aquifer. One important portion of the Water Management Plan recommended that the sustainable yield for the PHWMA be revised downward from the then current 225 million gallons of water per day (mgd) to 195 mgd. The purpose of the revision was to eliminate possible shrinkage of the aquifer in the PHWMA from over-withdrawal. Actual use in 1989 totaled 198.298 mgd, of which the military portion was about 13 percent. The major water users in the PHWMA are the Board of Water Supply (87.5 mgd) and the Oahu Sugar Company (78.6 mgd). In the revised plan, water allocation to the military is not decreased. The stated management policy of the CWRM is that "total allocation of authorized use will not at any time exceed sustainable yield." As of 1990, the military had an allocation of 28.125 mgd from the PHWMA, of which 22.670 mgd was authorized for the Navy. Of the total allocation to the U.S. Navy, Koolau Aquifer provides 20.333 mgd, and Waianae Basal Aquifer provides 2.337 mgd. (Navy 1990b)

4.1.4.13.2 Electricity Consumption. The electrical power service for the Pearl Harbor Naval Complex is provided by the Hawaiian Electric Company. The Hawaiian Electric Company power grid on the island of Oahu consists of three power plants with a total capacity of 1,271 MW, plus two plants in planning or under construction totaling 390 MW. The peak island demand in 1989 was approximately 1,090 MW.

The power plants are located at Kahe, Waiau, and downtown Honolulu and are inter-connected via 138-kV transmission and 46-kV sub-transmission circuits. The Pearl Harbor Naval Complex is served via three 46-kV feeders, each from a separate 80-MVA transformer at the Makalapa substation, which is part of the island's 138-kV grid. The feeders serve two Hawaiian Electric Company substations located on the base (Puuloa and Kuahua), which step the voltage down to 11.5 kV, and serve two normally separated 11.5-kV networks.

One of the 46-kV feeders serves only the Puuloa substation. The second serves only the Kuahua substation. The third serves both substations. Any one feeder has the capacity to carry the entire Pearl Harbor load or approximately 57 MVA. In addition to the three feeders from the Makalapa substation, there are two alternate 46-kV circuits, one a dedicated spare, from the Waiau power plant.

The Puuloa substation consists of two 20/33-MVA transformers located in the Pearl Harbor Naval Shipyard area and serves the Pearl Harbor Naval Shipyard, Naval Station Pearl Harbor, and

Ford Island. The Kuahua substation consists of two 15/20-MVA transformers located in the Submarine Base Pearl Harbor area and serves the Submarine Base Pearl Harbor and Naval Supply Center Pearl Harbor areas.

4.1.4.13.3 Fuel Consumption. One major type of energy use is vehicular fuel consumption. No estimates are available to differentiate vehicle fuel use at Pearl Harbor from other areas. The ferry system consumed 152,088 gallons of diesel fuel in 1988. An occupancy rate of 1.5 persons per vehicle was used, so the ratio of fuel consumed per person per trip was 0.144 gallon of diesel fuel per person crossing. The second major source of energy consumption originates in buildings. The analysis of building energy use is based on standards for energy consumption per unit of designated building floor area by type of building and the geographical location.

4.1.4.13.4 Wastewater Systems and Discharges. Sewage at the Pearl Harbor Naval Complex is collected and treated in several separate systems. Most of the sewage generated by U.S. Navy shore activities and family housing areas receives secondary treatment at Navy-operated sewage treatment plants. The largest volume is treated at the Fort Kamehameha Sewage Treatment Plant which serves the Naval Station Pearl Harbor, Pearl Harbor Naval Shipyard, Naval Supply Center Pearl Harbor Complexes, Camp Smith, Navy and Air Force housing areas, Hickam Air Force Base, and other adjacent military areas.

4.1.4.13.5 Energy Conservation. To minimize the use of fossils fuels and conserve energy, the military has adopted conservation criteria for new construction and major renovation projects. The policies used under the conservation criteria focus on meeting design energy targets, based on Btu/per square foot/per year (Btu/sf/yr). Guidelines are provided for ventilation, insulation, and energy life cycle cost of structures. (Navy 1990b)

4.1.4.14 Materials and Waste Management

The City and County of Honolulu's HPOWER (Honolulu Program of Waste Energy Recovery) "garbage-to-energy" facility at Campbell Industrial Park is currently in full operation and burning roughly 1,500 to 1,800 tons per day, which is most of the combustible rubbish generated on the island of Oahu. Approximately 20 percent (by weight) of the refuse handled by the HPOWER facility is reduced to ash and other residue which requires landfill disposal.

There are two city and county landfills: the Kapaa Landfill in Kailua (Windward Oahu) and the Waimanalo Gulch Landfill in Nanakuli (Leeward Oahu). The Kapaa Landfill has reached full capacity, and plans are underway to locate a new site in Windward Oahu. The Nanakuli facility, which opened in September 1989, is programmed for 1,000 tons per day for seven to eight years. According to the city, the facility should be able to accommodate projected needs for at least 15 years and maybe longer. (Navy 1990b)

Solid radioactive waste materials are packaged in strong, tight containers, shielded as necessary, and shipped to burial sites licensed by the U.S. Nuclear Regulatory Commission or a State under agreement with the U.S. Nuclear Regulatory Commission. Shipyards and other shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. During 1992, approximately 110 cubic yards of routine low-level radioactive waste containing a total of 1 curie were shipped from the shipyard for burial.

Waste which is both radioactive and chemically hazardous is regulated under both the Atomic Energy Act and the Resource Conservation and Recovery Act as "mixed waste." Within the Naval Nuclear Propulsion Program, concerted efforts are taken to avoid commingling radioactive and chemically hazardous substances so as to minimize the potential for generation of mixed waste. For example, these efforts include avoiding the use of acetone solvents, lead-based paints, lead shielding in disposal containers, and chemical paint removers. Radioactive wastes, including those containing chemically hazardous substances, are handled in accordance with long-standing Program radiological requirements. Such handling includes solidification to immobilize the radioactivity, separation of the radioactive and chemically hazardous substances, removal of liquids from solids, and other simple techniques. A determination is then made as to whether the resulting waste is hazardous. As a result of Program efforts to avoid the use of chemically hazardous substances in radiological work, Program activities typically generate only a few hundred cubic feet of mixed waste each year. This small amount of mixed waste, along with limited amounts of mixed waste from Program work conducted prior to 1987, will be stored pending the licensing of commercial treatment and disposal facilities.

4.1.5 KENNETH A. KESSELRING SITE: WEST MILTON, NEW YORK

4.1.5.1 Overview

The Kenneth A. Kesselring Site of the Knolls Atomic Power Laboratory (KAPL) is located in the mid-eastern sector of New York State as shown on Figure 4.1.5-1. The Site is located near West Milton in Saratoga County, New York at 43°2'28" north latitude and 73°57'13" west longitude. This United States Government owned reservation consists of over 3900 acres centered about 15 miles north of the city of Schenectady and about 8 miles west of Saratoga Springs. The Site includes three operating naval nuclear propulsion prototype plants and support facilities. The Site also includes one prototype plant that is in the process of being permanently shut down; one of the three operating plants is currently scheduled to be shut down in 1996. All the operating facilities are located in a secure area near the center of the reservation (see Figure 4.1.5-2). A more detailed illustration of the site is provided in Figure 4.1.5-3.

4.1.5.2 Land Use

All the land within the Site perimeter is owned by the Department of Energy (DOE). There are no permanent residents within this area. The surrounding region, within 50 miles of the Site, contains a population of about 1,150,000 as obtained from the 1990 census.

Most of the land surrounding the Site is either wooded or is used for farming, with some residential areas. Both dairy farms and agricultural farms are located in the immediate vicinity of the reservation.

The West Milton area is located within the undulating transition zone between the Adirondack Highlands and the Hudson-Mohawk Lowlands physiographic provinces. The area is characterized by a series of irregular northwest-southwest trending topographic steps that descend from the highlands southeasterly towards the lowlands.

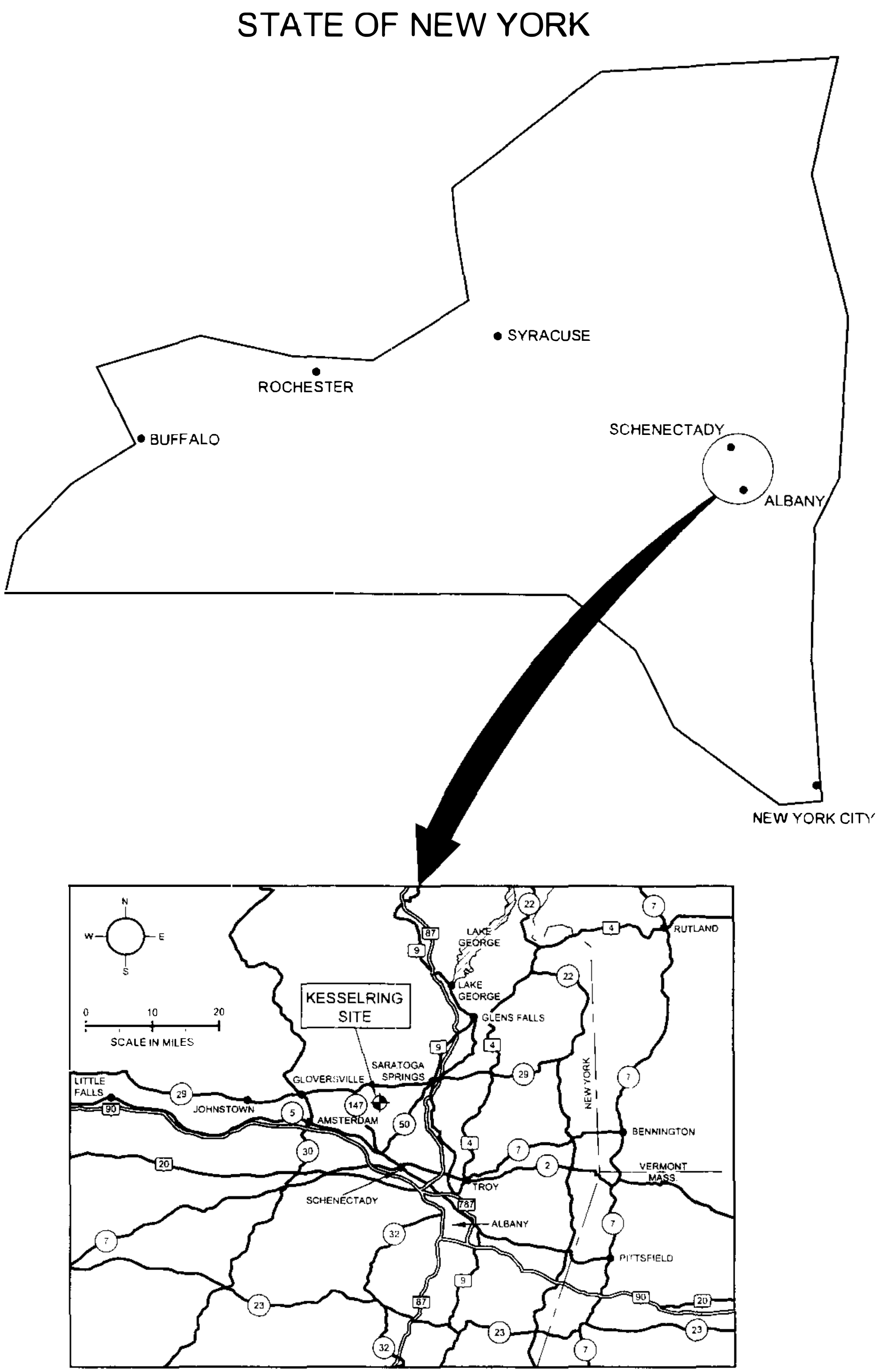


Figure 4.1.5-1. Kesselring Site vicinity map.

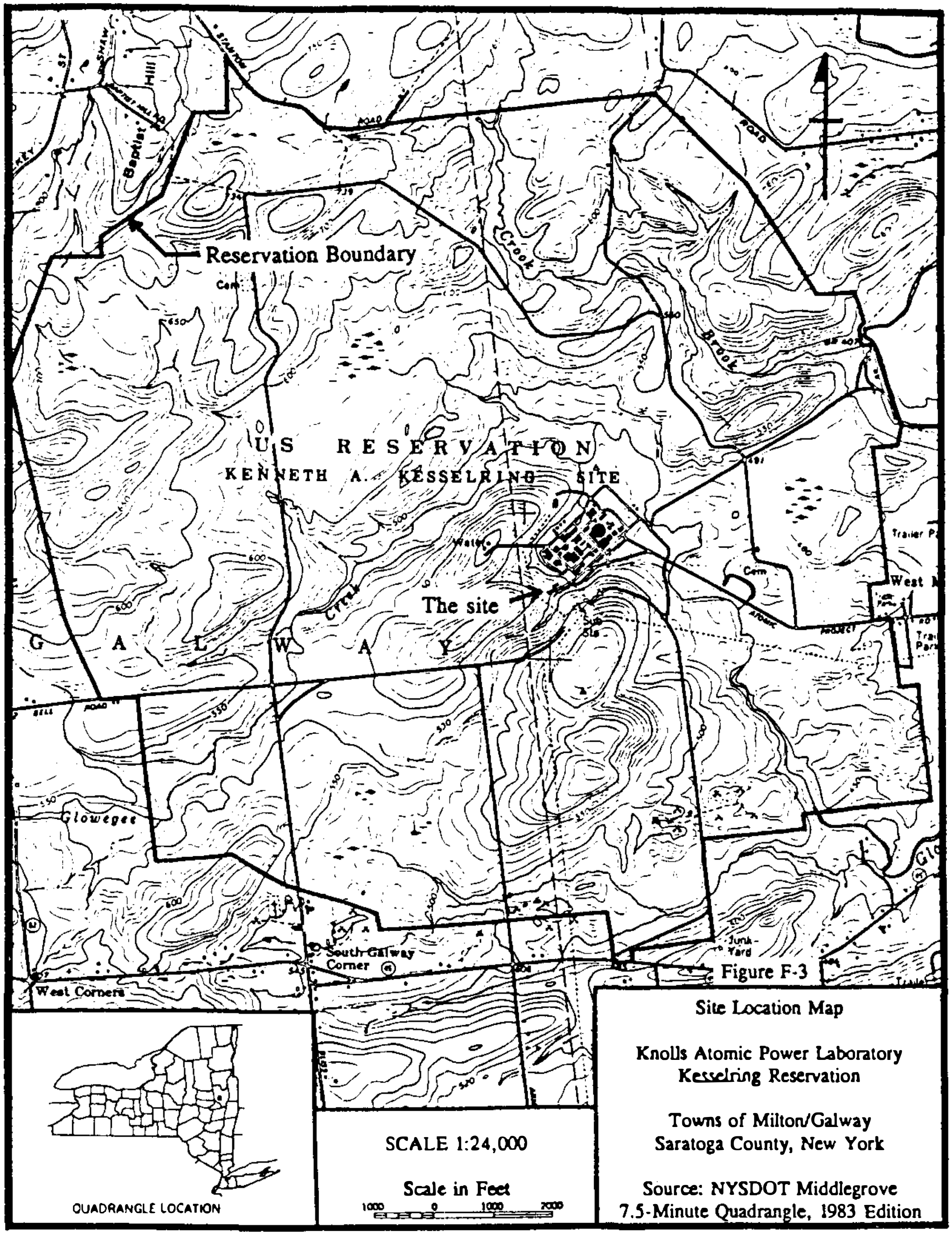


Figure 4.1.5-2. Kesselring Site location map.

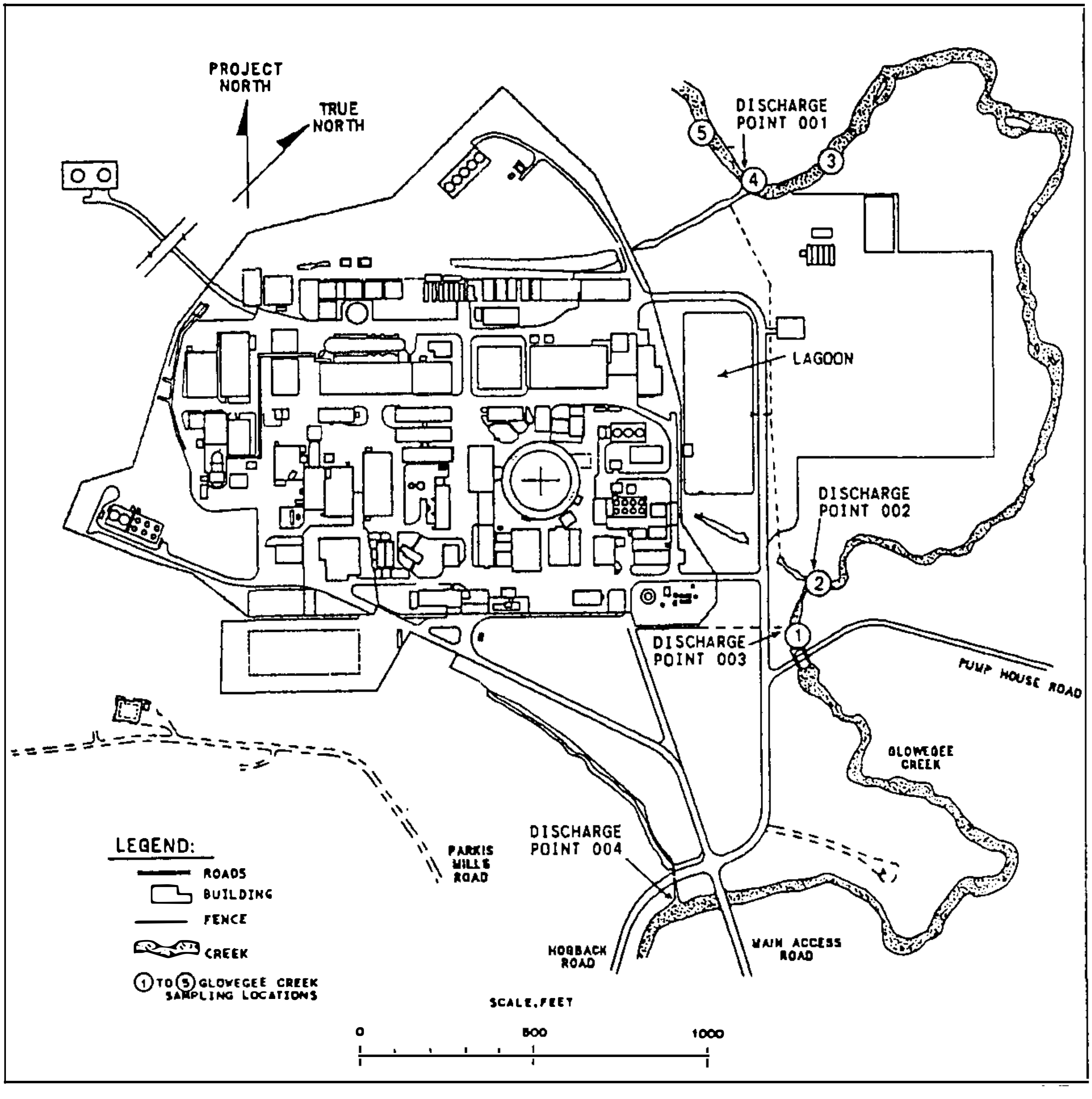


Figure 4.1.5-3. Kesselring Site map.

Ground elevations in the vicinity of the reservation range from 400 to 900 feet above mean sea level. The Glowegee Creek, its various tributaries, and the Crook Brook drain the reservation. The developed portion of the reservation, which contains the prototype plants, consists of approximately 50 acres (see Figure 4.1.5-2). The terrain surrounding the Site forms a partial bowl having a bottom diameter of about 2000 feet and a maximum height of 150 feet. The Site is essentially flat-lying with ground elevations ranging from 480 to 490 feet. The western half of the Site is surrounded by elliptical hills approximately 600 feet in elevation. Drainage from the Site is eastward, to the Glowegee Creek.

4.1.5.3 Socioeconomics

As of 1993, the Kesselring Site employed about 1,450 civilian workers, and about 1,250 naval personnel worked at the Site.

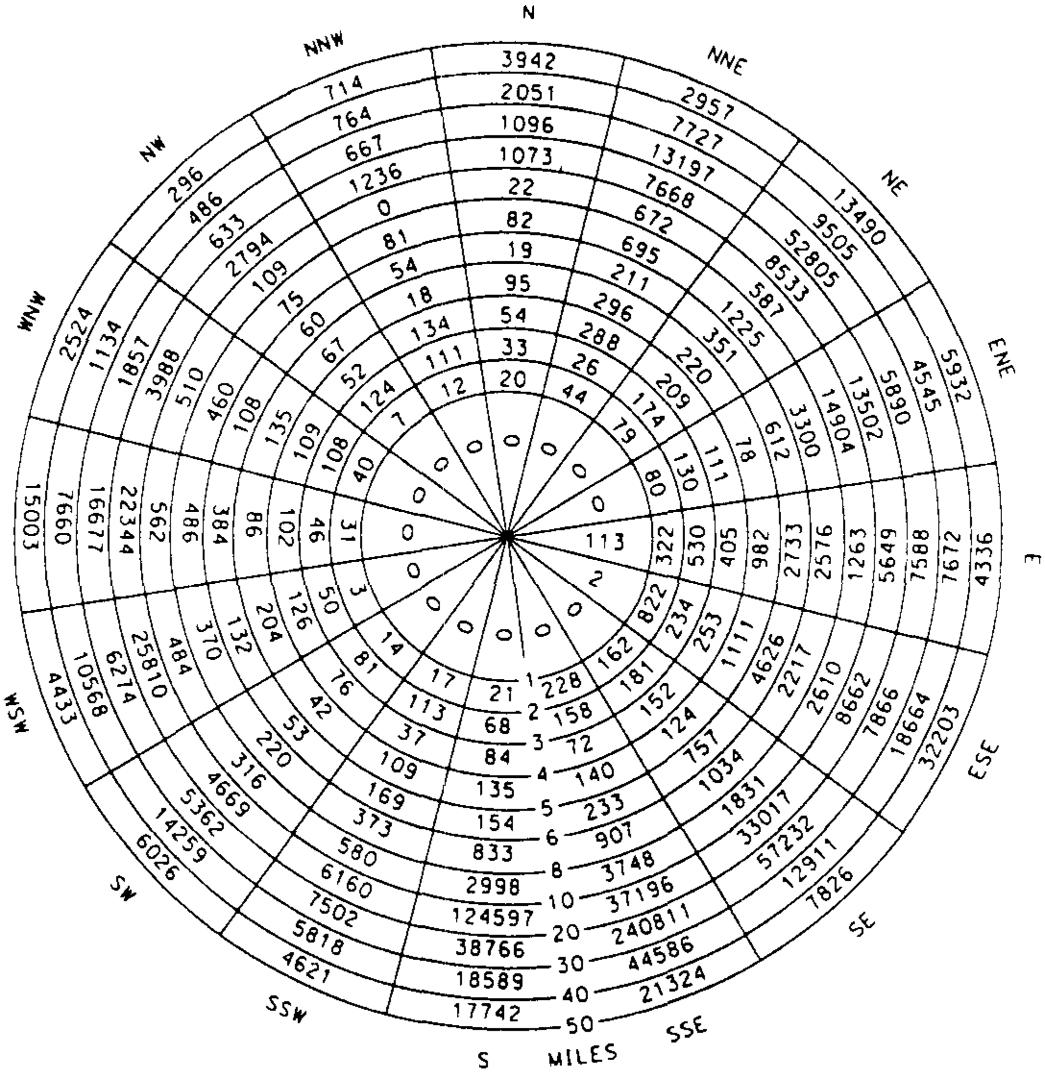
The only industry within 4 miles of the Site is the Cottrell Paper Company, located in Rock City Falls, about 3 miles from the Site.

The region surrounding the Site, within 50 miles, contains a population of about 1,150,000 as obtained from the 1990 census. Figure 4.1.5-4 provides a population distribution rose centered on the Site and lists the total population within concentric rings covering a 50-mile radius from the Site.

The majority of the labor force that would be employed at the Site for construction and operation of the naval spent nuclear fuel area would be expected to reside within about 20 miles from the Site. The calculated total population, labor force, and employment within this region for the base year (1995) are presented in Table 4.1.5-1. Projections of employment and population for the years beyond 1995 have not been presented because, as discussed in Section 5, the number of additional jobs that might be created at the Site under any alternative could be small.

Table 4.1.5-1. Regional employment factors at the Kesselring Site.

Regional Employment	Regional Labor Force	Regional Population
165,830	176,600	373,970



Miles	People	Cumulative People
0-5	10,290	10,290
5-10	56,786	67,076
10-20	306,898	373,974
20-30	464,323	838,297
30-40	166,939	1,005,236
40-50	143,351	1,148,587

Based on 1990 Census

Figure 4.1.5-4. 50-mile population distribution around the Kesselring Site.

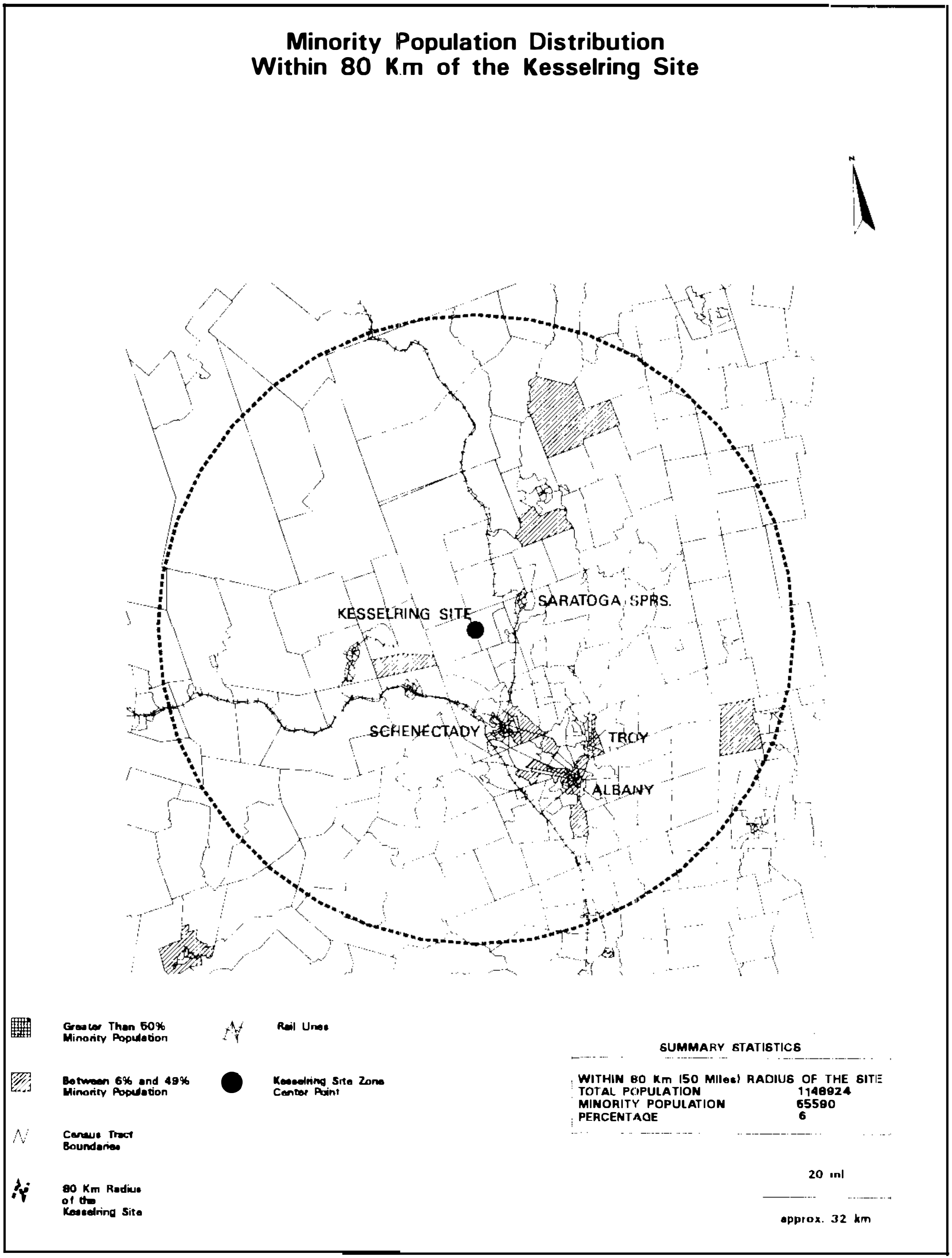
Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the Kesselring Site, consistent with the population data provided in Figure 4.1.5-4.

Figure 4.1.5-5 shows the locations of populations in which minority membership exceeds the average within the 50-mile radius by more than 20 percentage points and populations which have more than 50 percent minority members. These populations have been identified following an approach developed by the Environmental Protection Agency which, for purposes of environmental justice evaluation, defines minority communities as those which have percentages of minorities greater than the average in the region analyzed (EPA 1994).

Figure 4.1.5-6 shows the locations of populations which have more than 25 percent of their members living in poverty, reflecting a common definition of low-income communities (EPA 1993). The U. S. Census Bureau characterizes persons in poverty as those whose income is less than a "statistical poverty threshold." For the 1990 census, this threshold was based on a 1989 income of $12,500 per household.

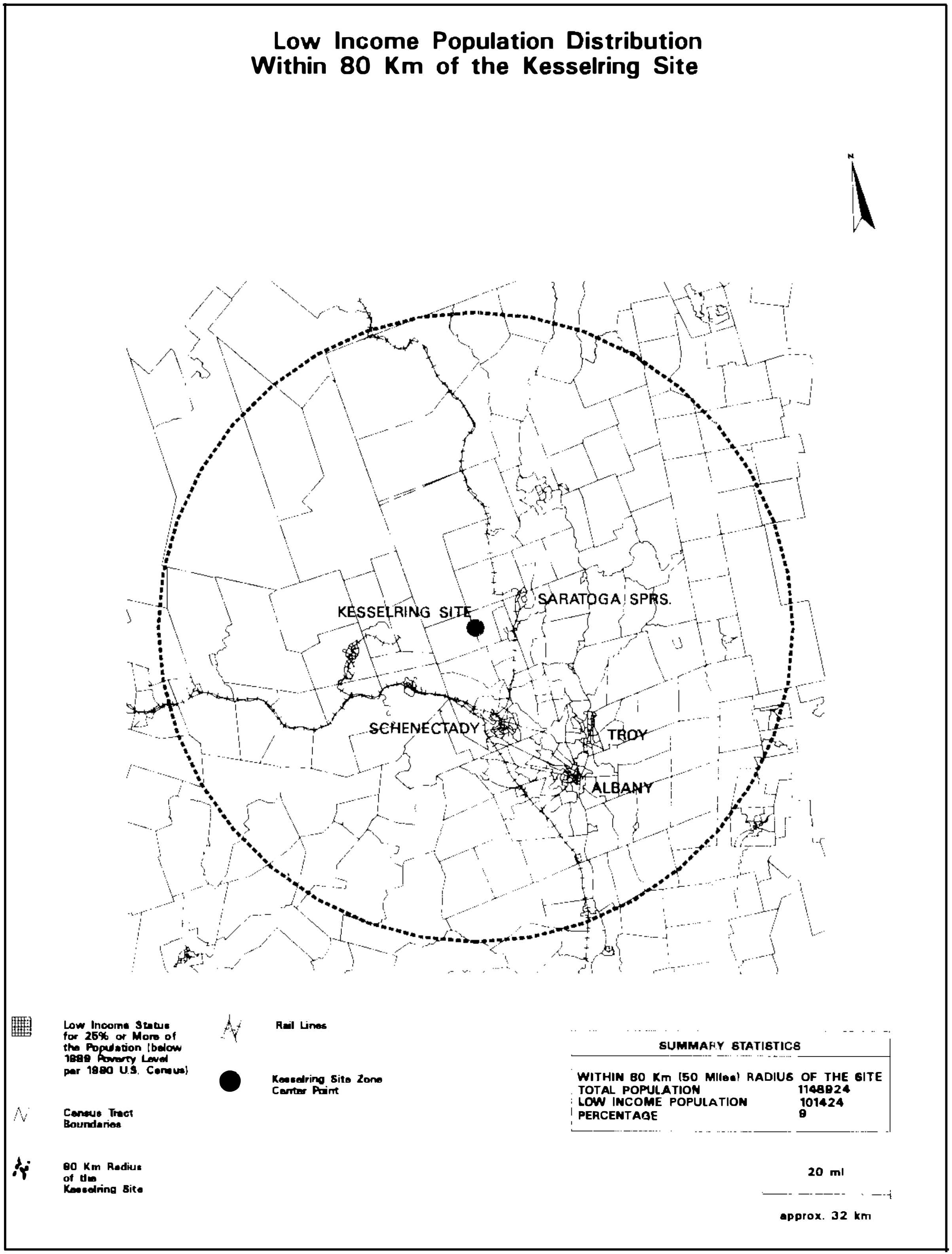
4.1.5.4 Cultural Resources

Historically, the Kesselring Site reservation was used for agricultural purposes. Although old farmhouse foundations, grove sites, stone walls, and land fences exist on the Kesselring Reservation, there are no known archaeological, cultural, or Native American sites in the secure area of the Kesselring Site (USAEC 1972). There are no historic structures on the Site that are potentially eligible for or are listed on the National Register of Historic Places (NPS 1991).



Based on 1990 Census

Figure 4.1.5-5. Minority population distribution within 50 miles of the Kesselring Site.



Based on 1990 Census

Figure 4.1.5-6. Low-income population distribution within 50 miles of the Kesselring Site.

4.1.5.5 Aesthetic and Scenic Resources

The Kesselring Site is located in an area of moderately undulating topography at the northern edge of the Hudson-Mohawk Lowlands. Most of the Site facilities including the prototype reactor plants are located within a fenced security area. This security area and adjacent parking lots are located near the center of the Government reservation. (UE&C 1973) Since the balance of the reservation consists of wooded lands, there is very little public viewing opportunity of the Site facilities from the boundaries of the Government reservation. The area within the Site fenced security region where naval spent nuclear fuel would be stored has low visual sensitivity since the area is an industrial site.

4.1.5.6 Geology

4.1.5.6.1 General Geology. In 1973, a Site evaluation and foundation engineering investigation were conducted for the Kesselring Site (UE&C 1973) to establish suitable parameters for the analysis and design of the S8G prototype structures. A prior evaluation of the Site was conducted for the Modifications and Addition to Reactor Facilities. In both investigations, the local and regional geology and seismicity of the West Milton area were examined through a literature search, a detailed subsurface investigation, and a geophysical survey involving refraction and cross-hole velocity measurements. Major soil boring, sampling, and laboratory testing for the S8G Site evaluation were reported in various documents (UE&C 1973; EDCE 1974a; EDCE 1974b). Additional boring information and a geophysical field investigation performed for the Modifications and Addition to Reactor Facilities project were also utilized in the S8G Site evaluation. A 1974 Site geology evaluation was also conducted and a report issued (DGC 1974).

4.1.5.6.2 Geologic Resources. At Kesselring, unconsolidated materials, primarily of glacial origin, overlie bedrock. The thickness of these materials or overburden sequence is variable, ranging from 0 to several hundred feet. The overburden sequence, in ascending order, 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 (drumlins) 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 reservation's southeastern quadrant. The ice-contact/outwash deposits mostly consist of stratified sands and gravels. The ice contact/outwash deposits, characterized by low clay and silt content, have better aquifer potential than the silt-and-clay-rich glacier and lake deposits.

Bedrock geology is also variable at the reservation and consists of crystalline rocks, Potsdam Sandstone, Galway Formation (dolomites and sandstones), Gailor Dolomite, Trenton/Amsterdam/ Lowville Limestones, and Canajoharie Shale. The Canajoharie Shale underlies the majority of the reservation. This black shale generally is considered a poor aquifer and its productivity is dependent on the presence or absence of fractures. Also, its water may contain naturally occurring hydrogen sulfide.

At the Site, approximately 20 to 30 feet of overburden deposits overlie the Canajoharie Shale. These deposits consist of layers of deposits from glaciers and lakes. Locally, these deposits have been altered as the result of facility construction. Generally, groundwater exists from 5 to 10 feet below the ground surface. Groundwater flows easterly, toward the nearby Glowegee Creek.

There are no economic geologic resources at the Site.

4.1.5.6.3 Seismic and Volcanic Hazards. In 1973, a seismicity evaluation of the Kesselring Site was conducted (UE&C 1973). An additional investigation was conducted in 1981 (EDCE 1981). The following is a summary of their findings.

Three branch faults exist in the vicinity of the Site: The West Galway, the East Galway, and the Rock City Falls faults. These branch faults are the lines of demarcation between the various bedrock formations in the immediate area. The East Galway branch lies approximately 3500 feet northwest of the Site and is believed to be the predominant influence on the earthquake loading for Site facilities. The two Galway faults are end branches of the Hoffman's Ferry fault.

Seismic risk related to structural damage may be represented in the United States by a relative scale of 0 through 4, with Zone 0 not expected to encounter damage and Zone 4 expected to encounter the greatest seismic risk. The Site is located in Zone 2A according to the "Uniform Building Code" (UBC 1991). The Uniform Building Code seismic classification provides a means for a comparable assessment of the seismic hazard between the alternate sites. If the Record of Decision identifies this site for the interim storage of naval spent fuel, then a detailed seismic evaluation would be conducted. More detailed information regarding the design basis considerations for storage of naval spent nuclear fuel at the Site is provided in Attachment D.

Data accumulated indicate that the maximum intensity earthquake for the region within a 100-mile radius of the Site had a value of VII. The most recent earthquake of that intensity occurred at Lake George, New York, on April 30, 1931. It is postulated that this event had an epicenter at the point where the Rock City Falls fault meets the Hoffman's Ferry fault. Since the West Galway and East Galway branch faults are extensions of the Hoffman's Ferry fault, an earthquake of similar intensity might occur anywhere along the East Galway fault within the lifetime of the Site structures.

Several earthquakes having an intensity VIII or greater have occurred at distances greater than 100 miles from the Site. However, due to attenuation effects, the ground motion at the Site associated with these earthquakes has not been greater than that equivalent to an intensity VI. The most recent event occurred in 1983 at Newcomb, New York (about 75 miles northwest of the Site) and was of intensity VI.

Details regarding the seismic characteristics of the area and the design bases seismic evaluations performed for the Kesselring Site are provided in the "Site Geology Evaluation Report - S8G for Kesselring Site" (UE&C 1973) and in "Geotechnical Site Investigation, Kesselring Site, West Milton, New York" (EDCE 1981).

There are no volcanic hazards in the vicinity of the Site.

4.1.5.7 Air Resources

4.1.5.7.1 Climate and Meteorology. The east-central part of New York State, in which the West Milton area is located, is situated at the northern end of the Hudson River Valley and is approximately 150 miles inland from the Atlantic coastline and about 200 miles south of the Canadian border. The climate of the region is primarily continental in character, but is subjected to some modification by the Atlantic Ocean. The moderating effect on temperatures is more pronounced during the warmer months than in winter when outbursts of cold air sweep down from Canada. In the warmer seasons, temperatures rise rapidly in the daytime, but also fall rapidly after sunset so that the nights are relatively cool. Occasionally, there are extended periods of oppressive heat up to a week or more in duration.

During the winter months, winds are generally from the west or northwest. During the warmer months, the winds are from the south. Wind velocities are moderate, and generally average less than 10 mph. Destructive winds (i.e., winds in excess of 80 mph) occur infrequently and tornadoes are rare. Tornadoes are rare in the region served by the Albany, New York weather station.

The mean monthly temperature of the region is about 50°F. Daily extremes can range from -30°F in the winter months to 100°F in the summer. On an annual basis, the mean daytime relative humidity values range from 50 to 80 percent. During the summer months, relative humidity values frequently approach 100 percent during the night.

Total yearly precipitation averages about 36 inches. The average yearly snowfall is about 58 inches and the maximum snowfall in 24 hours is about 22 inches. On the average, a frost depth of about 3 feet can be expected.

For weather reporting purposes, the West Milton area of northeastern New York is included in the National Weather Service Zone Forecast for Saratoga County. The principal weather recording location is at the Albany, New York airport. Its elevation is 275 feet above mean sea level. Because of the proximity of West Milton to Albany, temperature data for the Site should differ little from the Albany data. The two locations are generally within one or two degrees of each other, with West Milton tending to have lower temperatures.

4.1.5.7.2 Air Quality. The principal sources of industrial gaseous effluents from the Kesselring Site are two 21-million, one 30-million, and one 110-million Btu/hr steam generating boilers. The number 2 fuel oil that is used to fire all of the boilers contains less than 0.5 weight percent sulfur. Combustion gases from the boilers are released through three elevated exhaust stacks. Operations such as ozalid reproduction, carpenter shops, welding hoods, paint shop, and industrial cleaning processes constitute other permitted point sources of airborne effluents. All point source emissions conform to the applicable state and federal clean air standards. Sulfur emitted from all boiler units is monitored via analysis of fuel sulfur content and reported to the Environmental Protection Agency (EPA) on a quarterly basis in compliance with the EPA's New Source Performance Standards in The

Code of Federal Regulations, Title 40, Part 60. Sulfur emissions from the boilers are well within the EPA's New Source Performance Standards emission standard for stationary combustion installations. All other industrial emission sources at the Kesselring Site do not require monitoring under terms of the current New York State permits due to the very low levels of the emissions.

An area can be designated by the Environmental Protection Agency as having air quality that is better than defined by the National Ambient Air Quality Standards (attainment) or as exceeding one or more of those standards (nonattainment for one or more pollutants). The Code of Federal Regulations, Title 40, Part 81, states that the Air Quality Control Region for this site is in marginal nonattainment for ozone and is better than national standards for total suspended particulate matter and SO_2. The area has no specific classification for carbon monoxide and NO_2.

The nearest Class I area is at Lye Brook Wilderness, Suarderland, Vermont, which is 46 miles from the Site.

4.1.5.7.3 Existing Radiological Conditions. Radiological facilities at the Kesselring Site are designed to ensure that there are no discharges of radioactivity in airborne exhausts in excess of prescribed operational limits. Radiological controls are exercised to preclude exposure of working personnel to airborne radioactivity exceeding federal limits. Air exhausted from radiological work facilities is passed through high-efficiency particulate air filters and monitored during discharges. The annual airborne radioactive emissions from Kesselring Site do not result in any measurable radiation exposure to the general public. As described in the "Knolls Atomic Power Laboratory Environmental Monitoring Report for Calendar Year 1992" (KAPL 1992), the estimated 1992 radiation exposure to off-site individuals attributed to radioactive air emissions from Kesselring Site operations was less than 1 percent of the Environmental Protection Agency standards given in Subpart H of 40CFR61 (CFR 1989). In order to quantify the risk of normal (non-accident) Kesselring Site radiological airborne releases to the general public, detailed analyses were performed based on conservative estimates of radioisotopic releases in the exhaust air. In 1992, the airborne radioactivity emissions from the Kesselring Site totaled about 2 curies (KAPL 1992).

4.1.5.7.4 Existing Non-radiological Conditions. New York State emission standards for all permitted emission sources at the Kesselring Site, with the exception of the site boilers, are stipulated in the individual permits for these sources. State regulations provide specific guidance on what types of emissions require a permit. Compliance with the operating permit is the responsibility of the permit holder under the condition that all planned changes in operating permit conditions require prior review and approval by the New York State Department of Environmental Conservation (NYSDEC). In addition, all operating permits are reviewed and renewed at least every 5 years.

Stationary combustion sources such as the Site's boilers are not specifically regulated by NYSDEC, but fall under the federal New Source Performance Standards in The Code of Federal Regulations, Title 40, Part 60. Compliance with these standards is accomplished by utilization of number 2 fuel oil certified by the vendor that it contains less than 0.5 percent sulfur. Reports documenting fuel use and sulfur content are provided to the EPA Region II office on a quarterly basis.

4.1.5.8 Water Resources

The hydrology information contained herein was extracted from two independent evaluations. One was performed by the U. S. Geological Survey in November 1951. The second survey was performed in 1955. Additional hydrological surveys were performed in 1975 (Moody 1975; DGC 1975), and 1985 and 1986 (DGC 1986).

4.1.5.8.1 Surface Water. Most of the Site is drained by the Glowegee Creek, which meanders through rolling farmlands and woodlands to a junction with Kayaderosseras Creek at a point approximately 1 mile east of West Milton. The quality of the water in Kayaderosseras Creek and Glowegee Creek is satisfactory for public water supply and most industrial purposes, although Glowegee Creek is not used for these purposes. The average stream flow measured at the U. S. Coast and Geodetic Survey gaging station 0.5 mile downstream of the Site is 41 cfs. The range of elevation for Glowegee Creek is approximately 580 feet above mean sea level at the western entry to the Site to about 380 feet above mean sea level at its junction with the Kayaderosseras Creek. Swamp area and natural surface storage in the basin are small, but the soils and the unconsolidated materials below the soils can hold a considerable volume of groundwater. A number of perennial springs exist in the area. There are no records indicating flooding of the Site.

The Kayaderosseras Creek empties into Saratoga Lake and ultimately, by way of Fish Creek, into the Hudson River. Kayaderosseras Creek rises in the Kayaderosseras Range on the southern edge of the Adirondack Mountains. The basin above West Milton ranges approximately 1600 feet in elevation and contains a sizeable aggregate area of swamps.

The Flood Insurance Rate Map (FIRM COMMUNITY-PANEL No. 360 722 B) shows that the Kesselring Site is not in a 100 or 500 year floodplain.

4.1.5.8.2 Groundwater. At the Site, the overburden sequence, consisting of glacier and lake deposits, and the underlying Canajoharie Shale generally form poor aquifer systems. In the West Milton area. neither of these systems are designated as sole source aquifers by the EPA or as primary/principal aquifers by New York State.

The dense glacial deposits and fine-grained lake deposits have characteristically low permeabilities in comparison to ice-contact/outwash deposits. Historically, both the glacier and lake deposits produce very low volumes of groundwater. At the Site, shallow water table mapping shows that the groundwater gradient is low. This low gradient combined with the low permeability of the glacial deposits indicates that the groundwater flow rate is very low, on the order of 5 to 10 feet/year. Also, water table mapping indicates that the Glowegee Creek, approximately 200 to 1000 feet east of the operating facilities boundary, forms an aquifer boundary.

The source of potable water is a well field, located on the far eastern side of the Site, and is composed of six wells which draw water from both deep and shallow aquifers. Monitoring of groundwater from the Site service water well field has shown that all chemical constituents measured are within the New York State drinking water standards (KAPL 1992). This well field, which is adjacent to the Kayaderosseras Creek, is underlain by two sand and gravel aquifers. The uppermost aquifer exists under water-table conditions and extends to a depth of approximately 30 feet below ground surface. The lowermost aquifer exists under artesian head pressure with the potentiometric surface rising several feet above the static water-table surface. The depth of the artesian aquifer is approximately 55 to 100 feet below the ground surface. Recharge to the water-table aquifer during simultaneous water withdrawal comes primarily from the Kayaderosseras Creek, and to a lesser degree from Crook Brook. (DGC 1986)

There are 19 monitoring wells within the operating area. These recently installed wells are used to provide depth-to-groundwater information, related water table mapping, and water quality assessment. Test borings on the reservation have generally showed the water table to be within 5 to

10 feet of the ground surface. The test boring data also indicate that the configuration of the water table is, for the most part, a replica of the configuration of the surface topography, but at a lower elevation and somewhat softened in relief.

4.1.5.8.3 Existing Radiological Conditions. The liquid effluent environmental monitoring program at the Kesselring Site consists of radiological monitoring of the Glowegee Creek water, aquatic life, and sediment in the vicinity of the Site to confirm that the general public is not affected by operations at the Site. There is no detectable radioactivity present in the Glowegee Creek sediment due to Site operations (KAPL 1992). The concentrations of chemical constituents in liquid effluent from the Kesselring Site resulted in no adverse effect on the quality of Glowegee Creek aquatic life. This is substantiated by results of fish and aquatic life surveys that confirmed the existence of a diverse and healthy aquatic community in the creek water. Only naturally occurring radionuclides were detected in the Glowegee Creek water samples. The results of analysis for fish collected from Glowegee Creek show no radioactivity attributable to Site operations.

Currently, Kesselring Site does not discharge radioactive liquid effluent to the environment. Since the beginning of prototype operations, the release of radioactivity into Glowegee Creek has been small (about 15 curies) and has had no measurable effect on the natural background radioactivity in the sediment. Over 98 percent of the radioactivity discharged to the creek was tritium but included traces of other radionuclides such as cobalt-60, iron-55, nickel-63, and antimony-125 (KAPL 1992). The amount of tritium released was greatly decreased when water reuse was started by the prototype plants. In addition, the average concentration of tritium discharged to Glowegee Creek was over 1000 times lower than allowed by federal regulations. In over three decades of operation, there has been no measurable impact from Kesselring Site operations on the environment or adverse effect on the community or the public.

4.1.5.9 Ecological Resources

4.1.5.9.1 Terrestrial Ecology. The conceptual location where naval spent nuclear fuel would be stored is illustrated in Attachment D. This location is within an existing industrial complex and is surrounded by buildings and paved areas. The industrial nature of the Site and the fact that the land has already been disturbed from its natural state by earlier activities mean that plant or animal species sensitive to disturbance by human activities would not be expected to be present.

4.1.5.9.2 Wetlands. There are 13 areas located on the Kesselring Site classified as either Class II or III wetlands in accordance with the New York State Department of Environmental Conservation (NYCRR 1987). Current operations which include the secured area of the Site, parking lots, well field, and pumphouse area do not impact the listed wetlands. Access and perimeter roadways abut listed wetlands at four locations (within 100 feet); however, construction of these roadways predates all current regulatory requirements.

4.1.5.9.3 Aquatic Ecology. In accordance with the Environmental Statement for the S8G Prototype, Kesselring Site, West Milton, New York (USAEC 1972), an expanded chemical and biological monitoring program was initiated in Glowegee Creek early in 1975. An important part of this monitoring program is an annual fish survey in Glowegee Creek upstream and downstream of Site discharges because Glowegee Creek is classified as a Class "C" trout stream by New York State. These surveys conducted by the New York State Department of Environmental Conservation and by environmental consultants from the Knolls Atomic Power Laboratory indicate that stocking downstream merely supplements the fish population that is removed by fishermen. The section of Glowegee Creek above the Site, although not stocked, contains a population of native trout which is maintained by natural spawning of the fish.

4.1.5.9.4 Endangered and Threatened Species. There are several endangered and threatened species listed by the New York State Department of Environmental Conservation located in the Saratoga County area. The endangered species are the karner blue butterfly, bald eagle, and peregrine falcon, and the threatened species is the red-shouldered hawk. To date, there have been no direct observations of these species documented on the Kesselring Site.

4.1.5.10 Noise

Plant operations and maintenance at the Kesselring Site generate noise equivalent to light industrial activity.

4.1.5.11 Traffic and Transportation

Two corridors, the Hudson-Champlain, 10 to 17 miles to the east, and the Mohawk-Hudson, 10 to 17 miles to the south and southwest, contain the major transportation systems and the relevant industrial complexes in the vicinity of the Site. The Cottrell Paper Company, located in Rock City Falls, 3 miles from the Site, is the only industry within a 5-mile radius.

Except for their use by Kesselring Site employees, the secondary routes bounding the Site are auxiliary commuting and delivery routes for small products and produce. State Route 29 runs 2 miles to the north, State Route 147 runs 4 miles to the west, and State Route 67 runs 4 miles to the south. State Route 50, 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 I-87 or parallel route U.S. Highway 9, in the Hudson-Champlain corridor, 10 miles to the east.

Two lines of the Delaware and Hudson Railroad cross the region within 10 miles of the Site. The main north-south line runs through Ballston Spa, just over 5 miles to the east, and a trunkline runs just over 5 miles to the northeast into the central Adirondack area.

Commercial barge traffic occurs on the New York State Barge Canal, 12 miles southwest of the Site at its closest point, and on the less used Champlain Division, 17 miles east of the Site.

Saratoga County has the nearest airport, 4-1/2 miles east of the Site, followed by Schenectady and Albany airports, approximately 15 and 20 miles to the south-southeast. Data furnished by air traffic representatives for the three area airports indicate that regular flight patterns for military, commercial, and private aircraft, large and small, do not pass within a 5-mile radius of the Site. Only the instrument approach to the Saratoga County Airport, designated by the Federal Aviation Administration (FAA), has the potential for overflying the Site.

Albany County Airport, 22 miles south-southeast of the Site, is the nearest airport with scheduled flights by commercial jet aircraft. Schenectady County Airport, 15 miles south of the Site, is an auxiliary field with a low volume of traffic relative to size. No air carriers provide scheduled service out of Schenectady. The bulk of the airport's traffic is corporate and private aircraft, with the majority of the balance being military aircraft of the 109th New York Air National Guard.

Naval spent nuclear fuel has been removed from the prototypes and transported to the Idaho National Engineering Laboratory Expended Core Facility (ECF) for examination and evaluation as a matter of routine. Naval spent nuclear fuel shipments from the Kesselring Site to ECF were initiated in 1961. Since that time, 21 shipments of naval spent nuclear fuel originating at the Kesselring Site have been made to ECF. The shipping containers were transported by heavy-lift transporter to a nearby commercial rail line where the containers were then transported by rail. Attachment A provides a list of these shipments made to date by year. Attachment A also contains detailed descriptions of the shipping containers used for naval spent nuclear fuel shipments from shipyards.

The Site exclusion area boundary, which is the boundary of the Site, defines the restricted area. No activities unrelated to plant operation are permitted within the exclusion area. Access to the fenced-in security area containing the operating facilities (centered within the exclusion area boundary) is permitted only through one permanent gate facility which is manned by security guards on a 24-hour-per-day basis.

No public roads, highways, railways, or navigable waterways traverse the exclusion area.

4.1.5.12 Occupational and Public Health and Safety

4.1.5.12.1 Occupational Radiological Health and Safety. The Navy has well established and effective Occupational Safety, Health, and Occupational Medicine programs at all of its facilities. In regard to radiological aspects of these programs, the Naval Nuclear Propulsion Program policy is to reduce to as low as reasonably achievable the external exposure to personnel from ionizing radiation associated with naval nuclear propulsion plants. These stringent controls on minimizing occupational radiation exposure have been successful. No personnel at the Naval Reactors Department of Energy facilities have ever exceeded the applicable federal annual radiation exposure limit. The annual limit was 15 rem per year in 1958 and is currently 5 rem per year. No one has exceeded the Program's limit of 5 rem per year since this limit was established in 1967 and since 1980, no one has received more than 2 rem per year from radiation associated with naval nuclear propulsion plants. The average occupational exposure of each person monitored at Naval Reactors DOE facilities is 0.12 rem per year. The average lifetime accumulated radiation exposure from radiation associated with the Naval Nuclear Propulsion Program for the 141,000 personnel who have been monitored at the DOE Naval Reactors facilities is about 0.35 rem (NNPP 1994c). This corresponds to the likelihood of a cancer fatality of 1 in 7142.

Naval Reactors policy on occupational exposure from ingested or inhaled radioactivity is to prevent significant radiation exposure to personnel from internal radioactivity. The limits invoked to achieve this objective are one-tenth of the levels allowed by federal regulations for radiation workers. Since 1972 as a result of this policy, no one has received more than one-tenth the federal annual occupational exposure limit from internal radiation exposure caused by radioactivity associated with work at the DOE Naval Reactors facilities.

For work operations involving the potential for spreading radioactive contamination, containments are used to prevent personnel contamination or generation of airborne radioactivity. The controls for contamination are so strict that precautions sometimes have had to be taken to prevent tracking contamination from fallout and natural sources into radiological areas because the contamination control limits used in these areas were well below the levels of fallout and natural contamination occurring outside in the general public areas. A basic requirement of contamination control is monitoring all personnel leaving any area where radioactive contamination could possibly occur. Workers are trained to survey themselves (i.e., frisk), and their performance is checked by radiological control personnel. Frisking of the entire body is required, normally using sensitive hand-held survey instruments. Major work facilities are equipped with portable monitors, which are used in lieu of hand-held friskers. These stringent controls to protect the workers and the public from contamination have proven effective in the past.

In 1991, researchers from Johns Hopkins University, Baltimore, Maryland, completed a very comprehensive epidemiological study of the health of workers at the six naval shipyards and two private shipyards that service the Navy's nuclear-powered ships (Matanoski 1991). This independent study evaluated a population of 70,730 civilian workers over a period from 1957, beginning with the first overhaul of the first nuclear-powered submarine, USS NAUTILUS, through 1981, to determine whether there was an excess risk of leukemia or other cancers associated with exposure to low levels of gamma radiation. This study is also of particular relevance to workers at the Naval Reactors prototypes because the type of radioactivity, level of exposure, and method of radiological controls at these shipyards are similar to the Naval Reactors prototypes.

The Johns Hopkins study found no evidence to conclude that the health of people involved in work on U.S. naval nuclear-powered ships has been adversely affected by exposure to low levels of radiation incidental to this work. The average annual radiation exposure for these shipyard workers is about two times higher than the exposure received by personnel assigned to Naval Reactors nuclear propulsion prototype sites. Additional studies are planned to investigate the observations and update the shipyard study with data beyond 1981.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to transportation workers for all historical shipments is 16.6 person-rem, which statistically corresponds to 0.0066 cancer fatalities. The maximum exposed individual (MEI) is a transportation worker, since the workers are closer to the shipment for a longer time than any member of the general population. Under the limiting assumption that the same worker is associated with every shipment for the entire historical period, this person would receive a total exposure of 7.5 rem over the approximately 40-year period, or about 0.19 rem per year, which is within DOE standards for occupationally exposed individuals. The radiation exposures to workers correspond to much less than one incident cancer, which means that it is unlikely that there have been any past health impacts due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.5.12.2 Occupational Non-radiological Health and Safety. In the non-radiological Occupational Safety, Health and Occupational Medicine area, the Navy complies with the Occupational Safety and Health Administration Regulations. The Navy's policy is to maintain a safe and healthful work environment at all naval facilities. Engineered systems and administrative controls are the primary means employed for minimizing potential employee exposure to occupational hazards. If exposures cannot be controlled with engineering or administrative controls, personal protective equipment is used to provide additional protection. Due to the varied nature of work at these facilities, there is a potential for certain employees to be exposed to physical and chemical hazards. These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to high noise levels or heat stress. In addition, employees are monitored for their exposure to chemical hazards such as organic solvents, lead, asbestos, etc., and where appropriate are placed into medical surveillance programs for these chemical hazards.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact due to the historical shipment of naval spent nuclear fuel over the entire history of such shipments.

4.1.5.12.3 Public Radiological Health and Safety. The effluent and environmental monitoring results show that the radioactivity in liquid and gaseous effluents from 1992 operations at the Kesselring Site had no measurable effect on background radioactivity levels. Therefore, any radiation exposures from Site operations to off-site individuals were too small to be measured and must be calculated using conservative methods. In accordance with the "Knolls Atomic Power Laboratory Environmental Monitoring Report for Calendar Year 1992" (KAPL 1992), the following estimates were determined: (1) the radiation exposure to the maximally exposed individual in the vicinity of the Site was less than 0.1 mrem, (2) the average exposure to members of the public residing in the 80-kilometer (50-mile) radius assessment area surrounding the Site was less than 0.001 mrem, and (3) the collective exposure to the population residing within 50 miles of the Site was less than 0.1 person-rem.

The hypothetical exposures calculated in Attachment F for the period 1995 through 2035 were adjusted from an annual basis (1995) to the historical basis by multiplying by 40 years (to account for the period of site operations) and by a factor of 1.7 to take into consideration variations in the number of prototypes and operations.

The calculated accumulated exposures through 1995 to the general population within 50 miles of the site (about 1.15 million people) are 3.9 person-rem. To provide perspective, the exposures received due to natural radiation sources through 1995 are approximately 14 million person-rem, based on 0.3 rem per person per year.

The results show that the estimated exposures were less than 0.1 percent of that permitted by the radiation protection standards listed in DOE Order 5400.5 (DOE 1993), and that the estimated exposure to the population residing within 80 kilometers (50 miles) of the Site was less than 0.001 percent of the natural background radiation exposure to the population. In addition, the estimated exposures were less than 1 percent of that permitted by the numerical guide listed in 10CFR50, Appendix I (CFR 1986) for whole-body exposure, demonstrating that exposures are as low as is reasonably achievable. The exposure attributed to radioactive air emissions was less than 1 percent of the EPA standard given in 40CFR61 (CFR 1989).

The collective radiation exposure to the public along travel routes from Kesselring Site shipments of radioactive materials during 1992 was calculated using data given by the NRC in the "Final Environmental Statement of the Transportation of Material by Air and Other Modes" (NUREG

1977). Based on the type and number of shipments made, the collective annual radiation exposure to the public along the transportation routes, including transportation workers, was approximately 1 person-rem. This is less than 0.001 percent of the exposure received by the same population from natural background radiation.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to the general population for all historical shipments is 1.95 person-rem, which statistically corresponds to 0.00098 cancer fatalities.

All of the radiation exposures to the general population correspond to much less than one incident cancer, which means that it is unlikely that there has been any past health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.5.12.4 Public Non-radiological Health and Safety. Liquid effluents from the Kesselring Site are derived from several sources: Site boiler blowdown, sewage treatment plant, cooling tower blowdown and overflow, retention basin discharges, storm water, and site service cooling water. Liquid effluents from the Kesselring Site enter Glowegee Creek through two surface channels (discharges 001 and 002), a submerged drain line from the sewage treatment plant (discharge 003), and a storm water runoff (discharge 004).

With the exception of the sewage treatment plant, intermittent cooling tower blowdowns, and once-through cooling systems that operate continuously, all effluents are released in batches. Control of effluent concentrations is achieved by the analysis of liquid collected from the continuous flow systems and from the collection tanks prior to each release from the batch systems.

A series of gates are located in discharge channels 001, 002, and the lagoon to provide a means to contain effluent if concentrations should ever exceed applicable discharge limits. In addition, continuous pH and temperature monitoring systems are installed in discharge channels 001, 002, and the lagoon. These systems automatically control the discharge gates and provide an alarm if there is ever an out-of-specification pH or temperature level. Periodic samples collected from the effluent channels are analyzed for chemical constituents, and demonstrate compliance with the Site's

New York State Department of Environmental Conservation State Pollutant Discharge Elimination System permit.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.1.5.13 Utilities and Energy

4.1.5.13.1 Water Consumption. The Site Service Water System provides the Kesselring Site with water for operations, fire protection, sanitary, and potable use. The Site uses approximately 512 million gallons of well water per year. The Site is supplied by two pressurized mains from pumps located at the well field. Main and backup chlorination facilities are located at two of the pump locations. Five loops, on site, comprise the central distribution system which is capable of delivering up to 3,800 gallons per minute. Surge capacity for fire fighting and peak usage is provided by two elevated head tanks with a combined capacity of 500,000 gallons.

4.1.5.13.2 Electricity Consumption. The Kesselring Site is provided with two separate off-site commercial electrical power sources from the Niagara Mohawk Power Company. One source is the 115-kv Transmission Line No. 1 that runs between Spier Falls, New York and Rotterdam, New York. This line is approximately 40 miles long and is tapped at approximately the midpoint to provide service to the Site. The overhead line from the 115-kv tap on Line No. 1 to the Site is 2.4 miles long. The second physically independent commercial source feeding the Site is a 34.5-kv overhead transmission line supplied from a radial system fed from Ballston Spa, New York. The 34.5-kv line is approximately 9.6 miles long. The Site uses 47 thousand megawatt-hours of electricity annually for security, building lighting, and prototype plant support.

4.1.5.13.3 Fuel Consumption. There is no natural gas used on the Kesselring Site. Number 2 fuel oil is used to fire four Site steam generating boilers for Site heating for which the annual fuel oil consumption averages 640,000 gallons.

4.1.5.13.4 Wastewater Systems and Discharges. The sewage treatment facility for the Kesselring Site is a third-level treatment facility utilizing the extended aeration/contact stabilization of activated sludge and chemical precipitation of phosphorus followed by sand filtration. This facility meets all federal and New York State standards for sewage treatment. Discharges are controlled in conformance with the terms of a New York State Pollutant Discharge Elimination permit. Waste sludge is stored in a holding tank and is periodically removed by a licensed subcontractor for disposal at a state-approved, off-site disposal area. The treatment plant is automatic and operates unattended. Routine analysis and adjustments are made daily. Approximately 9.125 million gallons of sewage are processed by the Site Sewage Treatment Facility each year.

4.1.5.13.5 Energy Consumption. The following energy conservation initiatives for the Kesselring Site are scheduled for completion between now and the year 2000:

(1) The shutdown of one prototype plant.

(2) The conversion from fuel oil to natural gas for operating the Site steam heating boilers.

(3) Replacing the existing building lighbts and windows with modern, more energy efficient systems.

(4) Major building renovations including energy conservation upgrades to various administration and testing facilities.

4.1.5.14 Materials and Waste Management

Operation of the Kesselring Site results in the generation of various types of radioactive materials that require detailed procedures for handling, packaging, transportation, and, if necessary, disposal at a government-operated burial site. Radioactive materials that do not require disposal are handled and transferred in accordance with detailed material control and accountability procedures.

Internal reviews are made prior to the shipment of any radioactive materials from the Site to ensure that the material is properly identified, surveyed, and packaged in accordance with federal, state, and local requirements.

Low-level radioactive solid waste material that requires disposal includes filters, metal scrap, resin, rags, paper, and plastic. The volume of waste contaminated with radioactivity that is generated and shipped is minimized through the use of special work procedures that limit the amount of material that becomes contaminated during work on radioactive systems and reactor components. In addition, compressible wastes are compacted in order to further reduce the volume of waste to be buried. Radioactive liquids are solidified prior to shipment. All radioactive wastes are packaged to meet applicable regulations of the Department of Transportation given in 49CFR, Parts 171-175 and 177-178 (CFR 1985). The waste packages also comply with all applicable requirements of the NRC, the DOE, and the burial sites. All shipments of low-level radioactive solid wastes were made by authorized common carriers to government-owned burial sites located outside of New York State. During 1992, approximately 215 cubic meters (281 cubic yards) of routine low-level radioactive waste containing 987 curies were shipped from the Site for burial.

Site operations produce a variety of industrial waste products including sewage treatment plant sludge and effluent, once-through cooling water, chemical wastes, boiler exhaust gases, and other such products typical of a large laboratory facility. All such waste products are controlled in accordance with various permits as required by federal and state laws. Chemically hazardous solids are controlled and disposed of in accordance with the requirements of the Resource Conservation and Recovery Act (RCRA) in accordance with a permit held by the Site and administered by New York State.

All hazardous wastes are transported off-site for disposal at permitted, commercially available, facilities. No treatment (with the exception of exempt simple treatment and elementary neutralization) or disposal occurs at the Kesselring Site. In 1992, the Kesselring Site shipped approximately 15 tons of various hazardous wastes for off-site disposal. In accordance with RCRA, the Site has prepared a hazardous waste minimization plan. The plan requires specific actions to identify and minimize waste-producing operations, compare minimization efforts year to year to demonstrate progress, and establish waste minimization goals. This is accomplished by establishment of strict procurement procedures, substitution of non-hazardous materials where practical, and other similar measures.

Waste which is both radioactive and chemically hazardous is regulated under both the Atomic Energy Act and the RCRA as "mixed waste." Within the Naval Nuclear Propulsion Program, concerted efforts are taken to avoid commingling radioactive and chemically hazardous substances so as to minimize the potential for generation of mixed waste. For example, these efforts include avoiding the use of acetone solvents, lead-based paints, lead shielding in disposal containers, and chemical paint removers. Radioactive wastes, including those containing chemically hazardous substances, are handled in accordance with long-standing Program radiological requirements. Such handling includes solidification to immobilize the radioactivity, separation of the radioactive and chemically hazardous substances, removal of liquids from solids, and other simple techniques. A determination is then made as to whether the resulting waste is hazardous. As a result of Program efforts to avoid the use of chemically hazardous substances in radiological work, Program activities typically generate only a few hundred cubic feet of mixed waste each year. This small amount of mixed waste, along with limited amounts of mixed waste from Program work conducted prior to 1987, will be stored pending the licensing of commercial treatment and disposal facilities.

Sanitary wastewater is processed at a conventional extended aeration treatment plant at the southeast corner of the fenced security area. The treatment train consists of equipment to break down large solids, aeration tanks in which air is bubbled through the waste to provide mixing with activated sludge to reduce biochemical oxygen demand, and a clarifier for the separation of liquids and solids. The treatment plant is effective in reducing biochemical oxygen demand and suspended solids by over 90 percent in the effluent. Discharges are controlled in conformance with the terms of a New York State Pollutant Discharge Elimination System permit held by the Kesselring Site. As the need arises, accumulated sludge is removed from the plant by a New York State licensed subcontractor and disposed of at an approved off-site disposal facility also licensed by New York State.

Non-hazardous wastes are reused and recycled or disposed of off-site. Sanitary wastes such as cafeteria waste, scrap paper, and the like are also disposed of at a licensed off-site facility. No hazardous wastes are being buried in the landfill. Most metal solid waste is accumulated and sold to a scrap salvage vendor.

4.2 IDAHO NATIONAL ENGINEERING LABORATORY

4.2.1 Overview

There are three naval reactor prototype plants at the Idaho National Engineering Laboratory (INEL) at the Naval Reactors Facility (NRF). These plants contain nuclear reactor plants, but they have reached the end of their usefulness and are being placed in layup and safe storage. Dismantlement of each of the prototype plants will be accomplished in the future; however, no specific time has yet been set for this work. Appropriate documentation under the National Environmental Policy Act (NEPA) will be prepared for prototype dismantlement when a specific proposal for these actions has been developed.

Also located at the Naval Reactors Facility is the Expended Core Facility (ECF) to which naval spent nuclear fuel has been shipped for examination since 1957. After examination at the ECF, the spent nuclear fuel is transferred to the Idaho Chemical Processing Plant, also at INEL, for storage. This section provides a brief summary of the INEL affected environment. A detailed description of the affected environment at the INEL is provided in Volume 1, Appendix B and Volume 2, Section 4. The reader should refer to the applicable sections therein for additional information.

4.2.2 Land Use

The INEL site (which has been designated a National Environmental Research Park) occupies approximately 2300 square kilometers (about 890 square miles) of dry, cool desert in southeastern Idaho. Land at the INEL site is currently used for industrial and support operations associated with energy research and waste management activities, grazing, infrastructure, recreational uses, and environmental research. Only about 2 percent of the land is used for facilities and operations. Public access to most facility areas is restricted. Land surrounding the INEL site is primarily used for grazing, mineral and energy production, wildlife management, range land, and recreational uses.

4.2.3 Socioeconomics

INEL plays a substantial role in the regional economy. For fiscal year 1990, INEL directly employed approximately 11,100 personnel, or nearly 12 percent of the total regional employment. The population directly supported by INEL employment was approximately 38,000 persons, or 17 percent of the total regional population. Over 97 percent of INEL employees reside in the region of influence affected by the INEL. The INEL region of influence includes the seven counties surrounding and including the INEL: Bingham, Bonneville, Butte, Clark, Jefferson, Bannock, and Madison counties. Employment in this region experienced an annual average growth rate of approximately 1.3 percent from 1980 to 1991 while the population growth in the same region between 1980 and 1990 was about 0.6 percent per year. Volume 1, Appendix B provides a complete description of the affected environment at the INEL in this category.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the INEL, and are provided in Appendix B to this volume of the Environmental Impact Statement. These data were developed in a manner which ensures that they are consistent with the data on the total population provided in Appendix B.

4.2.4 Cultural Resources

Approximately 4 percent of the INEL has been surveyed for archaeological resources. Over 1500 sites have been identified; however, none are currently on the National Register of Historic Places, but may be placed there after formal evaluation. One structure on the INEL related to nuclear research and development, the Experimental Breeder Reactor I, is on the National Register of Historic Places and is a National Historic Landmark while a number of other reactors and associated buildings are eligible for inclusion. The entire INEL site is culturally important to Native Americans, since they believe the land is sacred. Further information on cultural resources at INEL is provided in Volume 1, Appendix B, Section 4.4 and in Volume 2, Section 4.4.2.

4.2.5 Aesthetic and Scenic Resources

The INEL site is bordered on the north and west by the Bitterroot, Lemhi, and Lost River mountain ranges. Volcanic buttes near the southern boundary of the INEL can be seen from most locations on the site. Most of the area within the INEL site consists of open, undeveloped land. Although many of the site facilities are visible to the public, most facilities are located over 0.5 mile from public roads. The reader should refer to the detailed description of the affected environment in this category at the INEL in Volume 1, Appendix B.

4.2.6 Geology

The INEL site is located on the Eastern Snake River Plain which extends in a broad arc from the Idaho-Oregon border in the west to the Yellowstone Plateau in the east. The resources found within the site are sand, gravel, and pumice.

The Eastern Snake River Plain has low seismicity but is surrounded by an area of high seismicity. A summary of the seismicity at the ECF site is provided in Attachment B.

Volcanic hazards at the INEL site have a low probability of occurrence. Volcanism hazards in the INEL area consist of possible recurrence of silicic volcanism, silicic dome emplacement, and basaltic eruptions. Of these three volcanic hazards, basaltic eruptions have been determined to have the highest expectation of occurrence. The potential for basaltic volcanism that could affect ECF is less than 10^{-5} per year. The reason that the risk from volcanic hazards at ECF is so low is that the facility is more than 9 miles north of the highest potential source of basaltic eruptions. Because of the viscous nature of basaltic lava flows, they are very slow moving and can be diverted in terrain such as that on the INEL. The potential for silicic volcanism impacting ECF is negligible because the center of silicic volcanism is now located under Yellowstone National Park which is about 125 miles east of ECF. Several small silicic domes were emplaced in the vicinity of INEL in the past 1.5 million years. These silicic domes are about 17 miles south of the Expended Core Facility and would have minimal impact on the site. (Rizzo 1994)

4.2.7 Air Resources

The Eastern Snake River Plain climate exhibits low relative humidity, wide daily temperature swings, and large variations in annual precipitation. The average seasonal temperatures at the INEL site range from -7.3 degrees C (18.8 degrees F) in winter to 18.2 degrees C (64.8 degrees F) in summer. Annual precipitation is light, averaging 22.1 centimeters (8.7 inches). The average annual snowfall is 70.1 centimeters (27.6 inches). Other than thunderstorms, severe weather is uncommon.

The air quality on the INEL site and off-site is generally good and within applicable guidelines. Details of the non-radiological air quality and the radiological air quality are provided in Appendix B of Volume 1.

4.2.8 Water Resources

Surface water features near the INEL site are the Big Lost River, Little Lost River, Birch Creek, and on-site man-made ponds. Water in the rivers does not exceed the applicable drinking water quality standards. The potential for flooding has been assessed. Details on the INEL flood plains can be found in Appendix B and Volume 2.

Groundwater in the area is contained in the Snake River Plain Aquifer. Subsurface water quality is affected by natural water chemistry and contaminants originating at the site. Previous waste discharges to unlined ponds and deep wells have introduced radionuclides, non-radioactive metals, inorganic salts, and organic compounds into the subsurface water. For a complete description of the affected environment in this category, the reader should refer to Volume 1, Appendix B.

4.2.9 Ecological Resources

Vegetation on the INEL site is primarily shrub-steppe vegetation, with sagebrush being the dominant plant. The INEL supports animal communities typical of shrub-steppe vegetation and habitats. Over 270 vertebrate species have been observed on the site. A more thorough treatment of the topic of ecological resources at the INEL is provided in Volume 1, Appendix B. Also presented therein is a description of the threatened and endangered species which include the bald eagle and the peregrine falcon.

4.2.10 Noise

The major sources of noise at the INEL occur primarily in developed operational areas and include various facilities, equipment, and machines. Existing INEL-related noises which might affect the public are those from transporting people and materials to and from the INEL and in-town facilities via buses, trucks, private vehicles, helicopters, and freight trains. In addition, air cargo and business travel of INEL personnel via commercial air transport represent an appreciable fraction of all such travel in and out of regional airports.

4.2.11 Traffic and Transportation

The INEL is surrounded by a system of interstate highways, U.S. highways, state highways, railroads, and airports. The regional railroads include main and branch Union Pacific lines in Southeastern Idaho. The two major airports in Idaho Falls and Pocatello provide passenger and cargo service.

The INEL transportation infrastructure consists of an on-site road system and rail service. There are about 140 kilometers (87 miles) of paved roads, of which 29 kilometers (18 miles) are considered service roads and are closed to the public. The Union Pacific Railroad crosses the southern portion of the INEL and provides rail service to the site. Rail shipments are limited to bulk commodities, spent nuclear fuel, and radioactive materials.

4.2.12 Occupational and Public Health and Safety

4.2.12.1 Occupational Radiological Health and Safety. Radiation exposures to workers at ECF in recent years have averaged approximately 100 millirem per year, compared to the limit of 5000 millirem per year specified by The Code of Federal Regulations, Title 10, Part 20. The total radiation exposure to workers at ECF makes up about 30% of the occupational exposure to radiation experienced by workers at NRF. Approximately 280 workers at ECF work in radiological areas and are monitored for occupational radiation exposure. The average lifetime accumulated radiation exposure from radiation associated with naval nuclear propulsion plants for the 141,000 personnel who have been monitored at the DOE Naval Reactors facilities including ECF, is about 0.35 rem (NNPP 1994c). This corresponds to the likelihood of a cancer fatality of 1 in 7142.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to transportation workers for all historical shipments is 16.6 person-rem, which statistically corresponds to 0.0066 cancer fatalities. The maximum exposed individual (MEI) is a transportation worker, since the workers are closer to the shipment for a longer time than any member of the general population. Under the limiting assumption that the same worker is associated with every shipment for the entire historical period, this person would receive a total exposure of 7.5 rem over the approximately 40-year period, or about 0.19 rem per year, which is within Department of Energy (DOE) standards for occupationally exposed individuals. The radiation exposures to workers correspond to much less than one incident cancer, which means that it is unlikely that there have been any past health impacts due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.2.12.2 Occupational Non-radiological Health and Safety. In the non-radiological Occupational Safety, Health, and Occupational Medicine area, the Navy complies with the Occupational Safety and Health Administration Regulations. The Navy's policy is to maintain a safe and healthful work environment at all naval facilities. Due to the varied nature of work at these facilities, there is a potential for certain employees to be exposed to physical and chemical hazards. These employees are routinely monitored during work and receive medical surveillance for physical hazards such as exposure to high noise levels or heat stress. In addition, employees are monitored for their exposure to chemical hazards such as organic solvents, lead, asbestos, etc., and where appropriate are placed into medical surveillance programs for these chemical hazards.

Operations at ECF have resulted in fewer than 210 days of work lost to injuries in the seven years between 1987 and 1993 out of 736 total lost days of work at NRF during that period. Recordable injuries at ECF represented about 12 percent of the total number of such injuries at NRF during the same period.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. Approximately 0.028 fatalities are estimated as a result of non-radiological sources (vehicle emissions) associated with all historical shipments of spent nuclear fuel. This number includes both the workers and the general public. Since this number is much less than one, it is unlikely that there has been any non-radiological health impact due to the historical shipment of naval spent nuclear fuel over the entire history of such shipments.

Limited quantities of some materials classified as hazardous chemicals are handled at ECF, but the precautions used during the work prevent exposure of the workers to these materials.

4.2.12.3 Public Radiological Health and Safety. The Naval Reactors Facility has from its beginning monitored potential sources of releases of radioactivity to the environment from the NRF site in liquid and airborne effluents. Releases of water containing low levels of radioactivity to various disposal basins, leaching pits, and retention basins were made principally in the 1950s and 1960s. This practice was discontinued in 1979 and the residual activity in the soil from this practice is estimated to be approximately 150 curies, consisting primarily of cesium-137, strontium-90, and cobalt-60. The Naval Reactors Facility maintains a program to monitor these areas to provide assurance that they continue to not present a hazard to the public. Operations at NRF, including ECF, have had no effect on the groundwater of the Snake River Plain Aquifer. Monitoring of the aquifer on the NRF site indicates radioactivity is at or near natural background levels. The comprehensive INEL site radiation monitoring program (Hoff et al. 1992) shows that radiation exposure to persons off-site as a result of all NRF operations is too small to be measured.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. The radiation exposure to the general population for all historical shipments is 1.95 person-rem, which statistically corresponds to 0.00098 cancer fatalities. The maximum exposed individual (MEI) is a transportation worker, since these workers are closer to the shipment for a longer time than any member of the general population. The maximum exposure to an individual of the general population is 0.062 rem over the entire historical period, which statistically corresponds to 0.000031 cancer fatalities.

4.2.12.4 Public Non-radiological Health and Safety. Since operations began, NRF has monitored site water and air released from operations at the site to ensure that they meet the requirements of applicable federal and state environmental standards. Results of all effluent monitoring confirm that the operation of NRF has no discernible impact on the environment

(WECNRF 1993). Operations at NRF have not caused degradation of the quality of the groundwater of the Snake River Plain Aquifer. Monitoring results indicate no detectable toxic chemicals, solvents, or laboratory chemicals in the groundwater in the vicinity of NRF. Low levels of sodium and chloride (like table salt) used to soften site water and nitrates (which leaked through cracks in the sewage lagoon liners) and discharges to the industrial waste ditch are detectable in the immediate vicinity of NRF at levels below the applicable drinking water standards. No constituent measured in groundwater exceeds applicable drinking water standards.

Attachment A provides a discussion of the calculation of past health impacts associated with all transportation of naval spent nuclear fuel and test specimens. As stated in Section 4.2.12.2, it is unlikely that there has been any non-radiological health impact to the public due to all historical shipments of naval spent nuclear fuel over the entire history of such shipments.

4.2.13 Utilities and Energy

The following discussion briefly describes the current utility and energy usage at INEL. For more detailed information, refer to Volume 1, Appendix B.

Commercial electrical power is supplied to the INEL site by the Idaho Power Company. The water supply for INEL is provided by a system of wells, pumps, and storage tanks which are administered by the DOE. Because of the distance between site facility areas, the water supply systems for each facility are independent of each other. Wastewater systems at most on-site facility areas consist primarily of septic tanks and drain fields, although two areas also have wastewater treatment facilities. The fuels consumed at the site (fuel oil, gasoline, diesel, kerosene, coal, and liquid petroleum gas) are transported to the site by various distributors for storage and use.

4.2.14 Materials and Waste Management

The following discussion briefly describes the current waste disposal practices at the INEL. For more detailed information, refer to Volume 1, Appendix B.

High-level waste is currently in storage at the INEL Idaho Chemical Processing Plant. Liquid waste is blended and then treated by calcination to produce a granular calcine solid.

Transuranic waste is kept in retrievable storage at the Radioactive Waste Management Complex. Although there is no currently available disposal facility, all transuranic wastes are intended to ultimately be retrieved, repackaged, certified, and shipped to the Waste Isolation Pilot Plant for final disposal.

Low-level waste has been stored and disposed of at the Radioactive Waste Management Complex. Most low-level waste is reduced in volume before disposal through incineration, compaction, and sizing at the Waste Experimental Reduction Facility; however, this treatment has been curtailed since 1991 awaiting an operating permit from the State of Idaho. Low-level waste awaiting treatment is stored on asphalt/concrete pads at the Waste Experimental Reduction Facility and in radioactive waste storage containers at the generating facilities.

Most of the mixed low-level waste currently stored at the INEL is alpha-contaminated low-level mixed waste shipped to the INEL for storage and treatment from off-site generators. Currently, only low-level mixed waste from INEL contractors is accepted at INEL for treatment and disposal. All low-level mixed waste generated at INEL is stored at interim storage facilities until treatment systems become available or operational.

Hazardous waste generated at the INEL is not treated or permanently stored at the INEL. It is collected and temporarily stored at the Hazardous Waste Storage Facility, or at temporary accumulation areas, and shipped off-site to permitted treatment, storage, or disposal facilities.

The industrial/commercial solid waste generated at the INEL is disposed of in the INEL Landfill Complex located at the Central Facilities Area. Waste segregation takes place at each INEL facility so recyclable materials do not enter the solid waste stream.

4.3 SAVANNAH RIVER SITE

4.3.1 Overview

As mentioned previously, naval spent nuclear fuel has been shipped to the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) for examination since 1957. One of the alternatives under consideration is to create a facility similar to ECF at or adjacent to the DOE-owned Savannah River Site (SRS) in South Carolina. A detailed description of the environment at the SRS is provided in Volume 1, Appendix C. This section provides a summary of some of the highlights from Volume 1, Appendix C. Therefore, specific source references for information contained in this section are omitted here but can be found in Volume 1, Appendix C.

Two sites have been identified as possible locations for the construction of a full-capability Expended Core Facility. One location for the Savannah River ECF is just to the east of the geographic center of the complex (see Site A on Figure 4.3-1). The other location (Site B) is the unused Barnwell Nuclear Fuel Plant located just outside of the eastern boundary of the present SRS complex. In either case, a separate security area would be established specifically to enclose the Savannah River ECF, with all access controlled by the Naval Reactors Program as has always been the case at the INEL-ECF.

4.3.2 Land Use

The SRS (which has been designated a National Environmental Research Park) 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. Land use on the Savannah River Site can be grouped into three major categories: forest/undeveloped, water/wetlands, and developed facilities. Land use bordering SRS is primarily forest and agricultural. There is also a large amount of open water and non-forested wetlands along the Savannah River Valley. The SRS does not contain any public recreation facilities and only about 5 percent of the land is occupied by constructed facilities.

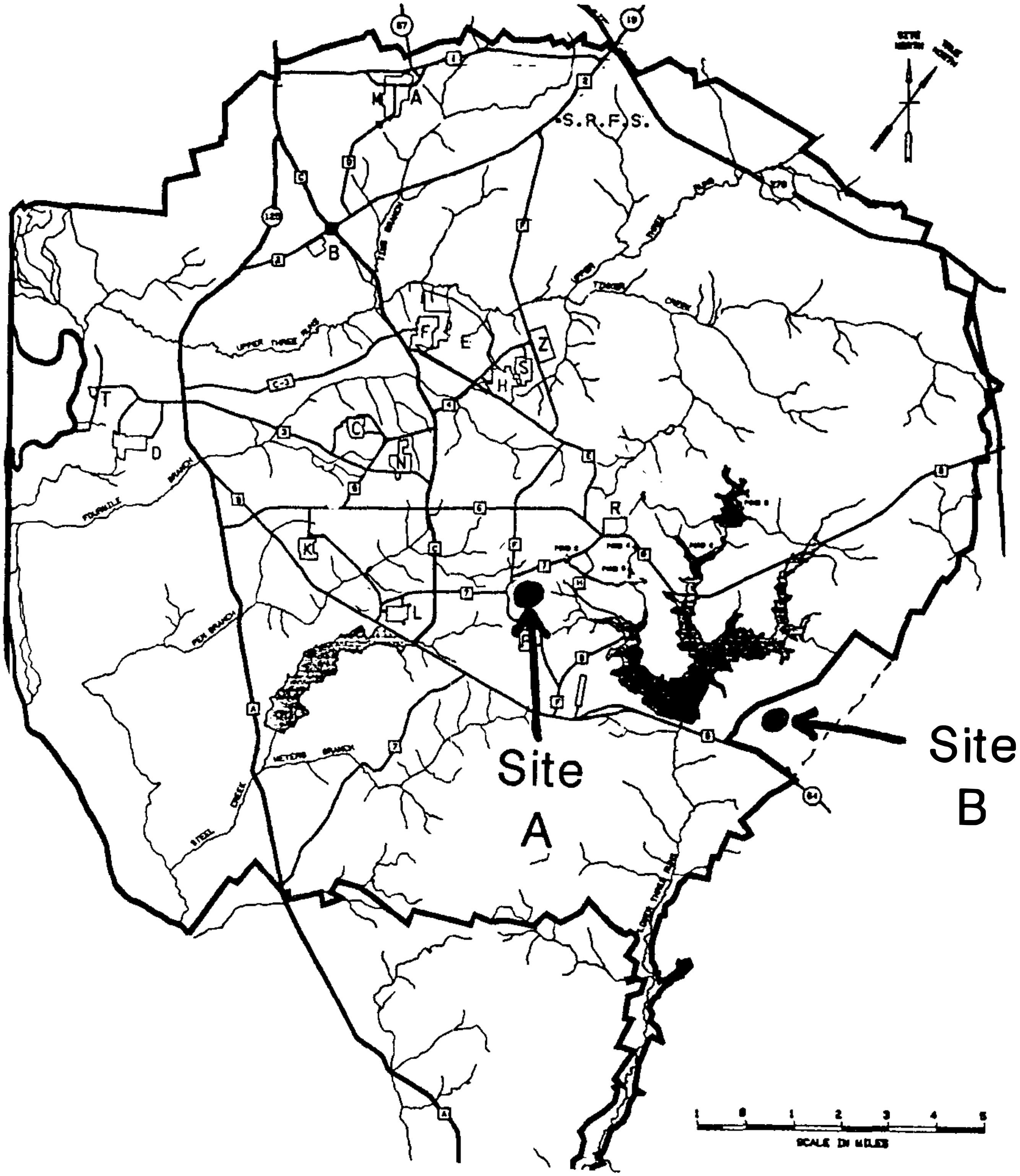


Figure 4.3-1. Candidate sites for an Expended Core Facility.

4.3.3 Socioeconomics

Approximately 90 percent of the SRS work force lives within the region of influence affected by the SRS. The SRS region of influence includes Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina, and Columbia and Richmond Counties in Georgia. Employment in this region experienced an annual average growth rate of approximately 5 percent between 1980 and 1990. Over this same time period, the labor force in the six-county region of influence grew approximately 39 percent. Personal income in the region of influence is about $7 billion. Population in the region of influence increased 13 percent from 376,058 in 1980 to 425,607 in 1990. Appendix C of Volume 1 provides a complete description of the affected environment at the SRS in this category.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the SRS, and are provided in Appendix C to this volume of the Environmental Impact Statement. These data were developed in a manner which ensures that they are consistent with the data on the total population provided in Appendix C.

4.3.4 Cultural Resources

Cultural resources on the SRS can be summarized by stating that approximately 60 percent of the SRS area has been examined by the South Carolina Institute of Archaeology, University of South Carolina, in consultation with the South Carolina State Historic Preservation Officer, and more than 850 archaeological sites have been identified. These range in age from Clovis Paleoindian to 1950s farms. Most structures were demolished during initial establishment of the SRS. Appendix C of Volume 1 provides a complete description of the affected environment at the SRS in this category.

4.3.5 Aesthetic and Scenic Resources

The dominant aesthetic setting in the vicinity of the SRS consists mainly of agricultural land and forest, with some limited residential and industrial areas. Because of the distance to the site boundary, the rolling terrain, normally hazy atmospheric conditions, and heavy vegetation, SRS facilities are not generally visible from off the Site. The land on the SRS is heavily wooded, and developed areas occupy only approximately 5 percent of the total land area.

4.3.6 Geology

The SRS is on the Upper Atlantic Coastal Plain of South Carolina, which consists of approximately 200 to 400 meters of sands, clays, and limestones formed millions of years ago. These sediments are underlain by sandstones of Triassic age and older metamorphic and igneous rocks.

There are no known capable faults as defined by the Nuclear Regulatory Commission regulatory guidelines in the SRS region. Therefore, earthquakes capable of producing structural damage are not likely in the vicinity of SRS. Two notable earthquakes have occurred within 320 kilometers (200 miles) of the SRS. The first was a major earthquake in 1886 centered in the Charleston area with an estimated Richter magnitude of 6.8. The second earthquake was the Union County, South Carolina, earthquake of 1913, which had an estimated Richter magnitude of 6.0 and occurred about 160 kilometers (100 miles) from the SRS. Two earthquakes have occurred on the SRS during recent years. One on June 8, 1985, with a local magnitude of 2.6, and the other on August 5, 1988, with a local magnitude of 2.0. Appendix C of Volume 1 provides a complete description of the affected environment at the SRS in this category.

4.3.7 Air Resources

The annual average temperature at the SRS is 17.8 degrees C (64 degrees F); monthly averages range from 7.2 degrees C (45 degrees F) in January to 27.2 degrees C (81 degrees F) in July. Relative humidity readings taken four times per day range from 36 percent in April to 98 percent in August. The average annual precipitation at the SRS is approximately 122 centimeters (48 inches). Precipitation distribution is fairly even throughout the year, with the highest precipitation in the summer and the lowest in autumn. Winter storms in the SRS area occasionally bring strong and gusty surface winds with speeds as high as 32 meters per second (72 miles per hour).

The SRS is in a Class II area in attainment with National Ambient Air Quality Standards (NAAQS) for pollutants, which include sulfur dioxide, nitrogen oxides, particulate matter, lead, ozone (as volatile compounds), and carbon monoxide. The SRS has demonstrated its compliance with the South Carolina Department of Health and Environmental Control regulation R.61-62.5, Standard 8, "Toxic Air Pollutants," which regulates the emission of 257 toxic substances. Appendix C of Volume 1 provides a more detailed description of the affected environment in this category.

4.3.8 Water Resources

The Savannah River bounds the SRS on its southern border for about 32 kilometers (20 miles), approximately 260 kilometers (160 miles) from the Atlantic Ocean. At the SRS, Savannah River flow averages about 283 cubic meters (10,000 cubic feet) per second. Five principal tributaries to the Savannah River are on the SRS: Upper Three Runs Creek, Four Mile Branch Creek, Pen Branch Creek, Steel Creek, and Lower Three Runs Creek. Neither of the sites identified for the Savannah River ECF is located on the 100-year floodplain. Further discussion on the creeks in the SRS as well as the 100-year floodplain is available in Volume 1, Appendix C. Approximately 200 Carolina Bays are scattered across the SRS. Carolina Bays are naturally occurring closed depressions that often hold water. The quality of the water in the Savannah River and the SRS streams is such that on April 24, 1992, the South Carolina Department of Health and Environmental Control changed the classification of these waterways from "Class B waters" to "Freshwaters." This action imposes a more stringent set of water quality standards.

Excellent quality groundwater is abundant in this region of South Carolina from many local aquifers. The main source of recharge to the groundwater is rainfall and the direction of flow in the vadose zone is predominantly downward. In general, the vadose zone thickness ranges from approximately 40 meters (130 feet) in the northernmost part of the SRS to 0 meter where the water table intersects wetlands, streams, or creeks. The groundwater beneath 5 to 10 percent of the SRS has been contaminated by industrial solvents, metals, tritium, or other constituents used or generated on the Site. Appendix C of Volume 1 provides a complete description of the affected environment at the SRS in this category.

4.3.9 Ecological Resources

At the time of acquisition by the U.S. Government, the SRS was approximately two-thirds forested and one-third cropland and pasture. At present, more than 90 percent is forested and an extensive forest management program is conducted by the Savannah River Forest Station. The SRS is an important contributor to the biodiversity of Georgia and South Carolina. Carolina Bays, the Savannah River Swamp, and several relatively intact longleaf pine-wiregrass communities provide important contributions to the diversity of biota of the SRS and of the entire region.

The removal of all human inhabitants in 1951 and the restoration of forest cover since then have provided the wildlife associated with the wetlands of the Savannah River and the pine-dominated sand hills of coastal South Carolina found on the SRS with excellent wildlife habitat. A more thorough treatment of the topic of ecological resources at the SRS is provided in Volume 1, Appendix C. Also presented therein is a description of threatened, endangered, and candidate plant and animal species known to occur or that might occur on the SRS.

4.3.10 Noise

The major noise sources at SRS occur primarily in developed operational areas and include various facilities, equipment, and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles). Major noise sources outside the operational areas consist primarily of vehicles and railroad operations. Existing SRS-related noise sources of importance to the public are those resulting from the transportation of people and materials to and from the Site. These sources include trucks, private vehicles, helicopters, and freight trains. In addition, a portion of the air cargo and business travel using commercial air transport through the airports at Augusta, Georgia, and Columbia, South Carolina, are attributable to SRS operations. Appendix C of Volume 1 provides a complete description of the affected environment at the SRS in this category.

4.3.11 Traffic and Transportation

The SRS is surrounded by a system of interstate highways, U.S. highways, state highways, and railroads. The regional transportation networks service the four South Carolina counties and two Georgia counties that generate about 90 percent of SRS commuter traffic.

The SRS transportation infrastructure consists of more than 230 kilometers (143 miles) of primary roads, 1,931 kilometers (1,200 miles) of unpaved secondary roads, and 103 kilometers (64 miles) of railroad track. These roads and railroads provide connections among the various SRS facilities and to off-site transportation linkages.

4.3.12 Occupational and Public Health and Safety

The sources of radiation exposure to individuals consist of natural background radiation from cosmic, terrestrial, and internal body sources; radiation from medical diagnostic and therapeutic practices; and radiation from man-made sources, including consumer products, industrial products, and nuclear facilities. Programs are in place at the Savannah River Site to protect workers from radiological and non-radiological hazards. These programs help to maintain the doses to workers well below the regulatory dose limit of 5 rem/year and the DOE Administrative Control Level of 2 rem/year. Appendix C of Volume 1 provides a complete description of the affected environment at the SRS in this category.

4.3.13 Utilities and Energy

The principal source of water for SRS facilities is the Savannah River, with the remainder supplemented by groundwater wells. The Savannah River Site has its own electric-generating facility, although it purchases much of the power it uses from the South Carolina Electric and Gas Company.

4.3.14 Materials and Waste Management

The SRS generates high-level radioactive waste, transuranic waste, low-level radioactive waste, hazardous waste, mixed waste, and sanitary waste. DOE treats and stores waste generated from on-site operations at the SRS in waste management facilities. This includes approximately 20,000 cubic meters (700,000 cubic feet) of low-level waste generated annually. SRS packages low-level waste for disposal on the site in accordance with the waste category and its estimated surface dose rate.

Mixed low-level waste contains low-level radioactive materials and hazardous wastes. The SRS mixed waste program consists primarily of providing safe storage until treatment and disposal facilities are available. Appendix C of Volume 1 provides a complete description of the affected environment for this category.

4.4 HANFORD SITE

4.4.1 Overview

As mentioned previously, naval spent nuclear fuel has been shipped to the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) for examination since 1957. An alternative under consideration to performing spent naval nuclear fuel inspections at the INEL-ECF is to construct a facility providing similar capabilities at the Hanford Site. Two options for relocating an alternate ECF at the Hanford Site are to: (1) construct a new ECF between the 200 East and 200 West Areas adjacent to the proposed spent nuclear fuel storage facility, or (2) modify the currently unused Fuels and Materials Examination Facility (FMEF), located in the 400 Area, to perform ECF operations (see Figure 4.4-1).

This section provides a brief summary of the affected environment at Hanford. A detailed discussion of the Hanford Site affected environment is contained in Volume 1, Appendix A. The reader should refer to the applicable sections therein for additional information.

4.4.2 Land Use

The Hanford Site (which has been designated a National Environmental Research Park) encompasses approximately 1450 square kilometers (560 square miles) and includes several Department of Energy (DOE) operational areas. Most of the site is open, vacant land with only about 6 percent of the land occupied by constructed facilities. Land uses in the surrounding area include urban and industrial development, irrigated and dry-land farming, and grazing.

The Hanford Site includes some land-use resources that Native Americans have expressed an interest in, regarding the Treaty of 1855. DOE is assisting them in this effort. Details are provided in Volume 1, Appendix A.

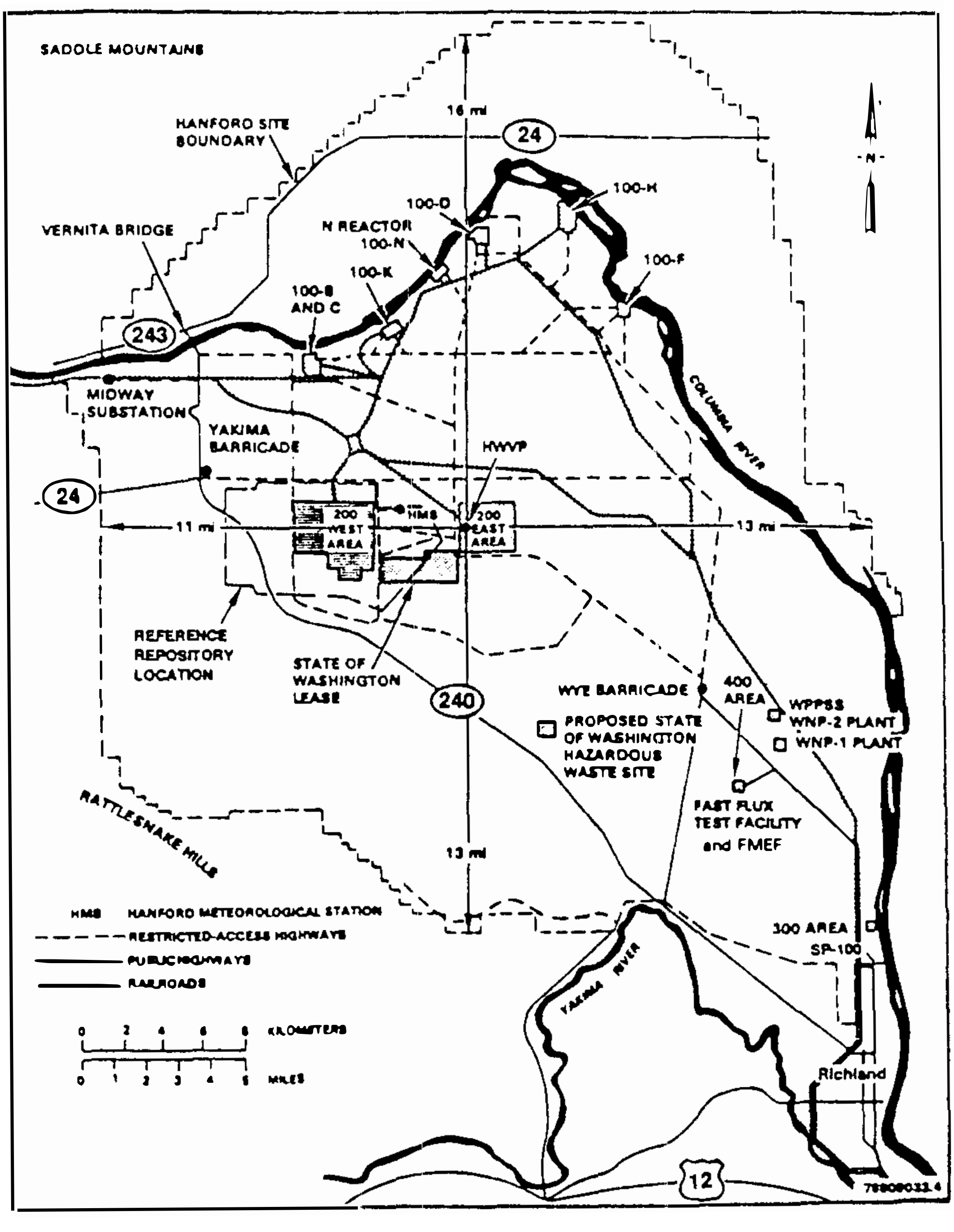


Figure 4.4-1. Hanford Site map.

4.4.3 Socioeconomics

The Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities (Richland, Pasco, and Kennewick) and other parts of Benton and Franklin counties. Approximately 380,000 people live within an 80-kilometer (50-mile) radius of the site. The agricultural community also represents a sizeable part of the local economy. Any major changes in Hanford activity would potentially most affect the Tri-Cities and other areas of Benton and Franklin counties. These areas in particular, but generally the 10 counties surrounding the Hanford Site, constitute the designated region of influence (Volume 1, Appendix A).

Hanford employment accounted for nearly one-quarter of the total non-agricultural jobs in Benton and Franklin counties in 1991. Approximately 93 percent of the direct employment at Hanford consists of residents of Benton and Franklin counties; approximately 81 percent reside in the Tri-Cities area. Population in the two counties increased by about 4 percent from 1980 to 1990.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the Hanford Site, and are provided in Appendix A to this volume of the Environmental Impact Statement. These data were developed in a manner which ensures that they are consistent with the data on the total population provided in Appendix A.

4.4.4 Cultural Resources

The Hanford Site is rich in cultural resources. It contains numerous, well-preserved archaeological sites representing both the prehistoric and historical periods and is still thought of as a homeland by many Native American people. Two single sites and seven archaeological districts are included in the National Register of Historic Places. Management of Hanford's cultural resources follows the Hanford Cultural Management Plan and is conducted by the Hanford Cultural Resources Laboratory of Pacific Northwest Laboratory. DOE is assisting Native Americans who have expressed an interest in renewing their use of some Hanford land-use resources, in accordance with the Treaty of 1855. Details are provided in Volume 1, Appendix A.

4.4.5 Aesthetic and Scenic Resources

The land in the vicinity of the Hanford Site is generally flat. Rattlesnake Mountain forms the western boundary of the Site, and Gable Mountain and Gable Butte are the highest land forms within the Site. Both the Columbia River, flowing across the northern part of the Site and forming the eastern boundary, and the spring-blooming desert flowers provide a source of visual enjoyment to people. The White Bluffs, steep bluffs above the northern boundary of the river in this region, are a striking feature of the landscape.

4.4.6 Geology

The Hanford Site is located within the central part of the Pasco Basin of the Columbia Plateau. Its surface features were formed by catastrophic floods and have undergone little modification since, with the exception of more recently formed sand dunes. The elevation of the Site varies from about 105 meters (345 feet) above mean sea level in the southeast corner to about 245 meters (803 feet) in the northwest. Much of the Hanford Site is underlain by sand, gravel, and cobble deposits which could have economic value. The major geologic units and a description of them can be found in Volume 1, Appendix A.

Seismicity of the Columbia Plateau is relatively low when compared to other regions of the Pacific Northwest. There are several major volcanoes in the Cascade Range west of the Hanford Site. The nearest is Mount Adams which is about 165 kilometers (102 miles) from the Site. The most active volcano is Mount St. Helens which is about 220 kilometers (136 miles) west-southwest from Hanford.

4.4.7 Air Resources

The Hanford Site is located in a semi-arid region where the climate is mild and dry, with occasional periods of high winds. The summers are generally hot and dry; the winters are relatively cool and mild. Average monthly temperatures at the Hanford Site range from -1.5 degrees C (29.3 degrees F) in January to 24.7 degrees C (76.5 degrees F) in July. The annual average relative humidity is 54 percent and is usually highest in winter (approximately 75 percent) and lower in summer (about 35 percent). The Cascade Mountains west of the Hanford Site greatly influence the local climate by acting as a natural barrier to Pacific Ocean storm systems. This contributes to the Site's relatively low average annual precipitation of 16 centimeters (6.3 inches). This range also serves as a source of cold air drainage which has a considerable effect on the wind regime on the Hanford Site.

Air quality is within federal standards. Details of the non-radiological air quality and the radiological air quality are provided in Appendix A of Volume 1.

Information on severe weather, precipitation extremes, and air dispersion/stagnation characteristics is provided in Volume 1, Appendix A for the Hanford Site. The source of meteorological information used in analytical calculations is provided in Attachment F.

4.4.8 Water Resources

The major surface water features near the Hanford Site are the Columbia and Yakima Rivers. The Columbia River flows through the northern part of the Site at an average annual flow rate of about 3400 cubic meters per second (120,000 cubic feet per second). The Yakima River, which has a low annual flow rate compared to the Columbia River, flows along the southern portion of the Hanford Site at an average annual rate of 104 cubic meters per second (3673 cubic feet per second). The Hanford ECF site or the modified FMEF site would not be affected by a 500-year flood of the Columbia River. Details are provided in Volume 1, Appendix A.

The State of Washington Department of Ecology classifies the Columbia River as Class A (excellent) from the Grand Coulee Dam, past the Hanford Site, to the mouth of the river at the Pacific Ocean. The Hanford Reach of the Columbia River is the last free-flowing portion of the river in the United States. Radiological monitoring shows low levels of radionuclides in the Columbia River. Hydrogen-3 (tritium), iodine-129, and uranium are found in slightly higher concentrations downstream of the Hanford Site than upstream, but are well below concentration guidelines established by the DOE and the U.S. Environmental Protection Agency (EPA) drinking water standards.

Groundwater quality on the Hanford Site has been affected by defense-related activities to produce nuclear materials. While most of the Site does not have contaminated groundwater, large underlying areas of the Site do have elevated levels of both radiological and non-radiological constituents. The liquid effluents, discharged into the ground, have carried with them certain radionuclides and chemicals which move through the soil column at varying rates, eventually entering the groundwater forming plumes of contamination. Groundwater monitoring is conducted on an annual basis. Results indicate that concentrations of various radionuclides in some wells in or near operating areas exceeded drinking water standards. Tritium continues to slowly migrate with the groundwater flow where it enters the Columbia River. Nitrate concentrations also exceeded drinking water standards at various locations around the Hanford Site. More information on groundwater quality can be found in Volume 1, Appendix A.

4.4.9 Ecological Resources

The Hanford Site is a relatively large, undisturbed area of shrub-steppe vegetation that contains numerous plant and animal species adapted to the region's semi-arid environment. The vegetation at the Hanford Site consists of 10 major kinds of plant communities, with cheatgrass the dominant plant on fields. More than 300 species of insects, 12 species of amphibians and reptiles, and about 39 species of mammals are found on the Hanford Site. The horned-lark and western meadowlark are the most abundant nesting birds. A more thorough treatment of the topic of ecological resources at the Hanford Site is provided in Volume 1, Appendix A. Also presented therein is a description of threatened and endangered species. These include four species of plants, six species of birds, and one species each of mammals and insects.

4.4.10 Noise

Hanford measurements of the propagation of noise have been concerned primarily with occupational noise at work sites. Environmental noise levels have not been extensively evaluated because of the remoteness of most Hanford activities. Most industrial facilities on the Hanford Site are located far enough away from the site boundary that noise levels at the boundary are not measurable or are barely distinguishable from background noise levels. Some field activities, such as well drilling and sampling, have the potential for producing noise in the field apart from major permanent facilities that could be disruptive to wildlife.

4.4.11 Traffic and Transportation

The area is serviced by a system of interstate highways and state roads. Personnel and most material shipments are transported by road. Bulk materials or large items are shipped by barge. Rail transportation is used to move irradiated fuel and certain high-level radioactive solid wastes and to transport equipment and materials.

Hanford's on-site road network consists of rural arterial routes. Only 65 of the 288 miles of paved roads at Hanford are accessible to the public. On-site rail transport is provided by a short-line railroad owned and operated by the DOE. This line connects just south of the Yakima River with the Union Pacific, which in turn interchanges with the Washington Central and Burlington Northern Railroads at Kennewick. The Hanford Site infrequently uses the Port of Benton dock facilities on the Columbia River for off-loading large shipments. Overland trailers are then used to transport those shipments to the Site.

4.4.12 Occupational and Public Health and Safety

Programs are in place at the Hanford Site to protect workers from radiological and non-radiological hazards. In 1989, about 9000 individuals were monitored at the Hanford Site, of which 6000 received a measurable radiation dose equivalent to an average annual dose of 0.1 rem per person. This is well below the regulatory dose limit of 5 rem per year and the DOE administrative control level of 2 rem per year.

Doses and exposures to the public from airborne releases at the Hanford Site are calculated and reported annually. It is calculated that the maximally exposed off-site individual would receive an exposure of 0.02 millirem per year of radioactive emissions, while the average exposure to the public would be 0.002 millirem per year.

4.4.13 Utilities and Energy

The principal source of water in the Tri-Cities and at the Hanford Site is the Columbia River. Electrical power for the Hanford Site is purchased wholesale from the Bonneville Power Administration, a federal power marketing agency. Hydropower, and to a lesser extent coal and nuclear power, are used to generate the region's electricity.

4.4.14 Materials and Waste Management

The Hanford Site contains several waste areas associated with nuclear defense-related materials. These areas are scheduled for remediation in accordance with the Hanford Federal Facility Agreement and Consent Order.

The following discussion briefly describes the current waste disposal practices at the Hanford Site. For more detailed information, and information on historical waste disposal practices, refer to Volume 1, Appendix A.

Wastes at the Hanford Site are generated by both facility operations and environmental restoration activities. Non-dangerous solid waste is disposed of at the Solid Waste Landfill located in the 200 Area. The existing capacity of this landfill will be expended by the mid to late 1990s. Newly generated non-radioactive hazardous waste is shipped off-site for treatment, recycling, recovery, and/or disposal.

Low-level mixed waste contains low-level radioactive materials and hazardous wastes. These wastes are either stored until technology is modified or verified to allow treatment or are evaporated through an evaporator. Solid low-level radioactive waste is placed in unlined, shallow trenches at the 200 Area Low-Level Waste Burial Grounds. Hanford also receives low-level waste from off-site generators for disposal. High-level wastes are being stored in single-shell and double-shell tanks until a treatment facility is constructed to allow treatment and disposal of the waste.

Transuranic waste is stored in above-ground storage facilities in the Hanford Central Waste Complex and Transuranic Waste Storage and Assay Facility. This waste is planned to be shipped to the Waste Isolation Pilot Plant in New Mexico for final disposal.

4.5 OAK RIDGE RESERVATION

4.5.1 Overview

As mentioned previously, naval spent nuclear fuel has been shipped to the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) for examination since 1957. An alternative to continuing naval spent nuclear fuel operations at the ECF at INEL is to construct a facility providing similar capabilities at the Oak Ridge Reservation (ORR). The new ECF would be sited near the K-25 Site which is located on the western portion of the ORR (see Figure 4.5-1). A separate security area would be established specifically to enclose the ECF at ORR, with all access controlled by the Naval Reactors Program as has always been the case at the ECF at INEL.

This section provides a brief summary of the affected environment at the Oak Ridge Reservation. A detailed discussion of the ORR affected environment is contained in Volume 1, Appendix F. The reader should refer to the applicable sections of that appendix for additional information and for information source references.

4.5.2 Land Use

The ORR is located on approximately 54 square miles (140 square kilometers) of federal land within Anderson and Roane Counties, Tennessee, with Knox and Loudon Counties to the south. Most of the ORR is located within the corporate limits of the city of Oak Ridge. Knoxville is located approximately 30 miles (48 kilometers) southeast of Oak Ridge and is the largest city in the area. The ORR includes three intensively developed industrial areas at the Y-12 Plant, the Oak Ridge National Laboratory (ORNL), and the K-25 Site separated by mostly undeveloped forest land. Surrounding land uses include residential, commercial, public, and industrial areas in the city of Oak Ridge and rural areas characterized by residences, small farms, forest, and pastures. Approximately 21 square miles (54 square kilometers) of undeveloped ORR land have been designated as a National Environmental Research Park.

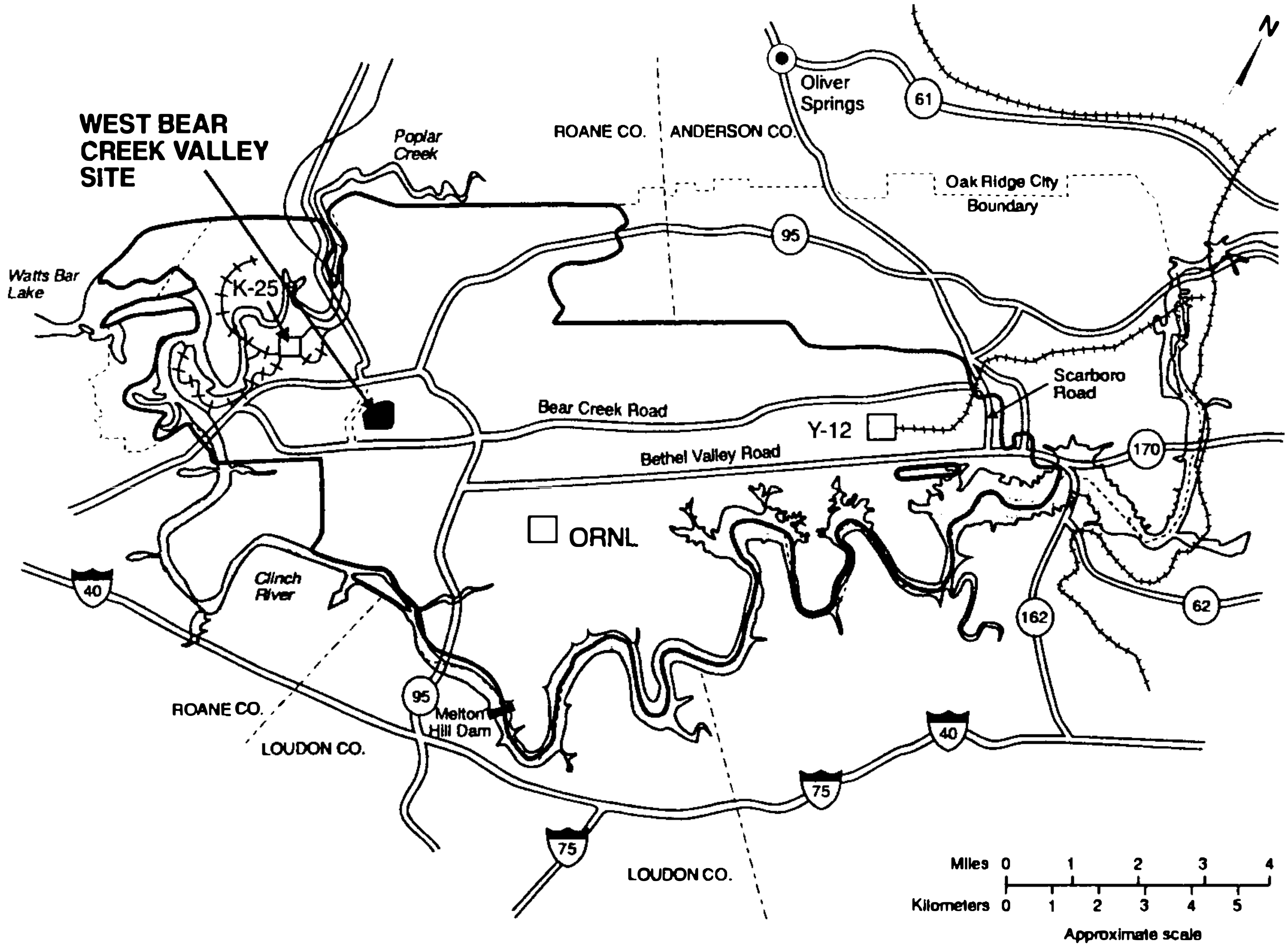


Figure 4.5-1. Oak Ridge Reservation site map.

4.5.3 Socioeconomics

Socioeconomic parameters are defined in this Environmental Impact Statement for a region of influence encompassing Anderson, Knox, Roane, and Loudon Counties, Tennessee. About 92 percent of ORR employees presently live in this region of influence. The employment level at the ORR in 1990 was 17,082 persons. The 1990 population of 489,230 in the region of influence is expected to increase at less than 1 percent annually through the year 2004, to 538,820 people. The housing stock, with a 1990 vacancy rate of 1.5 percent, is expected to grow in proportion to the population.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the ORR, and are provided in Appendix F to this volume of the Environmental Impact Statement. These data were developed in a manner which ensures that they are consistent with the data on the total population provided in Appendix F.

4.5.4 Cultural Resources

A cultural resources survey conducted in 1975 did not identify any cultural resources on the proposed Oak Ridge ECF site. Therefore, no prehistoric or historic resources are expected to be located on the proposed Oak Ridge ECF site. There are no known Native American resources on the proposed site of the Oak Ridge ECF. Further discussion is provided in Appendix F of Volume 1.

4.5.5 Aesthetic and Scenic Resources

The view on and near the ORR consists mainly of rural land. Views are limited by hilly terrain, forest cover, and frequent haziness. The three main developed areas at the Y-12 Plant, ORNL, and K-25 Site have low vulnerability to visual impacts (visual sensitivity); undeveloped ORR lands range from low to moderate visual sensitivity.

4.5.6 Geology

The ORR lies within the western portion of the Valley and Ridge Province, near the boundary with the Cumberland Plateau. The Valley and Ridge Province is characterized by numerous linear ridges and valleys which extend northeast-southwest. Local geology is characterized by sedimentary rocks of Cambrian and Ordovician age. Areas of the ORR underlain by limestones and dolomites contain sinkholes and caves ("karst" geology). Soils generally belong to the Ultisol order, characterized as moderately acidic soils that exhibit severe mineral weathering with precipitation of iron oxides. No prime or unique farmlands are located on the ORR.

From 1811 to 1975, five earthquakes or earthquake series with Modified Mercalli Intensity (MMI) of V to VI have affected the ORR area. No MMI VII earthquakes have been recorded in the ORR during this period. An MMI VII earthquake does not typically cause severe damage, but rather causes breaking of weak chimneys at the roof line, cracks in masonry, and the falling of plaster, loose bricks, and stones. MMI VII earthquakes generally occur one order of magnitude less frequently than MMI V to VI earthquakes. Seismic records indicate that the ORR is located in a region of moderate seismic activity having an average of one to two earthquakes per year with seismic activity occurring in bursts followed by long periods of no activity. No deformation of recent surface deposits has been detected, and seismic shocks from the surrounding, more seismically active areas are dissipated by distance from the epicenter. The ORR is located in Uniform Building Code Zone 2A.

4.5.7 Air Resources

Climate at the ORR is characterized by moderate temperatures (low daily average of 36.7°F in January and high daily average of 76.6°F in July), ample precipitation (annual average of 54.0

inches), and frequent summer thunderstorms. Although infrequently subjected to tornadoes, the ORR did experience a tornado from a severe thunderstorm in February 1993. The tornado passed the Y-12 Plant and ended just north of Knoxville. Wind speeds along the tornado path ranged from 40 miles per hour (18 meters per second) to nearly 130 miles per hour (58 meters per second). As of 1991, the areas within the Air Quality Control Region which includes the ORR were designated as in attainment with respect to all National Ambient Air Quality Standards. Great Smoky Mountains National Park, a Prevention of Significant Deterioration Class I area, is located roughly 30 miles to the southeast. The estimated 50-year effective dose equivalent to any member of the public due to airborne radiological emissions from the ORR is approximately 3.3 millirem. This level is well under regulatory limits.

4.5.8 Water Resources

The ORR is drained by the Clinch River and its network of tributaries. The Clinch River, a tributary of the Tennessee River, extends roughly 350 miles and drains roughly 4,410 square miles. The section of the river bordering the ORR is impounded by Melton Hill Dam and is a navigable component of the inland waterway system. The average discharge from Melton Hill Dam between 1963 and 1979 was 150 cubic meters (5,300 cubic feet) per second. The Clinch River is the principal source of water withdrawn to meet operational demands on the ORR. The only groundwater beneath the ORR suitable for withdrawal is found in the Knox Aquifer, but withdrawals are few due to the abundance of surface water. Concentrations of radiological and non-radiological contaminants above applicable water standards have been observed at a number of groundwater monitoring wells within the ORR. Such concentrations are probably a result of past waste disposal practices (such as the discharge of radioactive material to ponds and impoundments). However, data indicate that generally the contamination remains close to the source. Further discussion concerning the water quality at ORR is provided in Appendix F of Volume I.

4.5.9 Ecological Resources

Most undeveloped land on the ORR supports forest, including naturally established second growth forest and pine plantations that have been established on former agricultural lands. Aquatic habitats on the ORR include tailwaters, impoundments, reservoir embayments, large streams, small perennial streams, and wetlands. Wetlands on the ORR include shallow embayments on the Clinch

River impoundments, narrow strips of forested wetlands along groundwater seeps and creeks, and abandoned farm ponds. Twenty-five plant and animal species known to be present on the ORR are listed by the Tennessee Department of Environment and Conservation as either endangered, threatened, or of special concern.

4.5.10 Noise

Noise from the operation of industrial facilities and equipment on the ORR is primarily limited to the developed areas at the Y-12 Plant, ORNL, and K-25 Site. Noise from other parts of the ORR is generally limited to vehicular and rail traffic. Noise at the ORR boundary is generally indistinguishable from background noise.

4.5.11 Traffic and Transportation

Segments of some arterial roads in the vicinity of the ORR operate close to design capacity at certain times. Several arterial roads that are open to the public traverse ORR lands. The Clinch River is a navigable component of the inland waterway system but primarily serves only recreational boaters. Airports in the vicinity of the ORR include the McGhee Tyson Airport in Knoxville and numerous smaller private airfields.

4.5.12 Occupational and Public Health and Safety

Health impacts to the public are minimal due to administrative and design controls at ORR facilities that keep releases of radioactive or otherwise hazardous materials to the environment in compliance with applicable regulatory standards. Occupational doses to persons working at ORR facilities also fall within regulatory limits. Refer to Appendix F of this volume for detailed information in this area.

4.5.13 Utilities and Energy

The Clinch River and Melton Hill Reservoirs provide all water resources to the ORR and the city of Oak Ridge through two pumping stations. The ORR uses an average of 69.3 million liters

(18.3 million gallons) per day. Total potable water capacity available to the ORR is 152 million liters (40.2 million gallons) per day, obtained through the K-25 and Y-12 treatment plants. Electric power is provided to the ORR by the Tennessee Valley Authority. The current ORR power demand is approximately 115 megawatts, while the connected capacity of ORR facilities is approximately 920 megawatts. The average usage of natural gas at the ORR in 1994 was 3.6 billion Btu per day, compared to a contractual capacity of 7.6 billion Btu per day.

4.5.14 Materials and Waste Management

Each of the three main areas of the ORR is responsible for its own air and wastewater discharges and the associated treatment facilities. Non-radioactive hazardous wastes are also handled by each area, typically by shipment to off-site commercial treatment or disposal enterprises. Facilities for managing radioactive wastes, radioactive mixed wastes, and sanitary and industrial wastes generally involve more than one of the areas or involve land/facilities outside the area boundaries. Solid sanitary and industrial wastes are disposed of on the ORR. Most radioactive and mixed wastes are stored on-site pending future disposal actions. The Toxic Substance Control Act Incinerator, located at the K-25 Site, is used to incinerate uranium-contaminated polychlorinated biphenyl wastes and other mixed wastes.

4.6 NEVADA TEST SITE

4.6.1 Overview

As mentioned previously, naval spent nuclear fuel has been shipped to the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) for examination since 1957. Two of the alternatives under consideration result in the creation of a facility similar to ECF at the DOE-owned Nevada Test Site (NTS) in Nevada. A detailed description of the environment at the NTS is provided in Volume 1, Appendix F. This section provides a summary of some of the highlights from that volume. Therefore, specific source references for information contained in this section are omitted here but can be found in Volume 1, Appendix F.

A site has been identified as a possible location for the construction of a full-capability ECF at the Nevada Test Site. The potential location for the Nevada ECF is in Area 5 in the southeast section of the NTS, adjacent to Mercury Highway and south of the NFS High Explosive Assembly/ Disassembly Unit (see Figure 4.6-1). A separate security area would be established specifically to enclose the Nevada Test Site ECF, with all access controlled by the Naval Reactors Program as has always been the case at the Idaho ECF. This would place the Nevada ECF in close proximity to the location being proposed under one of the Centralization alternatives for construction and operation of an interim spent nuclear fuel storage facility.

4.6.2 Land Use

The NTS occupies an area of approximately 3,500 square kilometers (1,350 square miles) in southern Nevada in a remote area about 104 kilometers (65 miles) northwest of Las Vegas, Nevada. The southern two-thirds of the NTS is dominated by three large valleys or basins: Yucca, Frenchman, and Jackass flats. Mountain ridges and hills rise above gradually sloping stream-deposited soil fans, enclosing these basins. The northern and northwestern sections of the NTS are dominated by Pahute Mesa and Ranier Mesa. The NTS does not contain any public recreation facilities and only a very small percentage of the land is occupied by constructed facilities. The NTS is almost entirely surrounded by other federally owned lands which buffer it from lands open to the public. The NTS is

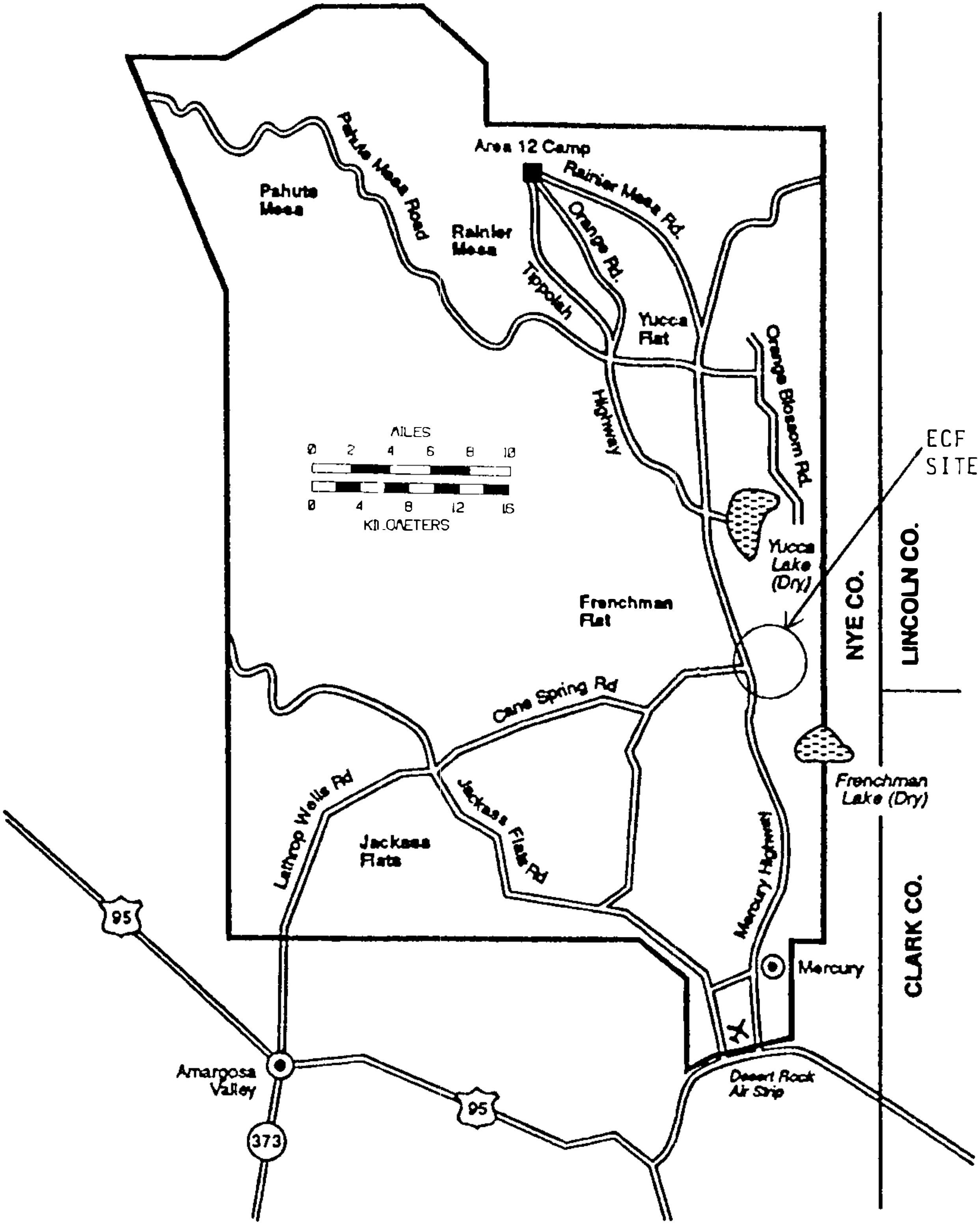


Figure 4.6-1. Candidate site for an Expended Core Facility at the Nevada Test Site.

bordered by the Nellis Air Force Range on the north, east, and west, and by the Bureau of Land Management on the south and southwest.

4.6.3 Socioeconomics

Socioeconomic parameters defined in this Environmental Impact Statement are for a two-county region of influence encompassing Clark and Nye Counties, Nevada. Ninety-eight percent of NTS employees live in Clark County (88 percent) or Nye County (10 percent). Economic conditions have continued to improve in Southern Nevada since the mid-1980s. Economic growth has been accelerated relative to the national trends because of the expansion in hotel and gaming markets. Appendix F of Volume 1 provides a complete description of the affected environment at the NTS in this category.

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs and activities on minority and low-income populations. An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. Data available from the U. S. Census of 1990 have been used to develop information on the locations of minority and low-income populations within approximately 50 miles of the NTS, and are provided in Appendix F to this volume of the Environmental Impact Statement. These data were developed in a manner which ensures that they are consistent with the data on the total population provided in Appendix F.

4.6.4 Cultural Resources

People have inhabited the NTS site for approximately 12,000 years. The area of the NTS was inhabited by Shoshone and Southern Paiute Native American tribes prior to European settlement. These tribes are known to be affiliated with sites located in the northern portions of the NTS including the Pahute and Rainier Mesas. No prehistoric or historic resources are expected to be located on the proposed site for the ECF facilities. Also, there are no areas contained in the site that are subject to Native American Treaty rights. Appendix F of Volume 1 provides a complete description of the affected environment at the NTS in this category.

4.6.5 Aesthetic and Scenic Resources

The view across the NTS comprises a mixture of open desert, mountain ranges, and industrial features. Areas on and surrounding the NTS are generally of low to moderate vulnerability to visual impact (visual sensitivity). Appendix F of Volume 1 provides a more complete description of the affected environment at the NTS in this category.

4.6.6 Geology

The NTS lies in the southern part of the Great Basin Section of the Basin and Range Physiographic Province. Local geology is characterized by sediment-filled topographically closed valleys surrounded by ranges composed of sedimentary rocks and compacted volcanic ash and lava. Appendix F of Volume 1 provides a complete description of the affected environment at the NTS in this category.

4.6.7 Air Resources

The climate at lower elevations at the NTS is characterized by bright sunlight, limited precipitation, low relative humidity, and large daily temperature ranges. Climatological parameters change markedly at higher elevations. In Pahute Mesa at an elevation of 2,000 meters (6,560 feet) above mean sea level, the average daily maximum/minimum temperatures are 4.4°C/2.2°C (40°F/28°F) in January and 26.7°C/16.7°C (80°F/62°F) in July. At Yucca Flat, at an elevation of 1,200 meters (3,920 feet) above mean sea level, the average daily maximum/minimum temperatures are 10.6°C/-6.1°C (51°F/21°F) in January and 35.6°C/13.9°C (96°F/57°F) in July.

The NTS is located in an attainment area for all criteria pollutants, and air quality in the region presently meets all applicable federal and Nevada regulations. For all activities on the NTS, the estimated effective dose equivalent to any member of the public from all airborne radionuclide emissions is approximately 0.01 millirem per year, which is well under regulatory limits.

4.6.8 Water Resources

Perennial surface water in the vicinity of the NTS is mostly limited to widely scattered springs, short river reaches, and playas (seasonally inundated lakes). Intermittent surface water bodies include ephemeral streams which briefly flow following heavy rainfall and playa lakes which contain standing water for brief periods following storms. Localized flash floods following rare heavy rainfalls can be destructive. Aquifers underlying the NTS are generally deep and between 660 and 1640 feet. Due to the scarcity of surface water, groundwater is the principal water source for NTS activities and surrounding communities. Appendix F of Volume 1 provides a complete description of the affected environment at the NTS in the general category of water resources, including both surface water and groundwater.

4.6.9 Ecological Resources

The NTS lies in an ecological transition area between the Mojave and Great Basin deserts. Terrestrial habitats on the NTS comprise desert scrub-shrub plant communities and a mountain, hill, and mesa community dominated by pinion pine and juniper. Aquatic habitats and wetlands on the NTS are limited to widely scattered springs, ephemeral stream channels, and playa lakes. Twenty-five federally and state listed threatened, endangered, or other special status species have been identified on or near the NTS. Of particular concern is the federally listed (threatened) desert tortoise, which is vulnerable to physical injury from construction and human activities, and the federally listed (endangered) Devils Hole pupfish, which is vulnerable to declining water levels.

4.6.10 Noise

Major noise sources at the NTS occur primarily in developed operational areas and include various facilities, equipment, and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles), aircraft operations, and testing. No NTS environmental noise survey data are available. At the boundary, away from most facilities, noise from most sources is barely distinguishable from background noise levels.

4.6.11 Traffic and Transportation

Arterial roads in the vicinity of the NTS, including Nevada Route 375 and U.S. Route 95, generally support free flow of traffic. Airports in the vicinity of the NTS include McCarran International Airport in Las Vegas and numerous smaller private airports. Additional information in this category can be found in Volume 1, Appendix F.

4.6.12 Occupational and Public Health and Safety

Health impacts to the public are minimal due to administrative and design controls at the NTS facilities that keep releases of radioactive or other hazardous materials to the environment in compliance with applicable regulatory standards. Occupational doses to persons working at NTS facilities also fall within regulatory limits. Appendix F of Volume 1 provides a complete description of the affected environment at the NTS in this category.

4.6.13 Utilities and Energy

Water is presently supplied to NTS facilities at a rate of 6139 gallons per minute by 12 active wells that tap underlying groundwater (aquifers). Between 40 and 45 megawatts of electrical power is presently available to the NTS from the Nevada Power Company. Proposed expansion will bring capacity to approximately 200 megawatts.

4.6.14 Materials and Waste Management

Numerous surface and subsurface contamination sites from previously conducted nuclear tests and ancillary operations have been identified on the NTS. Non-radiological contamination on the NTS is minimal because there have been no industrial-type production operations on the NTS.

A "Mixed Waste Management Unit" is located just north of the Radioactive Waste Management Station and will be part of routine disposal operations in the near future. In May 1990, mixed waste disposal operations ceased due to Environmental Protection Agency issuance of the Land Disposal Restrictions of the Resource Conservation and Recovery Act for the Third Thirds Wastes.

Active mixed waste disposal operations will commence upon completion of a National Environmental Policy Act documentation and issuance of a State of Nevada Part B permit.

Appendix F of Volume 1 provides additional documentation on materials and waste management practices at the Nevada Test Site.

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5. ENVIRONMENTAL CONSEQUENCES

5.1 NAVY AND PROTOTYPE SITES FOR NAVAL SPENT NUCLEAR FUEL

5.1.1 PUGET SOUND NAVAL SHIPYARD: BREMERTON, WASHINGTON

5.1.1.1 Overview of Environmental Impacts

The following sections discuss the major differences in potential environmental consequences associated with the choice of alternatives that include storage of naval spent nuclear fuel and inspection of high priority naval spent nuclear fuel at Puget Sound Naval Shipyard. The environmental consequences associated with storage of naval spent nuclear fuel at Puget Sound Naval Shipyard are based on the estimates of naval spent nuclear fuel that would be stored at Puget Sound Naval Shipyard through the year 2035 and current knowledge of the design features associated with spent fuel storage systems. The review of the environmental consequences associated with these alternatives has shown that the impact on the environment associated with these activities would be very small. There would be no impact to the Puget Sound Naval Shipyard regional environment associated with any alternatives that do not involve the Puget Sound Naval Shipyard.

5.1.1.2 Land Use

Construction of a storage area at Puget Sound Naval Shipyard for temporary naval spent nuclear fuel storage would require a modest change in the current land in use by the shipyard. A description of the alternate storage containers and water pools and approximate storage locations is provided in Attachment D. Attachment C provides a comparison of spent nuclear fuel storage in new water pools versus dry container storage. The shipyard area is already an industrial site; therefore, there would be no impact on land use. No additional land outside the naval complex would be required. The alternative of storing naval spent nuclear fuel in water pools would require that a water pool facility be constructed in the vicinity of the area that is designated for dry container storage or modification of the existing water pool to provide additional space. The water pool would have sufficient capacity to accommodate storage of all spent nuclear fuel expected to be stored at the shipyard.

In addition to the alternative involving storage at naval facilities of spent nuclear fuel generated in the future, the existing water pool facility would be used for the alternative where inspections of high priority naval spent nuclear fuel would be conducted at Puget Sound Naval Shipyard. A description of the Puget Sound Naval Shipyard water pool facility and the inspection operations under the alternative of inspecting high priority spent nuclear fuel at Puget Sound Naval Shipyard are also provided in Attachment D.

Native American rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.1.1.3 Socioeconomics

The calculated number of direct construction and operating jobs that would be required for the 10-year period between 1995 and 2004 for each storage alternative at the shipyard is provided in Table 5.1.1-1. Since there would be no naval spent nuclear fuel storage or inspection activities at the shipyard under the 1992/1993 Planning Basis and Centralization alternatives, no additional jobs would be required at the shipyard under these alternatives.

Table 5.1.1-1. Number of construction and operating jobs created at Puget Sound Naval Shipyard for each alternative.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Railcar(1)	1	1	8	1	1	1	1	1	1	1
Immobile Containers on Pads(2)	1	1	1	1	2	6	8	8	8	8
Shipping Containers on Pads (3)	1	1	1	1	2	6	2	2	2	2
Water Pool Storage(2)	16	16	73	113	138	99	106	40	40	40
Water Pool Inspection(3)	0	0	82	123	142	60	60	60	60	60

(1) Storage mode under the No Action and Decentralization alternatives.
(2) Storage mode under the Decentralization alternative.
(3) Inspection at Puget Sound would occur under the Decentralization B alternative.

The only discernible socioeconomic consequence of storing naval spent nuclear fuel at Puget Sound Naval Shipyard is that a relatively small number of construction workers (ranging from a few to a maximum of several hundred) would be required for construction of the storage area. The work force would consist of skilled craftsmen and unskilled laborers. This work force would be needed during the storage facility expansion and water pool modification and would be available from within the area.

The operation of the spent fuel storage area using dry storage containers would require additional workers to secure the fuel in the storage area and to support surveillance and monitoring activities. For the alternative involving storing fuel in immobile dry storage containers, about 20 workers would be required to handle the spent nuclear fuel when it is placed into the storage containers. This work force would normally only be needed when fuel is being inserted into the containers. For the alternative involving shipping containers, fewer workers would be needed to handle and secure the containers in the storage area. The operation of a water pool facility for the alternative involving storing naval spent nuclear fuel in a water pool would require approximately 40 additional workers. The operation of a water pool facility for the alternative involving inspection of spent nuclear fuel would require approximately 60 workers. The number required for any of the shipyard and prototype site storage alternatives would be small and is expected to be supplied from either within the existing shipyard work force or from the local work force. Considering that the Department of Defense employs approximately 10,200 civilians at the shipyard, the addition of workers to support the alternatives would have no discernible impact on the local socioeconomic conditions of the Puget Sound Naval Shipyard site and Bremerton area.

For the alternatives where dry storage containers would be manufactured, some additional jobs would be created in the locations where the containers are made. The process of selecting the container manufacturer is subject to federal procurement requirements and would be initiated after the Record of Decision. Consequently, the specific socioeconomic impacts from container fabrication cannot be specified. The net effect of container fabrication would be to create additional jobs and bolster the local economy of the area(s) where containers are made. It is considered unlikely that the selection of the contractor would depend on the alternative storage site selected, so the jobs associated with construction of casks provide no basis for selection of a storage site.

5.1.1.4 Cultural Resources

The action considered would not affect any site that is listed on the National Register of Historic Places (NPS 1991), any known archaeological areas, or any other cultural resources. Therefore, there would be no impacts to cultural resources associated with the alternative of storing or inspecting naval spent nuclear fuel at this location.

None of the alternatives considered would impact known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.1.1.5 Aesthetic and Scenic Resources

The naval spent nuclear fuel storage area would be located within the Puget Sound Naval Shipyard and would not affect the visual quality of the area since it is compatible with the landscape character of the site. Physical changes to the site resulting from the expansion of a spent nuclear fuel storage area would not alter this industrial setting. There are no particulate air emissions associated with storage of naval spent nuclear fuel and thus no visibility impacts are expected. No aesthetic or scenic resources in the vicinity of the shipyard would be affected by the construction and operation of the storage facility.

5.1.1.6 Geology

The expansion and operation of the naval spent nuclear fuel storage facility at this location is not expected to affect the geologic character or resources of the region. If an alternative were selected which required the storage area to be constructed, the ground would be excavated as necessary to prepare the surface. This would not affect the geologic characteristics of the underlying layers nor the characteristics of the aquifer or vadose zone.

5.1.1.7 Air Resources

5.1.1.7.1 Radiological Consequences. If the alternative where naval spent fuel would be stored in dry storage containers were to be selected, no airborne radioactivity releases would be expected to occur as a result of normal storage operations. The fuel would be contained such that at least two barriers exist to prevent fission products from becoming airborne. These barriers would retain the spent nuclear fuel in an air-tight containment until it is moved to a permanent storage site and there would be no airborne radioactive material released from routine operations for this method of storage. The only radiation exposure would be direct radiation from the array of filled storage containers. The filled storage containers would be fenced off and shielded if necessary such that there would be no distinguishable effect on the current radiation readings at the site perimeter.

For the alternatives where naval spent nuclear fuel would be stored in a water pool and the alternative where fuel would be inspected in the Puget Sound Naval Shipyard water pool, airborne radioactivity would be emitted beyond current emissions. The airborne releases are expected to be less than the emissions from the Idaho National Engineering Laboratory (INEL) Expended Core Facility (ECF) because the water pool size and the number of inspections performed would be smaller at the shipyard and the shipyard would not conduct the shielded cell operations that are performed at ECF. To conservatively estimate the radiological consequences, airborne releases based on ECF releases from 1991 are used. The radiological source term used and the detailed calculations performed to determine expected normal releases are provided in Attachment F.

The radiation exposures to human beings due to estimated radionuclide releases to the atmosphere plus direct radiation from the stored spent nuclear fuel at the shipyards for both the alternative involving water pool storage and the alternative involving dry storage were calculated as described in Attachment F. Postulated releases were calculated for wet storage of spent nuclear fuel in a water pool plus inspection of naval spent nuclear fuel.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from the stored spent fuel. The population data used to calculate population doses were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F. Estimated exposures to workers were also calculated.

The hypothetical exposures calculated are based on an exposure to the estimated average effluents and the direct radiation exposure for one year from the naval spent nuclear fuel stored at the shipyard. The calculations include the external effective exposure equivalent from the ground deposition, deposition to surface water, and air immersion pathways and the 50-year committed effective exposure equivalent from internal exposure through the ingestion and inhalation pathways. All pathways were considered for persons potentially exposed, except that the ingestion pathway was omitted for the workers because they do not grow their food on-site. Solubilities which would produce the highest calculated exposures were chosen for internal exposure factors. Values for human dietary consumption patterns were taken from "Age Dependent Values of Dietary Intake for Assessing Human Exposures to Environmental Pollutants" (Rupp 1980). The hypothetical exposures calculated can be converted into a risk of fatal cancer or a risk of non-fatal health detriments (e.g., non-fatal cancers, hereditary defects) based on recommendations of the International Commission on Radiological Protection (ICRP 1991).

Attachment F summarizes the calculated exposures and fatal cancers to the worker, maximally exposed off-site individual (MOI), nearest public access (NPA), and the population from releases of radioactivity and direct radiation exposure in one year for each location and storage mode. Section 3.7 provides a comparison of the annual number of fatal cancers calculated for the general population for each location and alternative.

The number of fatal cancers calculated is so small that there would be essentially no fatal cancers resulting from the storage of naval spent nuclear fuel during the time it could reasonably be expected to continue to be stored. Putting this into perspective, it could be stated that one member of the population might experience a fatal cancer due to incident-free storage of naval spent nuclear fuel at the Puget Sound Naval Shipyard if operations continued for 15,400 years.

5.1.1.7.2 Non-radiological Consequences. As noted in Attachment F, no increase in non-radioactive airborne emissions would be expected to result from spent nuclear fuel storage or examination facility operations. Storage and examination facility operations would not involve use of carcinogenic toxins, criteria pollutants, or other hazardous or toxic chemicals except that small quantities of industrial cleaning agents and paint thinner may be used for housekeeping and cleanliness control and these would be the same as those already used at the shipyard. Consequently, there would be no impact on ambient air quality as a result of implementing any of the alternatives at the shipyard.

If an alternative were to be selected that required a storage facility to be constructed or renovated, fugitive dust emissions would be expected to result from excavation operations. The quantity of dust generated would be small, consistent with typical excavation activities, and controlled within local requirements for dust control.

5.1.1.8 Water Resources

5.1.1.8.1 Radiological Consequences. Spent nuclear fuel storage and inspection operations at the shipyard would not result in discharges of radioactivity in liquid effluents during routine operation regardless of the alternative selected for storage or inspection of spent nuclear fuel. The health effect due to fallout of nuclides released to the air onto the surface water is included in the analysis results discussed in Section 5.1.1.7. The air fallout impact is so small that there would be no distinguishable radiation levels in the water.

Puget Sound Naval Shipyard does not reside in the 100 or 500 year floodplain. Consequently, the floodplain would not be impacted by spent naval nuclear fuel storage and examination activities at the shipyard.

5.1.1.8.2 Non-radiological Consequences. Other than chemicals used to maintain the storage area, no hazardous wastes would be generated by the storage of naval spent nuclear fuel at the shipyard. Any hazardous liquid effluents that may be generated at the storage area would be disposed of at an Environmental Protection Agency approved disposal site.

The only source for liquid discharges from the naval spent nuclear fuel storage operations to the environment consists of storm water runoff which would be consistent with the type of discharges associated with common light industrial facilities and related activities. It can be concluded that there would be no impact to the human environment due to runoff water from the naval spent nuclear fuel storage area.

The increased water usage associated with any alternative would be negligible compared to the existing shipyard demand.

5.1.1.9 Ecological Resources

Construction and operation of a spent fuel storage area would not impact any known habitats for threatened or endangered species and no major changes to the industrial environment are planned. Therefore, no major ecological impacts to the region would result from selection of any of the alternatives.

The conceptual location where naval spent nuclear fuel would be stored is illustrated in Attachment D. This location is within an existing industrial complex and is surrounded by buildings and paved areas. The industrial nature of the shipyard and the fact that the land has already been disturbed from its natural state by earlier activities mean that plant or animal species sensitive to disturbance by human activities would not be expected to be present. Therefore, there would be no ecological impacts associated with construction or operation of a spent nuclear fuel storage area at this location. The radiological controls that are in effect at the shipyard ensure that the radiation levels in the vicinity of the shipyard are maintained at or near natural background. Since these same controls would be applied to spent nuclear fuel activities, no ecological effects due to radioactive material would be expected to occur.

5.1.1.10 Noise

Puget Sound Naval Shipyard is an existing industrial-type environment characterized by noise from truck and automobile traffic; ship loading cranes and related diesel-powered equipment; and continuously operating transmission lines for steam, fuel, water, and related pumping systems for those and other liquids. No ambient noise level increases are expected to occur as a result of any of the alternatives. Therefore, no noise impacts would be expected to occur.

5.1.1.11 Traffic and Transportation

Shipments of radioactive materials in the Naval Nuclear Propulsion Program are required to be made in accordance with applicable regulations of the U.S. Department of Transportation, U.S. Department of Energy, and the U.S. Nuclear Regulatory Commission. The purpose of these regulations is to ensure that shipments of radioactive material are adequately controlled to protect the environment and the health and safety of the general public. These regulations are applicable to all radioactive material shipments and provide requirements for the container design, certification, and identification as applicable for the specific quantity, type, and form of radioactive material being shipped. Naval shipping container design requirements invoke shielding and integrity specifications and meet all regulatory requirements. They provide for testing of container designs, training and qualification of workers who construct containers, and quality control inspections during fabrication to ensure that the containers will meet their design requirements. A detailed description of the shipping containers used for naval spent nuclear fuel shipments is provided in Attachment A. A description of the impacts associated with normal and accident conditions associated with transportation of naval spent nuclear fuel is provided in Attachment A.

5.1.1.11.1 Regional Infrastructure. The alternatives under consideration are described in Section 3. The No Action alternative or the first variation of the Decentralization alternative would store the naval spent nuclear fuel on-site. This alternative would reduce the number of rail shipments from the shipyard or prototype site compared to the past practice of transporting all naval spent nuclear fuel to INEL. The second variation of the Decentralization alternative would ship about 10 percent of the naval spent nuclear fuel to Puget Sound. This would have some transportation impact, but not as much as transporting all naval spent nuclear fuel off-site. The third Decentralization alternative ships all naval spent nuclear fuel to INEL, examines it, and returns it to the original shipyard or prototype

site. This alternative involves more transportation than the previous practice of transporting naval spent nuclear fuel to INEL, since the naval spent nuclear fuel is not returned from INEL to the original site. The 1992/1993 Planning Basis alternative, the Regionalization at INEL alternative, or the Centralization at INEL alternative would involve the same transportation as has been required in the past, namely transportation to INEL and retention there. The Centralization alternative at the Hanford Site would result in more transportation impact than any of the previous alternatives, due to the distances and population distribution between Hanford and the shipyards and prototypes. The Centralization alternative at the Savannah River Site would result in the most transportation impact of naval spent nuclear fuel of any of the alternatives.

5.1.1.11.2 Site Infrastructure. The alternatives associated with naval spent nuclear fuel storage and inspection at Puget Sound Naval Shipyard would create some small amount of additional site highway traffic because any additional employees needed to operate the water pool facility under the inspection or storage alternatives would need to travel to and from work. This impact is expected to be very small considering the total number of employees at the Puget Sound Naval Shipyard and the fact that the additional workers might be provided from the existing work force. Spent fuel storage and inspection activities would increase the internal traffic in the shipyard in the short-term; however, the total impact on shipyard traffic would not be detectable.

5.1.1.12 Occupational and Public Health and Safety

Detailed analyses of incident-free naval spent nuclear fuel transportation and storage and handling impacts on worker and public health are described in Attachment A (transportation) and Attachment F (storage and inspection). The transportation analysis results, and the storage and handling analysis are summarized separately in the following subsections.

5.1.1.12.1 Incident-free Transportation Occupational and Public Health and Safety. The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.1.12.2 Incident-free Occupational and Public Health and Safety During Naval Spent Nuclear Fuel Storage and Handling. The public health and safety impacts of radioactivity releases and direct radiation from storage of naval spent nuclear fuel were analyzed as discussed in Section 5.1.1.7 and Attachment F. Attachment F summarizes the results of the analysis of radioactivity releases and direct radiation from stored naval spent nuclear fuel. This analysis shows that the exposure to the workers, maximally exposed off-site individual, and nearest public access from stored naval spent nuclear fuel would result in far less than one fatality per year. For perspective, it could be stated that one member of these population groups might experience a fatal cancer due to storage of naval spent nuclear fuel at Puget Sound Naval Shipyard if operations continued for 15,400 years.

Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

No public or occupational radiological health and safety impacts would be expected to result from naval spent nuclear fuel storage area construction activities since the construction would not involve radioactive work.

Attachment F also discusses toxic chemical issues for naval spent nuclear fuel handling and storage. Attachment F concludes that there would be no additional types or volumes of chemicals required at the shipyards or prototype site for naval spent nuclear fuel storage. Therefore, there is no incident-free non-radiological impact resulting from storage of naval spent nuclear fuel at the shipyards or prototype site.

5.1.1.12.3 Incident-free Occupational and Public Health and Safety Effects on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the management of naval spent nuclear fuel at the Puget Sound Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the Puget Sound Naval Shipyard do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game since environmental monitoring in the vicinity of this relatively small and restricted site has shown no detectable difference in the amounts of radioactivity present in the environment from levels in similar parts of the region.

To place the impacts on environmental justice in perspective, the risk associated with routine naval spent nuclear fuel management operations under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.1.1.13 Utilities and Energy

If an alternative associated with storage of spent nuclear fuel at Puget Sound Naval Shipyard were to be selected, construction and operation of the storage area would not be expected to require a large expenditure of utilities and energy resources. Construction activities would require quantities of water and electricity typical of any small to medium size construction project. Operation of a dry container spent fuel storage facility would likely require only minimal electricity for security lighting and to support industrial equipment necessary to move spent fuel.

Alternatives associated with water pool storage and inspection would require heating, ventilation, water, and electrical systems suitable for a work environment and to properly filter and exhaust the airborne discharges to the atmosphere. The utility and energy demands and impact would be less than that identified in Section 5.2.13 for operation of ECF (10,000 MWh per year) since the water pool facility at Puget is smaller and the scope of operations would be less.

The amount of utilities and energy expected to be consumed would be a small incremental increase in the total amount of utilities and energy used at the shipyard and would not result in any discernible environmental consequence.

5.1.1.14 Facility and Transportation Accidents

5.1.1.14.1 Facility Accidents. There has never been an accident in the history of the Naval Nuclear Propulsion Program that resulted in a significant release of radioactivity to the environment or that resulted in radiation exposure to workers in excess of abnormal occurrence limits on exposures as defined by the U.S. Nuclear Regulatory Commission. A description of potential accidents considered and a summary of the accident analyses that were conducted with regard to the inspection and storage of naval spent nuclear fuel are contained in Attachment F.

5.1.1.14.1.1 Radiological Accidents. Section 3.7.3 provides a summary of the impacts due to the most severe accidents considered for each site. The facility accident with the greatest potential impact at Puget Sound Naval Shipyard involves accidental drainage of the water pool. An accident of this magnitude would result in less than one fatal cancer to the general population over 50 years, as described in Attachment F. The likelihood of such an accident occurring is 1×10^{-5}, which is very small. For perspective, an accident such as this would not be expected to occur unless the facility operated for about 100,000 years.

5.1.1.14.1.2 Non-radiological Accidents. As discussed in detail in Attachment F, the limiting hypothetical non-radiological accident for naval spent nuclear fuel storage in a water pool at a shipyard or prototype location would be a diesel fuel spill and fire. A catastrophic failure of a diesel fuel storage tank that might be used for an emergency diesel generator to provide backup electrical power was postulated to occur, resulting in the spilling of the entire quantity of diesel fuel with a subsequent fire. The fire would generate the following toxic chemicals:

- Carbon monoxide
- Oxides of nitrogen (90% nitric oxide and 10% nitrogen dioxide)
- Lead
- Sulfur dioxide.

Measures would be taken to reduce the health impacts of potential releases of toxic materials. These measures would involve controls to protect both workers and the general public. The naval shipyard and prototype sites have emergency planning, emergency preparedness, and emergency response programs in place to protect hoth workers and the public, and involve established resources such as warning communications, fire departments, and emergency command centers.

The airborne concentrations of the comhustion products listed ahove, resulting from the fire, were calculated at the locations of the on-site individuals, an individual at the site boundary, and the general population within a 50-mile radius of the facility. Detailed results are presented in Attachment F. If the accidental fire that has been hypothesized were to actually occur, the safety measures that would be in place would ensure no adverse health impacts to the general public and minimal health impacts to the workers.

5.1.1.14.2 Transportation Accidents. Shipments of radioactive materials associated with naval spent nuclear fuel have never resulted in any measurahle release of radioactivity to the environment (NNPP 1994a). There have never been any significant accidents involving release of radioactive material during shipment since the Naval Nuclear Propulsion Program hegan. The effects of potential transportation accidents during the various stages of transportation of naval spent nuclear fuel are presented in Attachment A.

The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have heen assessed for the general population and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. Details of the transportation analysis are provided in Attachment A.

5.1.1.14.3 Other Impacts of Accidents. In addition to the possible human health effects associated with facility or transportation accidents described in the preceding sections, other effects

such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives. The analyses described in Attachment F showed that an area ranging from about 8 acres extending approximately a quarter mile (for an inadvertent criticality accident) to about 110 acres extending approximately 0.9 mile (for a large airplane crashing into a dry storage container) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, the exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. Persons who live in this area might be evacuated or otherwise experience restrictions in their daily activities for a brief period, and those who work at locations within this area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure. It should be noted that all of the affected area within approximately a half mile from the spent nuclear fuel facility would be inside the boundaries of the federally owned site.

An accident might result in short-term restrictions on access to a relatively small area, but there would be no enduring impacts on cultural or similar resources or concerns such as Native American rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area impacted would only vary slightly among the alternatives. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with any of the alternatives would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on plant and animal species in the area would also be small for all alternatives considered. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. There are no endangered or threatened species unique to the area surrounding the federally owned site, so an accident would not be expected to result in destruction of any species for any of the alternatives considered. The effects of accidents related to any of the alternatives and any associated cleanup which might be performed would be localized in a small area which extends only a short distance beyond the boundaries of the federally owned site and thus would not be expected to appreciably affect the potential for survival of any species in the area. Based on these considerations, evaluation of impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.1.1.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the Puget Sound Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is because the consequences of any accident would depend on the random conditions in effect at the time an accident occurred, and the wind directions at the Puget Sound Naval Shipyard are highly variable with no strongly dominant direction.

To place the impacts on environmental justice in perspective, the risk associated with accidents caused by naval spent nuclear fuel management under any of the alternatives considered would amount to less than one additional fatality per year for the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.1.1.15 Waste Management

The alternative in which naval spent nuclear fuel is stored at Puget Sound Naval Shipyard would produce limited amounts of solid municipal waste, solid low-level radioactive wastes, and hazardous wastes. In addition, no transuranic or high-level radioactive wastes would be generated by spent nuclear fuel activities at the site under any alternative. The quantity of industrial wastes generated would be small and most likely consist of industrial cleaning agents of the type normally encountered at the site. Small quantities of sanitary wastes would result from the additional work force but this volume would be small. The wastes produced from the storage of naval spent nuclear fuel would be controlled and minimized in accordance with the existing waste management programs at the shipyard. The amount of additional wastes generated would be minimal compared to the existing baseline and would not cause any adverse impacts to public health and safety and the environment in the vicinity of the shipyard.

5.1.1.16 Cumulative Impacts

5.1.1.16.1 Radiological Cumulative Impacts. Spent nuclear fuel storage and examination at Puget Sound would not result in discharges of radioactivity in liquid effluents during routine operations regardless of the alternative selected. Therefore, there would be no incremental addition of radioactivity to surface or ground water as a result of normal operations for any alternative. For alternatives involving the storage of spent nuclear fuel in dry storage and shipping containers, no airborne radioactivity emissions are expected, so there would be no cumulative air quality impacts associated with these storage methods. Consequently, the only radiological cumulative impacts that would result from dry storage alternatives would be due to direct radiation exposure from the stored containers of spent nuclear fuel.

For alternatives involving the storage and examination at Puget Sound of naval spent nuclear fuel in water pools, there would be no discernible direct radiation exposure to the public from the fuel elements due to the shielding provided by the water in the pool. Therefore, any cumulative impacts which would result from water pool storage (and examination at Puget Sound) would be primarily due to airborne emissions, and the addition of these emissions would cause an indiscernible change in the emissions in the area (see Section 5.1.1.7). Current operations at the site are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air

Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

A summary of the cumulative radiological impacts is provided in the following section.

An overview of the historical radiological impacts from naval nuclear operations at the Puget Sound Naval Shipyard and from transportation of naval spent nuclear fuel is provided in Section 4.1.1.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The radiological impacts associated with the alternatives where naval spent nuclear fuel would be inspected or stored at Puget Sound Naval Shipyard are very small and are described in Section 5.1.1.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the population in the vicinity of the Puget Sound Naval Shipyard from all of the alternatives considered would be approximately 5.30 person-rem. This means that there would be much less than one fatal cancer from these operations over the entire 40-year period evaluated. The total exposure to a theoretical maximally exposed off-site individual living at the shipyard boundary for the entire 40-year period would be 7.0×10^{-3} rem due to the alternative resulting in the largest exposure. This maximally exposed off-site individual would have a 3.5×10^{-6} risk of contracting a fatal cancer during his or her lifetime due to storage of spent nuclear fuel.

When existing site radiological impacts due to naval nuclear operations are added to the impacts of the most limiting spent nuclear fuel alternative, the exposure to the population would be 6.1 person-rem and to the maximally exposed off-site individual would be 7.6×10^{-3} rem. This still results in much less than one fatal cancer in the population and the risk of the maximally exposed off-site individual contracting a fatal cancer during his or her lifetime is 3.8×10^{-6}.

The total exposure related to naval spent nuclear fuel activities to a worker assumed to be working continually 100 meters from the spent nuclear fuel under the alternative resulting in the largest exposure is 0.22 rem accumulated over 40 years. That corresponds to a fatal cancer risk of 8.8×10^{-5} during the worker's lifetime. The exposure to the same worker when existing site radiological impacts due to naval nuclear operations are added to the spent nuclear fuel exposure is 0.222 rem over 40 years which corresponds to a fatal cancer risk of 8.9×10^{-5} during the worker's lifetime. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

Sections 4.1.1.14 and 5.1.1.15 describe the management of low-level radioactive waste and mixed waste at the site. The volume of low-level radioactive wastes which would be generated under the alternatives has not been calculated. However, considering the nature of radiological work that would be associated with spent nuclear fuel storage (and examination) activities, the amount of low-level radioactive waste produced during spent nuclear fuel activities would be much less than 20 percent of the current site generation rate (651 m^3 per year). This additional radioactive waste would not introduce any changes to the site's waste management practices. The small amount of additional material involved would not impose any discernible additional stress on the capacity of the radioactive waste burial ground. Therefore, any cumulative impacts associated with the generation and disposal of additional low-level wastes would be very small.

Since no mixed, transuranic, or high-level radioactive wastes would be generated by spent nuclear fuel activities at this site under any alternative, there would be no cumulative impacts associated with these materials.

5.1.1.16.2 Non-radiological Cumulative Impacts. An overview of the historical non-radiological impacts from naval nuclear operations at the Puget Sound Naval Shipyard and from transportation of naval spent nuclear fuel is provided in Section 4.1.1.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no non-radiological cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The non-radiological impacts associated with the alternative where naval spent nuclear fuel would be inspected or stored at Puget Sound Naval Shipyard are described in Section 5.1.1.12, with the detailed results of analyses provided in Attachment F. As summarized in Section 5.1.1.12, there would be no additional chemicals required at the shipyard for naval spent nuclear fuel storage and therefore no non-radiological impacts from normal operations. Consequently, no cumulative impacts to air quality or water resources would result since the incremental addition of chemicals at the shipyard that might result from naval spent fuel activities would be very small. There are no current environmental problems associated with these materials.

The non-radiological cumulative transportation impacts for the population from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A. The non-radiological impacts associated with the transportation and storage of naval spent nuclear fuel for all of the alternatives considered would be low.

No cumulative land use impacts would be expected to occur as a result of spent nuclear fuel storage and examination at Puget Sound. The land that would be dedicated for this purpose is on existing federal property and situated in an industrial setting which has already been disturbed from its natural state (approximately 327 acres are developed land). The conversion of this space for storage of spent nuclear fuel would not result in the need to disturb undeveloped land or for additional land to be added to the federally owned property in the foreseeable future.

From a socioeconomic perspective, the introduction of naval spent nuclear fuel activities at the site would create a small number of additional jobs and could have a very small cumulative socioeconomic impact. The site currently employs approximately 10,200 civilian personnel. No shipyard employment has been associated with spent nuclear fuel activities in the past since spent nuclear fuel activities have not been conducted at the site. An average of approximately 1 to 100 additional jobs might be added as a result of possible spent nuclear fuel activities in the future. The peak number of additional jobs created at the site in any given year would be approximately 280, which is associated with construction and operation of a water pool facility for storage of spent nuclear fuel and modification of the existing water pool for limited examination of fuel. Considering that the regional labor force consists of approximately 527,000 workers, the additional number of added jobs under any alternative would have little or no discernible socioeconomic impact. These jobs would be filled either from within the existing site work force or from the available regional labor force without discernible effect. There are no foreseeable future projects planned at the site and no known projects planned in the region that would cause the small number of workers involved in naval spent nuclear fuel activities to become an important impact.

The cumulative impacts associated with non-radiological waste management are likewise expected to be small. As stated previously, any industrial wastes generated from naval spent nuclear fuel storage and examination at Puget Sound would be small and limited to industrial cleaning agents of the type normally encountered at the site. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of additional non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of waste.

5.1.1.17 Unavoidable Adverse Effects

There are no discernible unavoidable adverse effects associated with the implementation of any of the alternatives and none which would help to choose among the alternatives. The alternative in which naval spent nuclear fuel is inspected or stored at the Puget Sound Naval Shipyard would cause the public to be exposed to small amounts of radiation, described in Section 5.1.1.12, and would result in less than one health effect in the entire population surrounding the shipyard.

Similarly, continued operation of the storage facility would produce limited amounts of solid municipal waste and solid low-level radioactive waste. These amounts of waste would not produce any major impacts in the vicinity of the Puget Sound Naval Shipyard. There will be no changes to the ecological, cultural, geological, and aesthetic resources due to the implementation of any of the alternatives. There will also be no impact on ambient noise levels.

5.1.1.18 Irreversible and Irretrievable Commitments of Resources

The only irreversible and irretrievable commitment of resources that results from the alternative in which naval spent nuclear fuel would be stored at the shipyard would be the money which would be spent by the federal government to construct the necessary facilities. The total cost of storing spent naval nuclear fuel at the shipyards and prototype ranges from approximately $1.5 billion to $5.7 billion. This cost represents the total cumulative cost over the 40-year period for all of the shipyards and prototype. This cost includes construction costs of the new storage facilities, and, depending on the alternative selected, the operation of a limited examination facility at Puget Sound Naval Shipyard combined with the costs associated with shutting down ECF, or the operational costs of the INEL-ECF. The major expense in the highest cost alternatives is the procurement of shipping containers. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

5.1.2 NORFOLK NAVAL SHIPYARD: PORTSMOUTH, VIRGINIA

5.1.2.1 Overview of Environmental Impacts

The following sections discuss the major differences in potential environmental consequences associated with the choice of alternatives that include storage of naval spent nuclear fuel at Norfolk Naval Shipyard. The environmental consequences associated with storage of naval spent nuclear fuel at Norfolk Naval Shipyard are based on the estimates of naval spent nuclear fuel that would be stored at Norfolk Naval Shipyard through the year 2035 and current knowledge of the design features associated with spent fuel storage containers. The review of the environmental consequences associated with these alternatives has shown that the impact on the environment at Norfolk Naval Shipyard associated with all activities is very small. There would be no impact to the Norfolk Naval Shipyard regional environment associated with any alternatives that do not involve the Norfolk Naval Shipyard.

5.1.2.2 Land Use

Norfolk Naval Shipyard has identified a centrally located area within the controlled industrial area as a potential site for spent nuclear fuel storage. The site is located approximately 1500 feet from the southern branch of the Elizabeth River. Public access to the 900 feet of river nearest the site evaluated is restricted. There are no known existing adverse environmental conditions at this site. The area is already an industrial site; therefore, there would be no impact on land use. The area identified should be sufficient depending on the type of storage mode ultimately chosen. A description of storage containers and water pools and their approximate storage locations is provided in Attachment D. Attachment C provides a comparison of spent nuclear fuel storage in new water pools versus dry container storage.

The alternative of storing naval spent nuclear fuel in water pools would require that a water pool facility be constructed in the vicinity of the area that is designated for dry container storage. The water pool would have sufficient capacity to accommodate storage of all spent nuclear fuel expected to be stored at the shipyard.

No additional land use outside the shipyard would be required.

Native American rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.1.2.3 Socioeconomics

The calculated number of direct construction and operating jobs that would be required for the 10-year period between 1995 and 2004 for each storage alternative at the shipyard is provided in Table 5.1.2-1. Since there would be no naval spent nuclear fuel storage or inspection activities at the shipyard under the 1992/1993 Planning Basis and Centralization alternatives, no additional jobs would be required at the shipyard under these alternatives.

Table 5.1.2-1. Number of construction and operating jobs created at Norfolk Naval Shipyard for each alternative.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Railcar(1)	1	1	8	1	1	1	1	1	1	1
Immobile Containers on Pads(2)	1	1	1	1	2	6	8	8	8	8
Shipping Containers on Pads (2)	1	1	1	1	2	6	2	2	2	2
Water Pools(2)	16	16	70	107	132	94	103	40	40	40

(1) Storage mode under the No Action and Decentralization alternatives.
(2) Storage mode under the Decentralization alternative.

The only discernible socioeconomic consequence of storing naval spent nuclear fuel at Norfolk Naval Shipyard is that a relatively small number of construction workers (ranging from a few to a maximum of several hundred would be required for construction of the storage area). The work force would consist of skilled craftsmen and unskilled laborers. This work force would be needed during the storage facility construction and would be available from within the area.

The operation of the spent fuel storage area using dry storage containers would require additional workers to support surveillance and monitoring activities. For the alternative involving storing fuel in immobile dry storage containers, about 20 workers would be required to handle the spent nuclear fuel when it is placed into the storage containers. This work force would normally only be needed when fuel is being inserted into the containers. For the alternative involving shipping containers, fewer workers would be needed to handle and secure the containers in the storage area. The operation of a water pool facility for the alternative involving storing naval spent nuclear fuel in a water pool would require approximately 40 additional workers. The number required for any of the shipyard and prototype site storage alternatives would be small and is expected to be supplied from either within the existing shipyard work force or from the local work force. Considering that the Department of Defense employs approximately 8,500 civilians at the shipyard, the addition of workers to support the alternatives would have no discernible impact on the local socioeconomic conditions of the Norfolk Naval Shipyard site.

For the alternatives where dry storage containers would be manufactured, some additional jobs would be created in the locations where the containers are made. The process of selecting the container manufacturer is subject to federal procurement requirements and would be initiated after the Record of Decision. Consequently, the specific socioeconomic impacts from container fabrication cannot be specified. The net effect of container fabrication would be to create additional jobs and bolster the local economy of the area(s) where containers are made. It is considered unlikely that the selection of the contractor would depend on the alternative storage site selected, so the jobs associated with construction of casks provide no basis for selection of a storage site.

5.1.2.4 Cultural Resources

The action considered would not affect any site that is listed on the National Register of Historic Places (NPS 1991), any known archaeological areas, or any other cultural resources. Therefore, there would be no impacts to cultural resources associated with the alternative of storing naval spent nuclear fuel at this location.

None of the alternatives considered would impact known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.1.2.5 Aesthetic and Scenic Resources

The naval spent nuclear fuel storage area would be located within the Norfolk Naval Shipyard which is an existing industrial setting and would not affect the visual quality of the area since it is compatible with the landscape character of the site. Physical changes to the site resulting from the construction of a spent nuclear fuel storage area would not alter this setting. There are no particulate air emissions associated with storage of naval spent nuclear fuel and thus no visibility impacts are expected. No aesthetic or scenic resources in the vicinity of the shipyard would be affected by the construction and operation of the storage facility.

5.1.2.6 Geology

The construction and operation of the naval spent nuclear fuel storage facility at the Norfolk Naval Shipyard is not expected to affect the geologic character or resources of the region. If an alternative were selected which required a storage facility to be constructed, the ground would only be excavated as necessary to prepare the surface. This would not affect the geological characteristics of the underlying layers nor the characteristics of the aquifer or vadose zone. For the alternative of storing fuel in a water pool facility, the ground surface would need to be excavated to a depth of approximately 40 feet. This excavation would not affect the geological characteristics of the area. Since the Columbia aquifer is at a depth of 3 to 5 feet throughout the shipyard, the hydraulic considerations make a water pool facility more difficult and expensive than an above-ground storage facility. However, if water pools were selected, all precautions necessary to protect the aquifer would be taken.

5.1.2.7 Air Resources

5.1.2.7.1 Radiological Consequences. If the alternative where naval spent fuel would be stored in dry storage containers were to be selected, no airborne radioactivity releases would be expected to occur as a result of normal storage operations. The fuel would be contained such that at least two barriers exist to prevent fission products from becoming airborne. These barriers would retain the spent nuclear fuel in an air-tight containment until it is moved to a permanent storage site and there would be no airborne radioactive material released from routine operations for this method of storage.

The only radiation exposure would be direct radiation from the array of filled storage containers. The filled storage containers would be fenced off and shielded if necessary such that there would be no distinguishable effect on the current radiation readings at the site perimeter.

For the alternative where naval spent nuclear fuel would be stored in a water pool, airborne radioactivity would be emitted beyond current emissions. The airborne releases for this alternative are expected to be less than the emissions from the Idaho National Engineering Laboratory (INEL) Expended Core Facility (ECF) because the water pool size and the number of inspections performed would be smaller at the shipyard and the shipyard would not conduct the shielded cell operations that are performed at ECF. To conservatively estimate the radiological consequences, airborne releases based on ECF releases from 1991 are used. The radiological source term used and the detailed calculations performed to determine expected normal releases are provided in Attachment F.

The radiation exposures to human beings due to estimated radionuclide releases to the atmosphere plus direct radiation from the stored spent nuclear fuel at the shipyards for both the alternative involving water pool storage and the alternative involving dry storage were calculated as described in Attachment F. Postulated releases were calculated for wet storage of spent nuclear fuel in a water pool plus inspection of naval spent nuclear fuel.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from the stored spent fuel. The population data used to calculate population exposures were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F. Estimated exposures to workers were also calculated.

The hypothetical exposures calculated are based on an exposure to the estimated average effluents and the direct radiation exposure for one year from the naval spent nuclear fuel stored at the shipyard. The calculations include the external effective exposure equivalent from the ground deposition, deposition to surface water, and air immersion pathways and the 50-year committed effective exposure equivalent from internal exposure through the ingestion and inhalation pathways. All pathways were considered for persons potentially exposed, except that the ingestion pathway was omitted for the workers because they do not grow their food on-site. Solubilities which would produce the bighest calculated exposures were chosen for internal exposure factors. Values for human dietary consumption patterns were taken from "Age Dependent Values of Dietary Intake for Assessing Human Exposures to Environmental Pollutants" (Rupp 1980). The hypothetical exposures calculated can be converted into a risk of fatal cancer or a risk of non-fatal health detriments (e.g., non-fatal cancers, hereditary defects) based on recommendations of the International Commission on Radiological Protection (ICRP 1991).

Attachment F summarizes the calculated exposures and fatal cancers to the worker, maximally exposed off-site individual (MOI), nearest public access (NPA), and the population from airborne releases of radioactivity and direct radiation exposure in one year for each location and storage mode. Section 3.7 provides a comparison of the annual number of fatal cancers calculated for the general population for each location and alternative.

The number of fatal cancers calculated is so small that there would be essentially no fatal cancers resulting from the storage of naval spent nuclear fuel during the time it could reasonably be expected to continue to be stored. Putting this into perspective, it could be stated that one member of the population might experience a fatal cancer due to incident-free storage of naval spent nuclear fuel at the Norfolk Naval Shipyard if operations continued for 7,100 years.

If a water pool facility would be constructed at the Norfolk Naval Shipyard and used for storage of spent nuclear fuel, the airborne emissions from the facility would be less than that identified for the Puget Sound Naval Shipyard because no spent nuclear fuel inspection operations beyond visual examinations would be conducted in the water pools.

5.1.2.7.2 Non-radiological Consequences. As noted in Attachment F, no increase in non-radioactive airborne emissions would be expected to result from spent nuclear fuel storage facility operations. Storage facility operations would not involve use of carcinogenic toxins, criteria pollutants, or other hazardous or toxic chemicals except for small quantities of industrial cleaning agents and paint thinner that may be used for housekeeping and cleanliness control and these would be the same as those already used at the shipyard. Consequently, there would be no impact on ambient air quality as a result of implementing any of the alternatives at the shipyard.

If an alternative were to be selected that required a storage facility to be constructed or renovated, fugitive dust emissions would be expected to result from excavation operations. The quantity of dust generated would be small, consistent with typical excavation activities, and controlled within local requirements for dust control.

5.1.2.8 Water Resources

5.1.2.8.1 Radiological Consequences. Spent nuclear fuel storage operations at the shipyard would not result in discharges of radioactivity in liquid effluents during routine operation regardless of the particular alternative chosen for storage of spent nuclear fuel. The health effect due to fallout of nuclides released to the air onto the surface water is included in the analysis results discussed in Section 5.1.2.7. The air fallout impact is so small that there would be no distinguishable radiation levels in the water.

Most of the Norfolk Naval Shipyard, including the location considered for the interim storage of naval spent nuclear fuel, is in the 100-year floodplain. However, the location considered for naval spent nuclear fuel is not in a high-hazard area (as defined by Title 10, Part 1022 of The Code of Federal Regulations for floodplains) which is an area where frequent flooding occurs. Since the majority of the shipyard is already developed and covered with impervious material, construction and operation of a naval spent nuclear fuel storage facility at the shipyard would produce no discernible impacts on the floodplain.

Flooding in the area where shipping and immobile dry storage containers are stored would not result in any adverse environmental consequences. These containers are completely sealed such that no radioactivity would be released from the interior even if they were completely submerged. In addition, the massive nature of these containers prevents them from floating or moving during a flood.

Since the shipyard resides in a floodplain, the design of the facility and equipment would minimize the potential for flooding and damage to the facility. However, in the event a water pool facility would be flooded, the exchange of pool water with the flood waters could occur. As discussed in Attachment F, Section F.1.4.2.1.6.2, the radioactivity concentration in the ECF water pool is below the Nuclear Regulatory Commission limits specified in Title 10, Part 20 of The Code of Federal Regulations for liquid effluent except for Co-60 which is slightly higher (water pools used for storage or examination of naval spent nuclear fuel would be maintained to comparable concentrations). Any release of radioactivity would have to result from the exchange of floodwater with the pool water. This exchange would reduce the level of radioactivity even further. Consequently, no adverse environmental impacts would result from flooding of water pools at naval spent nuclear fuel storage sites.

5.1.2.8.2 Non-radiological Consequences. Other than chemicals used to maintain the storage area, no hazardous wastes would be generated by the storage of naval spent nuclear fuel at Norfolk Naval Shipyard. Any hazardous liquid effluents that may be generated at the storage area would be disposed of at an Environmental Protection Agency approved disposal site.

The only source for liquid discharges from the naval spent nuclear fuel storage operations to the environment consists of storm water runoff which would be consistent with the type of discharges associated with common light industrial facilities and related activities. It can be concluded that there would be no impact to the human environment due to runoff water from the naval spent nuclear fuel storage area.

The increased water usage under any of the alternatives would be negligible compared to the existing shipyard demand.

5.1.2.9 Ecological Resources

There are no threatened or endangered species known to exist within the shipyard and no major changes to the industrial environment are planned. Therefore, no major ecological impacts to the region would result from selection of any of the alternatives.

The conceptual location where naval spent nuclear fuel would be stored is illustrated in Attachment D. This location is within an existing industrial complex and is surrounded by buildings and paved areas. The industrial nature of the shipyard and the fact that the land has already been disturbed from its natural state by earlier activities mean that plant or animal species sensitive to disturbance by human activities would not be expected to be present. Therefore, there would be no ecological impacts associated with construction or operation of a spent nuclear fuel storage area at this location. The radiological controls that are in effect at the shipyard ensure that the radiation levels in the vicinity of the shipyard are maintained at or near natural background. Since these same controls would be applied to spent nuclear fuel activities, no ecological effects due to radioactive material would be expected to occur.

5.1.2.10 Noise

Norfolk Naval Shipyard is an existing industrial-type environment characterized by noise from truck and automobile traffic; ship loading cranes and related diesel-powered equipment; and continuously operating transmission lines for steam, fuel, water, and related pumping systems for those and other liquids. No ambient noise level increases are expected to occur as a result of any of the alternatives. Therefore, no noise impacts would be expected to occur.

5.1.2.11 Traffic and Transportation

Shipments of radioactive materials in the Naval Nuclear Propulsion Program are required to be made in accordance with applicable regulations of the U.S. Department of Transportation, U.S. Department of Energy, and the U.S. Nuclear Regulatory Commission. The purpose of these regulations is to ensure that shipments of radioactive material are adequately controlled to protect the environment and the health and safety of the general public. These regulations are applicable to all radioactive material shipments and provide requirements for the container design, certification, and identification as applicable for the specific quantity, type, and form of radioactive material being shipped. Naval shipping container design requirements invoke shielding and integrity specifications and meet all regulatory requirements. They provide for testing of container designs, training and qualification of workers who construct containers, and quality control inspections during fabrication to ensure that the containers will meet their design requirements. A detailed description of the shipping containers used for naval spent nuclear fuel shipments is provided in Attachment A. A description of the impacts associated with normal and accident conditions associated with transportation of naval spent nuclear fuel is provided in Attachment A.

5.1.2.11.1 Regional Infrastructure. The alternatives under consideration are described in Section 3. The No Action alternative or the first variation of the Decentralization alternative would store the naval spent nuclear fuel on-site. This alternative would reduce the number of rail shipments from the shipyard or prototype site compared to the past practice of transporting all naval spent nuclear fuel to

INEL. The second variation of the Decentralization alternative would ship about 10 percent of the naval spent nuclear fuel to Puget Sound. This would have some transportation impact, but not as much as transporting all naval spent nuclear fuel off-site. The third Decentralization alternative ships all naval spent nuclear fuel to INEL, examines it, and returns it to the original shipyard or prototype site. This alternative involves more transportation than the previous practice of transporting naval spent nuclear fuel to INEL, since the naval spent nuclear fuel is not returned from INEL to the original site. The 1992/1993 Planning Basis alternative, the Regionalization at INEL alternative, or the Centralization at INEL alternative would involve the same transportation as has been required in the past, namely transportation to INEL and retention there. The Centralization alternative at the Hanford Site would result in more transportation impact than any of the previous alternatives, due to the distances and population distribution between Hanford and the shipyards and prototypes. The Centralization alternative at the Savannah River Site would result in the most transportation impact of naval spent nuclear fuel of any of the alternatives.

5.1.2.11.2 Site Infrastructure. If the alternative of storing naval spent nuclear fuel at Norfolk Naval Shipyard were to be selected, operation of a naval spent nuclear fuel storage facility would not noticeably affect site highway traffic because any increase in the work force would represent a very small incremental increase in overall traffic to and from the shipyard. Internal traffic in the Norfolk Naval Shipyard would increase in the short-term; however, the total impact on shipyard and surrounding area traffic would be very small.

5.1.2.12 Occupational and Public Health and Safety

Detailed analyses of incident-free naval spent nuclear fuel transportation and storage and handling impacts on worker and public health are described in Attachment A (transportation) and Attachment F (storage and inspection). The transportation analysis results, and the storage and handling analysis are summarized separately in the following subsections.

5.1.2.12.1 Incident-free Transportation Occupational and Public Health and Safety. The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.2.12.2 Incident-free Occupational and Public Health and Safety During Naval Spent Nuclear Fuel Storage and Handling. The public health and safety impacts of radioactivity releases and direct radiation from storage of naval spent nuclear fuel were analyzed as discussed in Section 5.1.2.7 and Attachment F. Attachment F summarizes the results of the analysis of radioactivity releases and direct radiation from stored naval spent nuclear fuel. This analysis shows that the exposure to the worker, maximally exposed off-site individual, and nearest public access from stored naval spent nuclear fuel would result in far less than one fatality per year. For perspective, it could be stated that one member of these population groups might experience a fatal cancer due to storage of naval spent nuclear fuel at Norfolk Naval Shipyard if operations continued for 7,100 years.

Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

No public or occupational radiological health and safety impacts would be expected to result from naval spent nuclear fuel storage area construction activities since the construction would not involve radioactive work.

Attachment F also discusses toxic chemical issues for naval spent nuclear fuel handling and storage. Attachment F concludes that there would be no additional types or volumes of chemicals required at the shipyards or prototype site for naval spent nuclear fuel storage. Therefore, there is no incident-free non-radiological impact resulting from storage of naval spent nuclear fuel at the shipyards or prototype site.

5.1.2.12.3 Incident-free Occupational and Public Health and Safety Effects on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the management of naval spent nuclear fuel at the Norfolk Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the Norfolk Naval Shipyard do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game since environmental monitoring in the vicinity of this relatively small and restricted site has shown no detectable difference in the amounts of radioactivity present in the environment from levels in similar parts of the region.

To place the impacts on environmental justice in perspective, the risk associated with routine naval spent nuclear fuel management operations under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.1.2.13 Utilities and Energy

If an alternative associated with storage of spent nuclear fuel at Norfolk Naval Shipyard were to be selected, construction and operation of the storage facility would not be expected to require a large expenditure of utilities and energy resources. Construction activities would require quantities of water and electricity typical of any small to medium size construction project. Operation of a dry container spent fuel storage facility would likely require only a small amount of electricity for lighting and to support industrial equipment necessary to move spent nuclear fuel. Alternatives associated with water pool storage would require heating, ventilation, water, and electrical systems suitable for a work environment and to properly filter and exhaust the airborne discharges to the atmosphere. The utility and energy demands would be less than those required to operate ECF (10,000 MWh per year) (Section 5.2.13) since the water pool used for spent fuel storage would be smaller and no spent fuel operations beyond visual examinations would be conducted in the water pool.

The amount of utilities and energy expected to be consumed would be a small incremental increase in the total amount of utilities and energy used at the shipyard and would not result in any discernible environmental consequence.

5.1.2.14 Facility and Transportation Accidents

5.1.2.14.1 Facility Accidents. There has never been an accident in the history of the Naval Nuclear Propulsion Program that resulted in a significant release of radioactivity to the environment or that resulted in radiation exposure to workers in excess of abnormal occurrence limits on exposures as defined by the U.S. Nuclear Regulatory Commission. A description of potential accidents considered and a summary of the accident analyses that were conducted with regards to the storage of naval spent nuclear fuel are contained in Attachment F.

5.1.2.14.1.1 Radiological Accidents. Section 3.7.3 provides a summary of the impacts due to the most severe accidents considered for each site. The facility accident with the greatest potential impact at Norfolk Naval Shipyard involves an airplane crash. An accident of this magnitude would result in a calculated 16 fatal cancers to the general population over 50 years, as described in Attachment F. The likelihood of such an accident occurring is 1×10^{-6}, which is very small. For perspective, an accident such as this would not be expected to occur unless the facility operated for about 1,000,000 years.

5.1.2.14.1.2 Non-radiological Accidents. As discussed in detail in Attachment F, the limiting hypothetical non-radiological accident for naval spent nuclear fuel storage in a water pool at a shipyard or prototype location would be a diesel fuel spill and fire. A catastrophic failure of a diesel fuel storage tank that might be used for an emergency diesel generator to provide backup electrical power was postulated to occur, resulting in the spilling of the entire quantity of diesel fuel with a subsequent fire. The fire would generate the following toxic chemicals:

- Carbon monoxide
- Oxides of nitrogen (90% nitric oxide and 10% nitrogen dioxide)
- Lead
- Sulfur dioxide.

Measures would be taken to reduce the health impacts of potential releases of toxic materials. These measures would involve controls to protect both workers and the general public. The naval shipyard and prototype sites have emergency planning, emergency preparedness, and emergency response programs in place to protect both workers and the public, and involve established resources such as warning communications, fire departments, and emergency command centers.

The airborne concentrations of the combustion products listed above, resulting from the fire, were calculated at the locations of the on-site individuals, an individual at the site boundary, and the general population within a 50-mile radius of the facility. Detailed results are presented in Attachment F. If the accidental fire that has been hypothesized were to actually occur, the safety measures that would be in place would ensure no adverse health impacts to the general public and minimal health impacts to the workers.

5.1.2.14.2 Transportation Accidents. Shipments of radioactive materials associated with naval spent nuclear fuel have never resulted in any measurable release of radioactivity to the environment (NNPP 1994a). There have never been any significant accidents involving release of radioactive material during shipment since the Naval Nuclear Propulsion Program began. The effects of potential transportation accidents during the various stages of transportation of naval spent nuclear fuel are presented in Attachment A.

The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. Details of the transportation analysis are provided in Attachment A.

5.1.2.14.3 Other Impacts of Accidents. In addition to the possible human health effects associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives. The analyses described in Attachment F showed that an area ranging from about 8 acres extending approximately a quarter mile (for an inadvertent criticality accident) to about 110 acres extending approximately 0.9 mile (for a large airplane crashing into a dry storage container) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, the exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. Persons who live in this area might be evacuated or otherwise experience restrictions in their daily activities for a brief period, and those who work at locations within this area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure. It should be noted that all of the affected area within about a quarter of a mile from the spent nuclear fuel facility would be inside the boundaries of the federally owned site.

An accident might result in short-term restrictions on access to a relatively small area, but there would be no enduring impacts on cultural or similar resources, partially because the area involved would be small and partly because the remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area impacted would vary only slightly among the alternatives. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with any of the alternatives would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for all alternatives considered. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. There are no endangered or threatened species unique to the area surrounding the federally owned site and an accident would not be expected to result in destruction of any species for any of the alternatives considered. The effects of accidents related to any of the alternatives and any associated cleanup which might be performed would be localized in a small area extending only a short distance beyond the boundaries of the federally owned site and would not be expected to appreciably affect threatened or endangered species in the area. Based on these considerations, evaluation of impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.1.2.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the Norfolk Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is because the consequences of any accident would depend on the random conditions in effect at the time an accident occurred, and the wind directions at the Norfolk Naval Shipyard are highly variable with no strongly dominant direction.

To place the impacts on environmental justice in perspective, the risk associated with accidents caused by naval spent nuclear fuel management under any of the alternatives considered would amount to less than one additional fatality per year for the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.1.2.15 Waste Management

The alternative in which naval spent nuclear fuel is stored at Norfolk Naval Shipyard would produce limited amounts of solid municipal waste, solid low-level radioactive wastes, and hazardous wastes. In addition, no transuranic or high-level radioactive wastes would be generated by spent nuclear fuel activities at the site under any alternative. The quantity of industrial wastes generated would be small and most likely consist of industrial cleaning agents of the type normally encountered at the site. Small quantities of sanitary wastes would result from the additional work force but this volume would be small. The wastes produced from the storage of naval spent nuclear fuel would be controlled and minimized in accordance with the existing waste management programs at the shipyard. The amount of additional wastes generated would be minimal compared to the existing baseline and would not cause any adverse impacts to public health and safety and the environment in the vicinity of the shipyard.

5.1.2.16 Cumulative Impacts

5.1.2.16.1 Radiological Cumulative Impacts. Spent nuclear fuel storage at the site would not result in discharges of radioactivity in liquid effluents during routine operations regardless of the alternative selected. Therefore, there would be no incremental addition of radioactivity to surface or ground water as a result of normal operations for any alternative. For alternatives involving the storage of spent nuclear fuel in dry storage and shipping containers, no airborne radioactivity emissions are expected, so there would be no cumulative air quality impacts associated with these storage methods. Consequently, the only radiological cumulative impacts that would result from dry storage alternatives would be due to direct radiation exposure from the stored containers of spent nuclear fuel.

For alternatives involving the storage of naval spent nuclear fuel in water pools, there would be no discernible direct radiation exposure to the public from the fuel elements due to the shielding provided by the water in the pool. Therefore, any cumulative impacts which would result from water pool storage would be primarily due to airborne emissions, and the addition of these emissions would cause an indiscernible change in the emissions in the area (see Section 5.1.2.7). Current operations at the site are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

A summary of the cumulative radiological impacts is provided in the following section.

An overview of the historical radiological impacts from naval nuclear operations at the Norfolk Naval Shipyard and from transportation of naval spent nuclear fuel is provided in Section 4.1.2.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The radiological impacts associated with the alternatives where naval spent nuclear fuel would be stored at Norfolk Naval Shipyard are very small and are described in Section 5.1.2.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the population in the vicinity of the Norfolk Naval Shipyard from all of the alternatives considered would be approximately 11.2 person-rem. This means that there would be much less than one fatal cancer from these operations over the entire 40-year period evaluated. The total exposure to a theoretical maximally exposed off-site individual living at the shipyard boundary for the entire 40-year period would be 0.12 rem due to the alternative resulting in the largest exposure. This maximally exposed off-site individual would have a 6.0×10^{-5} risk of contracting a fatal cancer during his or her lifetime due to storage of spent nuclear fuel. When existing site radiological impacts due to naval nuclear operations are added to the impacts of the most limiting spent nuclear fuel alternative, the exposure to the population would be 13.6 person-rem and to the maximally exposed off-site individual would remain at 0.12 rem. This still results in much less than one fatal cancer in the population and the risk of the maximally exposed off-site individual contracting a fatal cancer during his or her lifetime is essentially unchanged.

The total exposure related to naval spent nuclear fuel activities to a worker assumed to be working continually 100 meters from the spent nuclear fuel under the alternative resulting in the largest exposure is 0.23 rem accumulated over 40 years. That corresponds to a fatal cancer risk of 9.2×10^{-5} during the worker's lifetime. The exposure to the same worker when existing site radiological impacts due to naval nuclear operations are added to the spent nuclear fuel exposure is 0.232 rem over 40 years which corresponds to a fatal cancer risk of 9.3×10^{-5} during the worker's lifetime. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

Sections 4.1.2.14 and 5.1.2.15 describe the management of low-level radioactive waste and mixed waste at the site. The volume of low-level radioactive wastes which would be generated under the alternatives has not been calculated. However, considering the nature of radiological work that would be associated with spent nuclear fuel storage activities, the amount of low-level radioactive waste produced during spent nuclear fuel activities would be much less than 20 percent of the current site generation rate (1019 m^3 per year). This additional radioactive waste would not introduce any changes to the site's waste management practices. The small amount of additional material involved would not impose any discernible additional stress on the capacity of the radioactive waste burial ground. Therefore, any cumulative impacts associated with the generation and disposal of additional low-level wastes would be very small.

Since no mixed, transuranic, or high-level radioactive wastes would be generated by spent nuclear fuel activities at this site under any alternative, there would be no cumulative impacts associated with these materials.

5.1.2.16.2 Non-radiological Cumulative Impacts. An overview of the historical non-radiological impacts from naval nuclear operations at the Norfolk Naval Shipyard and from transportation of naval spent nuclear fuel is provided in Section 4.1.2.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no non-radiological cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The non-radiological impacts associated with the alternative where naval spent nuclear fuel would be inspected or stored at Norfolk Naval Shipyard are described in Section 5.1.2.12, with the detailed results of analyses provided in Attachment F. As summarized in Section 5.1.2.12, there would be no additional chemicals required at the shipyard for naval spent nuclear fuel storage and therefore no non-radiological impacts from normal operations. Consequently, no cumulative impacts to air quality or water resources would result since the incremental addition of chemicals at the shipyard that might result from naval spent fuel activities would be very small. There are no current environmental problems associated with these materials.

The non-radiological cumulative transportation impacts for the population from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A. The non-radiological impacts associated with the transportation and storage of naval spent nuclear fuel for all of the alternatives considered would be low.

No cumulative land use impacts would be expected to occur as a result of spent nuclear fuel storage. The land that would be dedicated for this purpose is on existing federal property and situated in an industrial setting which has already been disturbed from its natural state (over 1100 acres are developed land). The conversion of this space for storage of spent nuclear fuel would not result in the need to disturb undeveloped land or for additional land to be added to the federally owned property in the foreseeable future.

From a socioeconomic perspective, the introduction of naval spent nuclear fuel activities at the site would create a small number of additional jobs and could have a very small cumulative socioeconomic impact. The site currently employs approximately 8500 civilian personnel. No shipyard employment has been associated with spent nuclear fuel activities in the past since spent nuclear fuel activities have not been conducted at the site. An average of approximately 1 to 40 additional jobs might be added as a result of possible spent nuclear fuel activities in the future. The peak number of additional jobs created at the site in any given year would be approximately 132, which is associated with construction and operation of a water pool facility for storage of spent nuclear fuel. Considering that the regional labor force consists of approximately 533,000 workers, the additional number of added jobs under any alternative would have little or no discernible socioeconomic impact. These jobs would be filled either from within the existing site work force or from the available regional labor force without discernible effect. There are no foreseeable future projects planned at the site and no known projects planned in the region that would cause the small number of workers involved in naval spent nuclear fuel activities to become an important impact.

The cumulative impacts associated with non-radiological waste management are likewise expected to be small. As stated previously, any industrial wastes generated from naval spent nuclear fuel storage would be small and limited to industrial cleaning agents of the type normally encountered at the site. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of additional non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of waste.

5.1.2.17 Unavoidable Adverse Effects

There are no discernible unavoidable adverse effects associated with the implementation of any of the alternatives and none which would help to choose among the alternatives. The alternative in which naval spent nuclear fuel is stored at the Norfolk Naval Shipyard would cause the public to be exposed to small amounts of radiation, described in Section 5.1.2.12, and would result in less than one health effect in the entire population surrounding the shipyard. Similarly, continued operation of the storage facility would produce limited amounts of solid municipal waste and solid low-level radioactive waste. These amounts of waste would not produce any major impacts in the vicinity of the shipyard. There will be no changes to the ecological, cultural, geological, and aesthetic resources due to the implementation of any of the alternatives. There would also be no expected impact on ambient noise levels.

5.1.2.18 Irreversible and Irretrievable Commitments of Resources

The only irreversible and irretrievable commitment of resources that results from the alternative in which naval spent nuclear fuel would be stored at the Norfolk Naval Shipyard would be the money which would be spent by the federal government to construct the necessary facilities. The total cost of storing spent naval nuclear fuel at the shipyards and prototype ranges from approximately $1.5 billion to $5.7 billion. This cost represents the total cumulative cost over the 40-year period for all of the shipyards and prototype. This cost includes construction costs of the new storage facilities, and, depending on the alternative selected, the operation of a limited examination facility at Puget Sound Naval Shipyard combined with the costs associated with shutting down ECF, or the operational costs of the INEL-ECF. The major expense in the highest cost alternatives is the procurement of shipping containers. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

5.1.3 PORTSMOUTH NAVAL SHIPYARD: KITTERY, MAINE

5.1.3.1 Overview of Environmental Impacts

The following sections discuss the major differences in potential environmental consequences associated with the choice of alternatives that include storage of naval spent nuclear fuel at Portsmouth Naval Shipyard. The environmental consequences associated with storage of naval spent nuclear fuel at Portsmouth Naval Shipyard are based on the estimates of naval spent nuclear fuel that will be stored at Portsmouth Naval Shipyard through the year 2035 and current knowledge of the design features associated with spent fuel shipping containers, immobile storage containers, and storage systems. The review of the environmental consequences associated with each of these alternatives has shown that the associated impact on the environment is very small. There would be no impact to the Portsmouth Naval Shipyard regional environment associated with any alternatives that do not involve the Portsmouth Naval Shipyard.

5.1.3.2 Land Use

Construction of a storage area at Portsmouth Naval Shipyard would require a modest change in the current land use by the shipyard. A description of the alternative storage containers and their approximate storage locations is provided in Attachment D. Attachment C provides a comparison of spent nuclear fuel storage in new water pools versus dry container storage.

The alternative of storing naval spent nuclear fuel in water pools would require that a water pool facility be constructed in the vicinity of the area that is designated for dry container storage. The water pool would have sufficient capacity to accommodate storage of all naval spent nuclear fuel expected to be stored at the shipyard.

No additional land outside the shipyard would be required.

Native American rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.1.3.3 Socioeconomics

The calculated number of direct construction and operating jobs that would be required for the 10-year period between 1995 and 2004 for each storage alternative at the shipyard is provided in Table 5.1.3-1. Since there would be no naval spent nuclear fuel storage or inspection activities at the shipyard under the 1992/1993 Planning Basis and Centralization alternatives, no additional jobs would be required at the shipyard under these alternatives.

Table 5.1.3-1. Number of construction and operating jobs created at Portsmouth Naval Shipyard for each alternative.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Railcar(1)	1	1	6	1	1	1	1	1	1	1
Immobile Containers on Pads(2)	1	1	1	1	2	6(3)	4	4	4	4
Shipping Containers on Pads (2)	1	1	1	1	2	6(3)	1	1	1	1
Water Pools(2)	16	16	47	72	89	63	77	35	35	35

(1) Storage mode under the No Action and Decentralization alternatives.
(2) Storage mode under the Decentralization alternative.
(3) The construction jobs would last less than one year.

The only discernible socioeconomic consequence of storing naval spent nuclear fuel at Portsmouth Naval Shipyard is that a relatively small number of construction workers (ranging from a few to a maximum of several hundred would be required for construction of the area). The work force would consist of skilled craftsmen and unskilled laborers. This work force would be needed during the storage facility construction and would be available from within the area.

The operation of the spent fuel storage area using dry storage containers would require additional workers to secure the fuel in the storage area and to support surveillance and monitoring activities. For the alternative involving storing fuel in immobile dry storage containers, about 20 workers would be required to handle the spent nuclear fuel when it is placed into the storage containers. This work force would normally only be needed when fuel is being inserted into the containers. For the alternative involving shipping containers, fewer workers would be needed to handle and secure the containers in the storage area. The operation of a water pool facility for the alternative involving storing naval spent nuclear fuel in a water pool would require approximately 40 additional workers. The number required for any of the shipyard and prototype site storage alternatives would be small and is expected to be supplied from either within the existing shipyard work force or from the local work force. Considering that the shipyard employs approximately 5000 naval and civilian personnel, the addition of workers to support the alternatives would have no discernible impact on the local socioeconomic conditions of the Portsmouth Naval Shipyard site.

For the alternatives where dry storage containers would be manufactured, some additional jobs would be created in the locations where the containers are made. The process of selecting the container manufacturer is subject to federal procurement requirements and would be initiated after the Record of Decision. Consequently, the specific socioeconomic impacts from container fabrication cannot be specified. The net effect of container fabrication would be to create additional jobs and bolster the local economy of the area(s) where containers are made. It is considered unlikely that the selection of the contractor would depend on the alternative storage site selected, so the jobs associated with construction of casks provide no basis for selection of a storage site.

5.1.3.4 Cultural Resources

All construction contracts for the shipyard contain a clause such that if artifacts are uncovered, appropriate measures must be taken to ensure the safe recovery of such items. In most cases, these items are then placed in the shipyard museum.

The shipyard's historic district is considered a valued cultural resource and many buildings are listed on the historic register. The implementation of storage alternatives will not affect any site that is listed on the National Register of Historic Places (NPS 1991), any known archaeological areas, or any other cultural resources. Therefore, there would be no impacts to cultural resources associated with the alternative of storing naval spent nuclear fuel at the shipyard.

None of the alternatives considered would impact known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.1.3.5 Aesthetic and Scenic Resources

The naval spent nuclear fuel storage area would be located within the Portsmouth Naval Shipyard which is an existing industrial setting and would not affect the visual quality of the area since it is compatible with the landscape character of the site. Physical changes to the site resulting from the construction of a naval spent nuclear fuel storage facility will not alter this setting. There are no particulate air emissions associated with storage of naval spent nuclear fuel and thus no visibility impacts are expected. No aesthetic or scenic resources in the vicinity of the shipyard would be affected by the construction and operation of the storage facility.

5.1.3.6 Geology

If an alternative were to be selected which required naval spent nuclear fuel to be stored at Portsmouth Naval Shipyard, the construction and operation of the naval spent nuclear fuel storage facility would not be expected to affect the geologic character or resources of the region. During the storage facility construction phase, the ground would need to be excavated as necessary to prepare the surface. This would not affect the geological characteristics of the underlying layers. For the alternative of storing naval spent nuclear fuel in a storage pool facility, the ground surface would need to be excavated to a depth of approximately 40 feet. This excavation would not affect the geological characteristics of the area.

5.1.3.7 Air Resources

5.1.3.7.1 Radiological Consequences. No airborne radionuclide releases from normal operations are expected to occur as a result of the alternatives involving naval spent nuclear fuel being stored in dry storage containers. The fuel would be contained such that at least two barriers exist to prevent fission products from becoming airborne. These barriers would retain the spent nuclear fuel in an air-tight containment until moved to a permanent storage site and there would be no airborne radioactive material released from routine operations for this method of storage. The only radiation exposure would be direct radiation from the array of filled storage containers. The filled storage containers would be fenced off and shielded if necessary such that there would be no distinguishable effect on the current radiation readings at the site perimeter.

For the alternative where naval spent nuclear fuel would be stored in a water pool, airborne radionuclide releases are expected to be less than the emissions from the Idaho National Engineering Laboratory (INEL) Expended Core Facility (ECF) because the water pool size and number of inspections performed would be smaller at the shipyard and the shipyard would not conduct the shielded cell operations that are performed at ECF. To conservatively estimate the radiological consequences, airborne releases based on ECF releases from 1991 are used. The radiological source term used and the detailed calculations performed to determine expected normal releases are provided in Attachment F.

The radiation exposures to human beings due to estimated radionuclide releases to the atmosphere plus direct radiation from the stored spent nuclear fuel at the shipyards for both the alternative involving water pool storage and the alternative involving dry storage were calculated as described in Attachment F.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from the stored fuel. The population data used to calculate population exposures were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F. Estimated exposures to workers were also calculated.

The hypothetical exposures calculated are based on an exposure to the estimated average effluents and the direct radiation exposure for one year from the fuel stored at the shipyard. The calculations include the external effective equivalent exposure from the ground deposition, deposition to surface water, and air immersion pathways and the 50-year committed effective equivalent exposure from internal exposure through the ingestion and inhalation pathways. All pathways were considered for persons potentially exposed, except that the ingestion pathway was omitted for the workers because they do not grow their food on-site. Solubilities which would produce the highest calculated exposures were chosen for internal exposure factors. Values for human dietary consumption patterns were taken from "Age Dependent Values of Dietary Intake for Assessing Human

Exposures to Environmental Pollutants" (Rupp 1980). The hypothetical exposures calculated can be converted into a risk of fatal cancer or a risk of non-fatal health detriments (e.g., non-fatal cancers, hereditary defects) based on the "1990 Recommendations of the International Commission on Radiological Protection" (ICRP 1991).

Attachment F summarizes the calculated exposures and fatal cancers to the worker, maximally exposed off-site individual (MOI), nearest public access (NPA), and the population from releases of radioactivity and direct radiation exposure in one year for each location and storage mode. Section 3.7 provides a comparison of the annual number of fatal cancers calculated for the general population for each location and alternative.

The number of fatal cancers calculated is so small that there would be essentially no fatal cancers resulting from the storage of naval spent nuclear fuel during the time it could reasonably be expected to continue to be stored. Putting this into perspective, it could be stated that one member of the population might experience a fatal cancer due to incident-free storage of naval spent nuclear fuel at the Portsmouth Naval Shipyard if operations continued for 43,500 years.

If a water pool facility would be constructed at the Portsmouth Naval Shipyard and used for storage of naval spent nuclear fuel, the airborne emissions from the facility would be less than that identified for the Puget Sound Naval Shipyard because no naval spent nuclear fuel inspection operations beyond visual examination would be conducted in the water pool facility.

5.1.3.7.2 Non-radiological Consequences. As noted in Attachment F, no increase in non-radioactive airborne emissions would be expected to result from spent nuclear fuel storage facility operations. Storage facility operations would not involve use of carcinogenic toxins, criteria pollutants, or other hazardous or toxic chemicals except that small quantities of industrial cleaning agents and paint thinner may be used for housekeeping and cleanliness control and these would be the same as those already used at the shipyard. Consequently, there would be no impact on ambient air quality as a result of implementing any of the alternatives at the shipyard.

If an alternative were to be selected that required a storage facility to be constructed or renovated, fugitive dust emissions would be expected to result from excavation operations. The quantity of dust generated would be small, consistent with typical excavation activities, and controlled within local requirements for dust control.

5.1.3.8 Water Resources

5.1.3.8.1 Radiological Consequences. Spent nuclear fuel storage at the shipyard would not result in discharges of radioactivity to liquid effluents during routine operation regardless of the alternative selected for storage of spent nuclear fuel. The health effect due to fallout of nuclides released to the air onto the surface water is included in the analysis results discussed in Section 5.1.3.7. The air fallout impact is so small that there would be no distinguishable radiation levels in the water.

Portsmouth Naval Shipyard does not reside in the 100 or 500 year floodplain. Consequently, the floodplain would not be impacted by spent naval nuclear fuel storage and examination activities at the shipyard.

5.1.3.8.2 Non-radiological Consequences. Other than chemicals used to maintain the storage area, no hazardous wastes would be generated by the storage of naval spent nuclear fuel at Portsmouth Naval Shipyard. Any hazardous liquid effluents that may be generated at the storage area would be disposed of at an Environmental Protection Agency approved disposal site.

The only source for liquid discharges from the naval spent nuclear fuel storage operations to the environment consists of storm water runoff which would be consistent with the type of discharges associated with common light industrial facilities and related activities. It can be concluded that there would be no impact to the human environment due to runoff water from the proposed naval spent nuclear fuel storage area.

The increased water usage under any alternative would be negligible compared to the existing shipyard demand.

5.1.3.9 Ecological Resources

Both Maine and New Hampshire officials were consulted and have determined that there is no evidence to suggest that any threatened or endangered species reside on the Portsmouth Naval Shipyard (Appendix V.B. of the Navy's Natural Resources Management Plan (Navy 1993)). No major changes to the industrial environment are planned. None of the alternatives would affect the areas surrounding the shipyard. Therefore, no major ecological impacts to the region would result from selection of any of the alternatives.

The conceptual location where naval spent nuclear fuel would be stored is illustrated in Attachment D. This location is within an existing industrial complex and is surrounded by buildings and paved areas. The industrial nature of the shipyard and the fact that the land has already been disturbed from its natural state by earlier activities mean that plant or animal species sensitive to disturbance by human activities would not be expected to be present. Therefore, there would be no ecological impacts associated with construction or operation of a spent nuclear fuel storage area at this location. The radiological controls that are in effect at the shipyard ensure that the radiation levels in the vicinity of the shipyard are maintained at or near natural background. Since these same controls would be applied to spent nuclear fuel activities, no ecological effects due to radioactive material would be expected to occur.

5.1.3.10 Noise

Portsmouth Naval Shipyard is an existing industrial-type environment characterized by noise from truck and automobile traffic; ship loading cranes and related diesel-powered equipment; and continuously operating transmission lines for steam, fuel, water, and related pumping systems for those and other liquids. No ambient noise level increases are expected to occur as a result of any of the alternatives. Therefore, no noise impacts would be expected to occur.

5.1.3.11 Traffic and Transportation

Shipments of radioactive materials in the Naval Nuclear Propulsion Program are required to be made in accordance with applicable regulations of the U.S. Department of Transportation, U.S. Department of Energy, and the U.S. Nuclear Regulatory Commission. The purpose of these regulations is to ensure that shipments of radioactive material are adequately controlled to protect the environment and the health and safety of the general public. These regulations are applicable to all radioactive material shipments and provide requirements for the container design, certification, and identification as applicable for the specific quantity, type, and form of radioactive material being shipped. Naval shipping container design requirements invoke shielding and integrity specifications and meet all regulatory requirements. They provide for testing of container designs, training and qualification of workers who construct containers, and quality control inspections during fabrication to ensure that the containers will meet their design requirements. A detailed description of the shipping containers used for naval spent nuclear fuel shipments is provided in Attachment A. A description of the impacts associated with normal and accident conditions associated with transportation of naval spent nuclear fuel is provided in Attachment A.

5.1.3.11.1 Regional Infrastructure. The alternatives under consideration are described in Section 3. The No Action alternative or the first variation of the Decentralization alternative would store the spent nuclear fuel on-site. This alternative would reduce the number of rail shipments from the shipyard or prototype site compared to the past practice of transporting all spent nuclear fuel to INEL. The second variation of the Decentralization alternative would ship about 10 percent of the spent nuclear fuel to Puget Sound. This would have some transportation impact, but not as much as transporting all spent nuclear fuel off-site. The third Decentralization alternative ships all spent nuclear fuel to INEL, examines it, and returns it to the original shipyard or prototype site. This alternative involves more transportation than the previous practice of transporting spent nuclear fuel to INEL, since the spent nuclear fuel is not returned from INEL to the original site. The 1992/1993 Planning Basis alternative, the Regionalization at INEL alternative, or the Centralization at INEL alternative would involve the same transportation as has been required in the past, namely transportation to INEL and retention there. The Centralization alternative at the Hanford Site would result in more transportation impact than any of the previous alternatives, due to the distances and population distribution between Hanford and the shipyards and prototypes. The Centralization alternative at the Savannah River Site would result in the most transportation impact of spent nuclear fuel of any of the alternatives.

5.1.3.11.2 Site Infrastructure. The alternative associated with naval spent nuclear fuel storage at Portsmouth Naval Shipyard would not noticeably affect site highway traffic because any increase in the work force would represent a very small incremental increase in overall traffic to and from the shipyard. There would be no noticeable change in the internal traffic in the shipyard because fuel is held temporarily even when it is transported off-site.

5.1.3.12 Occupational and Public Health and Safety

Detailed analyses of incident-free spent nuclear fuel transportation and storage and handling impacts on worker and public health are described in Attachment A (transportation) and Attachment F (storage and inspection). The transportation analysis results, and the storage and handling analysis are summarized separately in the following subsections.

5.1.3.12.1 Incident-free Transportation Occupational and Public Health and Safety. The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.3.12.2 Incident-free Occupational and Public Health and Safety During Spent Nuclear Fuel Storage and Handling. The public health and safety impacts of radioactivity releases and direct radiation from storage of spent nuclear fuel were analyzed as discussed in Section 5.1.3.7 and Attachment F. Attachment F summarizes the results of the analysis of radioactivity releases and direct radiation from stored spent nuclear fuel. This analysis shows that the exposure to the worker, maximally exposed off-site individual, and nearest public access from stored naval spent nuclear fuel would result in far less than one fatality per year. For perspective, it could be stated that one member of these population groups might experience a fatal cancer due to storage of naval spent nuclear fuel at Portsmouth Naval Shipyard if operations continued for 43,500 years.

Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

No public or occupational radiological health and safety impacts would be expected to result from naval spent nuclear fuel storage area construction activities since the construction would not involve radioactive work.

Attachment F also discusses toxic chemical issues for spent nuclear fuel handling and storage. Attachment F concludes that there would be no additional types or volumes of chemicals required at the shipyards or prototype site for spent nuclear fuel storage. Therefore, there is no incident-free non-radiological impact resulting from storage of spent nuclear fuel at the shipyards or prototype site.

5.1.3.12.3 Incident-free Occupational and Public Health and Safety Effects on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the management of naval spent nuclear fuel at the Portsmouth Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the Portsmouth Naval Shipyard do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game since environmental monitoring in the vicinity of this relatively small and restricted site has shown no detectable difference in the amounts of radioactivity present in the environment from levels in similar parts of the region.

To place the impacts on environmental justice in perspective, the risk associated with routine naval spent nuclear fuel management operations under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.1.3.13 Utilities and Energy

If an alternative associated with the storage of naval spent nuclear fuel at Portsmouth Naval Shipyard were to be selected, construction and operation of the storage area would not be expected to require a large expenditure of utilities and energy resources. Construction activities will require quantities of water and electricity typical of any small to medium size construction project. Operation of the dry container naval spent nuclear fuel storage facility will likely require only a small amount of electricity for security lighting and to support industrial equipment necessary to move naval spent nuclear fuel (cranes, etc). Alternatives associated with water pool storage would require heating, ventilation, water, and electrical systems suitable for a work environment and to properly filter and exhaust the airborne discharges to the atmosphere. The utility and energy demands would be less than those required to operate ECF (10,000 MWh per year) (Section 5.2.13) since the water pool used for naval spent nuclear fuel storage would be smaller and no spent fuel operations beyond visual examinations would be conducted in the water pool.

The amount of utilities and energy expected to be consumed would be a small incremental increase in the total amount of utilities and energy used at the Portsmouth Naval Shipyard and will not result in any discernible environmental consequence.

5.1.3.14 Facility and Transportation Accidents

5.1.3.14.1 Facility Accidents. There has never been an accident in the history of the Naval Nuclear Propulsion Program that resulted in a significant release of radioactivity to the environment or that resulted in radiation exposure to workers in excess of abnormal occurrence limits on exposures as defined by the U.S. Nuclear Regulatory Commission. A description of potential accidents considered and a summary of the accident analyses that were conducted with regards to the storage of naval spent nuclear fuel are contained in Attachment F.

5.1.3.14.1.1 Radiological Accidents. Section 3.7.3 provides a summary of the impacts due to the most severe accidents considered for each site. The facility accident with the greatest potential impact at Portsmouth Naval Shipyard involves an airplane crash. An accident of this magnitude would result in 9 fatal cancers to the general population over 50 years, as described in Attachment F. The likelihood of an airplane crash is 1×10^{-7}. The facility accident with the greatest risk involves accidental drainage of the water pool. The drained water pool accident would result in less than one fatality over 50 years, but the likelihood of occurrence is 1×10^{-5}.

5.1.3.14.1.2 Non-radiological Accidents. As discussed in detail in Attachment F, the limiting hypothetical non-radiological accident for spent nuclear fuel storage in a water pool at a shipyard or prototype location would be a diesel fuel spill and fire. A catastrophic failure of a diesel fuel storage tank that might be used for an emergency diesel generator to provide backup electrical power was postulated to occur, resulting in the spilling of the entire quantity of diesel fuel with a subsequent fire. The fire would generate the following toxic chemicals:

- Carbon monoxide
- Oxides of nitrogen (90% nitric oxide and 10% nitrogen dioxide)
- Lead
- Sulfur dioxide.

Measures would be taken to reduce the health impacts of potential releases of toxic materials. These measures would involve controls to protect both workers and the general public. The naval shipyard and prototype sites have emergency planning, emergency preparedness, and emergency response programs in place to protect both workers and the public and involve established resources such as warning communications, fire departments, and emergency command centers.

The airborne concentrations of the combustion products listed above, resulting from the fire, were calculated at the locations of the on-site individuals, an individual at the site boundary, and the general population within a 50-mile radius of the facility. Detailed results are presented in Attachment F. If the accidental fire that has been hypothesized were to actually occur, the safety measures that would be in place would ensure no adverse health impacts to the general public and minimal health impacts to the workers.

5.1.3.14.2 Transportation Accidents. Shipments of radioactive materials associated with naval spent nuclear fuel have never resulted in any measurable release of radioactivity to the environment (NNPP 1994a). There have never been any significant accidents involving the release of radioactive material during shipment since the Naval Nuclear Propulsion Program began. The effects of potential transportation accidents during the various stages of transportation of naval spent nuclear fuel are presented in Attachment A.

The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.3.14.3 Other Impacts of Accidents. In addition to the possible human health effects associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives. The analyses described in Attachment F showed that an area ranging from about 8 acres extending approximately a quarter mile (for an inadvertent criticality accident) to about 110 acres extending approximately 0.9 mile (for a large airplane crashing into a dry storage container) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, the exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. Persons who live in this area might be evacuated or otherwise experience restrictions in their daily activities for a brief period, and those who work at locations within this area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure. It should be noted that all of the affected area within about a quarter mile from the spent nuclear fuel facility would be inside the boundaries of the federally owned site.

An accident might result in short-term restrictions on access to a relatively small area, but there would be no enduring impacts on cultural or similar resources, partially because the area would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area impacted would vary only slightly among the alternatives considered. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with any of the alternatives would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for all alternatives considered. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. There are no endangered or threatened species unique to the area surrounding the federally owned site, so an accident would not be expected to result in destruction of any species for any of the alternatives considered. The effects of accidents related to any of the alternatives and any associated cleanup which might be performed would be localized in a small area extending only a short distance beyond the boundaries of the federally owned site and thus would not be expected to appreciably affect the potential for survival of endangered or threatened species in southeastern Maine or New Hampshire. Based on these considerations, evaluation of impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.1.3.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the Portsmouth Naval Sbipyard would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is because the consequences of any accident would depend on the random conditions in effect at the time an accident occurred, and the wind directions at the Portsmouth Naval Shipyard are highly variable with no strongly dominant direction.

To place the impacts on environmental justice in perspective, the risk associated with accidents caused by naval spent nuclear fuel management under any of the alternatives considered would amount to less than one additional fatality per year for the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.1.3.15 Waste Management

The alternative in which naval spent nuclear fuel is stored at Portsmouth Naval Shipyard would produce limited amounts of solid municipal waste, solid low-level radioactive wastes, and hazardous wastes. In addition, no transuranic or high-level radioactive wastes would be generated by spent nuclear fuel activities at the site under any alternative. The quantity of industrial wastes generated would be small and most likely consist of industrial cleaning agents of the type normally encountered at the site. Small quantities of sanitary wastes would result from the additional work force but this volume would be small. The wastes produced from the storage of naval spent nuclear fuel would be controlled and minimized in accordance with the existing waste management programs at the Portsmouth Naval Shipyard. The amount of additional wastes generated would be minimal compared to the existing baseline and would not cause any adverse impacts to public health and safety and the environment in the vicinity of the Portsmouth Naval Shipyard.

5.1.3.16 Cumulative Impacts

5.1.3.16.1 Radiological Cumulative Impacts. Spent nuclear fuel storage at the site would not result in discharges of radioactivity in liquid effluents during routine operations regardless of the alternative selected. Therefore, there would be no incremental addition of radioactivity to surface or ground water as a result of normal operations for any alternative. For alternatives involving the storage of spent nuclear fuel in dry storage and shipping containers, no airborne radioactivity emissions are expected, so there would be no cumulative air quality impacts associated with these storage methods. Consequently, the only radiological cumulative impacts that would result from dry storage alternatives would be due to direct radiation exposure from the stored containers of spent nuclear fuel.

For alternatives involving the storage of naval spent nuclear fuel in water pools, there would be no discernible direct radiation exposure to the public from the fuel elements due to the shielding provided by the water in the pool. Therefore, any cumulative impacts which would result from water pool storage would be primarily due to airborne emissions, and the addition of these emissions would cause an indiscernible change in the emissions in the area (see Section 5.1.3.7). Current operations at the site are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

A summary of the cumulative radiological impacts is provided in the following section.

An overview of the historical radiological impacts from naval nuclear operations at the Portsmouth Naval Shipyard and from transportation of naval spent nuclear fuel is provided in Section 4.1.3.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The radiological impacts associated with the alternatives where naval spent nuclear fuel would be stored at Portsmouth Naval Shipyard are very small and are described in Section 5.1.3.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the population in the vicinity of the Portsmouth Naval Shipyard from all of the alternatives considered would be approximately 1.8 person-rem. This means that there would be much less than one fatal cancer from these operations over the entire 40-year period evaluated. The total exposure to a theoretical maximally exposed off-site individual living at the shipyard boundary for the entire 40-year period would be 2.2×10^{-3} rem due to the alternative resulting in the largest exposure. This maximally exposed off-site individual would have a 1.1×10^{-6} risk of contracting a fatal cancer during his or her lifetime due to storage of spent nuclear fuel. When existing site radiological impacts due to naval nuclear operations are added to the impacts of the most limiting spent nuclear fuel alternative, the exposure to the population would be 2.2 person-rem and to the maximally exposed off-site individual would be 2.5×10^{-3} rem. This still results in much less than one fatal cancer in the population and the risk of the maximally exposed off-site individual contracting a fatal cancer during his or her lifetime is 1.3×10^{-6}.

The total exposure related to naval spent nuclear fuel activities to a worker assumed to be working continually 100 meters from the spent nuclear fuel under the alternative resulting in the largest exposure is 0.11 rem accumulated over 40 years. That corresponds to a fatal cancer risk of 4.4×10^{-5} during the worker's lifetime. The exposure to the same worker when existing site radiological impacts due to naval nuclear operations are added to the spent nuclear fuel exposure is essentially the same over 40 years. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

Sections 4.1.3.14 and 5.1.3.15 describe the management of low-level radioactive waste and mixed waste at the site. The volume of low-level radioactive wastes which would be generated under the alternatives has not been calculated. However, considering the nature of radiological work that would be associated with spent nuclear fuel storage activities, the amount of low-level radioactive waste produced during spent nuclear fuel activities would be much less than 20 percent of the current site generation rate (57 m^3 per year). This additional radioactive waste would not introduce any changes to the site's waste management practices. The small amount of additional material involved would not impose any discernible additional stress on the capacity of the radioactive waste burial ground. Therefore, any cumulative impacts associated with the generation and disposal of additional low-level wastes would be very small.

Since no mixed, transuranic, or high-level radioactive wastes would be generated by spent nuclear fuel activities at this site under any alternative, there would be no cumulative impacts associated with these materials.

5.1.3.16.2 Non-radiological Cumulative Impacts. An overview of the historical non-radiological impacts from naval nuclear operations at the Portsmouth Naval Shipyard and from transportation of naval spent nuclear fuel is provided in Section 4.1.3.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no non-radiological cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The non-radiological impacts associated with the alternative where naval spent nuclear fuel would be inspected or stored at Portsmouth Naval Shipyard are described in Section 5.1.3.12, with the detailed results of analyses provided in Attachment F. As summarized in Section 5.1.3.12, there would be no additional chemicals required at the shipyard for naval spent nuclear fuel storage and therefore no non-radiological impacts from normal operations. Consequently, no cumulative impacts to air quality or water resources would result since the incremental addition of chemicals at the shipyard that might result from naval spent fuel activities would be very small. There are no current environmental problems associated with these materials.

The non-radiological cumulative transportation impacts for the population from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A. The non-radiological impacts associated with the transportation and storage of naval spent nuclear fuel for all of the alternatives considered would be low.

No cumulative land use impacts would be expected to occur as a result of spent nuclear fuel storage. The land that would be dedicated for this purpose is on existing federal property and situated in an industrial setting which has already been disturbed from its natural state (approximately 227 acres are developed land). The conversion of this space for storage of spent nuclear fuel would not result in the need to disturb undeveloped land or for additional land to be added to the federally owned property in the foreseeable future.

From a socioeconomic perspective, the introduction of naval spent nuclear fuel activities at the site would create a small number of additional jobs and could have a very small cumulative socioeconomic impact. The site currently employs approximately 4900 civilian personnel. No shipyard employment has been associated with spent nuclear fuel activities in the past since spent nuclear fuel activities have not been conducted at the site. An average of approximately 1 to 35 additional jobs might be added as a result of possible spent nuclear fuel activities in the future. The peak number of additional jobs created at the site in any given year would be approximately 89, which is associated with construction and operation of a water pool facility for storage of spent nuclear fuel. Considering that the regional labor force consists of approximately 121,550 workers, the additional number of added jobs under any alternative would have little or no discernible socioeconomic impact. These jobs would be filled either from within the existing site work force or from the available regional labor force without discernible effect. There are no foreseeable future projects planned at the site and no known projects planned in the region that would cause the small number of workers involved in naval spent nuclear fuel activities to become an important impact.

The cumulative impacts associated with non-radiological waste management are likewise expected to be small. As stated previously, any industrial wastes generated from naval spent nuclear fuel storage would be small and limited to industrial cleaning agents of the type normally encountered at the site. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of additional non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of waste.

5.1.3.17 Unavoidable Adverse Effects

There are no discernible unavoidable adverse effects associated with the implementation of any of the alternatives and none which would help to choose among the alternatives. The alternative in which naval spent nuclear fuel is stored at the Portsmouth Naval Shipyard would cause the public to be exposed to small amounts of radiation, described in Section 5.1.3.12, and would result in less than one health effect in the entire population surrounding the shipyard. Similarly, continued operation of the storage facility would produce limited amounts of solid municipal waste and solid low-level radioactive waste. These amounts of waste would not produce any major impacts in the vicinity of the shipyard. There will be no changes to the ecological, cultural, geological, and aesthetic resources due to the implementation of any of the alternatives. There will also be no impact on ambient noise levels.

5.1.3.18 Irreversible and Irretrievable Commitments of Resources

The only irreversible and irretrievable commitment of resources that results from the alternative in which naval spent nuclear fuel would be stored at the Portsmouth Naval Shipyard would be the money which would be spent by the federal government to construct the necessary facilities. The total cost of storing spent naval nuclear fuel at the shipyards and prototype ranges from approximately $1.5 billion to $5.7 billion. This cost represents the total cumulative cost over the 40-year period for all of the shipyards and prototype. This cost includes construction costs of the new storage facilities, and, depending on the alternative selected, the operation of a limited examination facility at Puget Sound Naval Shipyard combined with the costs associated with shutting down ECF, or the operational costs of the INEL-ECF. The major expense in the highest cost alternatives is the procurement of shipping containers. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

5.1.4 PEARL HARBOR NAVAL SHIPYARD: PEARL HARBOR, HAWAII

5.1.4.1 Overview of Environmental Impacts

The following sections discuss the major differences in potential environmental consequences associated with the choice of alternatives that include storage of naval spent nuclear fuel at Pearl Harbor Naval Shipyard (hereafter referred to as Pearl Harbor). The environmental consequences associated with storage of naval spent nuclear fuel at Pearl Harbor are based on the estimates of naval spent nuclear fuel that will be stored at Pearl Harbor through the year 2035 and the current knowledge of the design features associated with spent fuel storage systems. The review of the environmental consequences associated with these alternatives has shown that the impact on the environment at Pearl Harbor associated with all activities is very small. There would be no impact to the environment in the vicinity of Pearl Harbor associated with any alternatives that do not involve Pearl Harbor.

5.1.4.2 Land Use

Construction of a storage area at Pearl Harbor for temporary naval spent nuclear fuel storage would require a modest change in the current land in use by the shipyard. A description of the alternate storage containers and water pools and their approximate storage locations is provided in Attachment D. Attachment C provides a comparison of naval spent nuclear fuel storage in water pools versus dry container storage. The area is already an industrial site; therefore, there will be no impact on land use.

The alternative of storing naval spent nuclear fuel in water pools would require that a water pool facility be constructed in the vicinity of the area that is designated for dry container storage. The water pool would have sufficient capacity to accommodate storage of all naval spent nuclear fuel expected to be stored at the shipyard.

No additional land use outside the shipyard would be required.

Native Hawaiian rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.1.4.3 Socioeconomics

The calculated number of direct construction and operating jobs that would be required for the 10-year period between 1995 and 2004 for each storage alternative at the shipyard is provided in Table 5.1.4-1. Since there would be no naval spent nuclear fuel storage or inspection activities at the shipyard under the 1992/1993 Planning Basis and Centralization alternatives, no additional jobs would be required at the shipyard under these alternatives.

Table 5.1.4-1. Number of construction and operating jobs created at Pearl Harbor Naval Shipyard for each alternative.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Railcar(1)	1	1	6	1	1	1	1	1	1	1
Immobile Containers on Pads(2)	1	1	1	1	2	6(3)	4	4	4	4
Shipping Containers on Pads (2)	1	1	1	1	2	6(3)	1	1	1	1
Water Pools(2)	16	16	46	71	88	62	77	35	35	35

(1) Storage mode under the No Action and Decentralization alternatives.
(2) Storage mode under the Decentralization alternative.
(3) The construction jobs would last less than one year.

The only discernible socioeconomic consequence from the alternative of storing naval spent nuclear fuel at Pearl Harbor is that a relatively small number of construction workers (ranging from a few to a maximum of several hundred would be required for construction of the storage area). The work force would consist of skilled craftsmen and unskilled laborers. This work force would be needed during the storage facility construction and would be provided from within the area.

The operation of the naval spent nuclear fuel storage area using dry storage containers would require additional workers to secure the fuel in the storage area and to support surveillance and monitoring activities. For the alternative involving storing fuel in immobile dry storage containers, about 20 workers would be required to handle the naval spent nuclear fuel when it is placed into the storage containers. This work force would normally only be needed when fuel is being inserted into the containers. For the alternative involving shipping containers, fewer workers would be needed to handle and secure the containers in the storage area. The operation of a water pool facility for the alternative involving storing naval spent nuclear fuel in a water pool would require approximately 40 additional workers. The number required for any of the shipyard and prototype site storage alternatives would be small and would be expected to be supplied from either within the existing shipyard work force or the local work force. Considering that the Department of Defense employs approximately 10,900 civilians at the Pearl Harbor naval base, the addition of workers to support the alternatives would have no discernible impact on the local socioeconomic conditions of the Pearl Harbor site.

For the alternatives where dry storage containers would be manufactured, some additional jobs would be created in the locations where the containers are made. The process of selecting the container manufacturer is subject to federal procurement requirements and would be initiated after the Record of Decision. Consequently, the specific socioeconomic impacts from container fabrication cannot be specified. The net effect of container fabrication would be to create additional jobs and bolster the local economy of the area(s) where containers are made. It is considered unlikely that the selection of the contractor would depend on the alternative storage site selected, so the jobs associated with construction of casks provide no basis for selection of a storage site.

5.1.4.4 Cultural Resources

The action considered will not affect any site that is listed on the National Register of Historic Places (NPS 1991), any known archaeological areas, or any other cultural resources. Therefore, there would be no impacts to cultural resources associated with the alternative of storing naval spent nuclear fuel at this location.

None of the alternatives considered would impact known archaeological or Native Hawaiian sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.1.4.5 Aesthetic and Scenic Resources

The naval spent nuclear fuel storage area would be located within the Pearl Harbor site which is an existing industrial setting and would not affect the visual quality of the area since it is compatible with the landscape character of the site. Physical changes to the Pearl Harbor site resulting from storage area construction will not alter this setting. There are no particulate air emissions associated with storage of naval spent nuclear fuel and thus no visibility impacts are expected. No aesthetic or scenic resources in the vicinity of the shipyard would be affected by the construction and operation of the storage facility.

5.1.4.6 Geology

The construction and operation of the naval spent nuclear fuel storage facility at Pearl Harbor is not expected to affect the geologic character or resources of the region. If an alternative were selected which required a storage area to be constructed, the ground surface would be excavated as necessary to prepare the surface. This would not affect the geological characteristics of the underlying layers nor the characteristics of the Koolou and Wainae aquifers or vadose zone. For the alternative of storing fuel in a water pool facility, the ground surface would need to be excavated to a depth of approximately 40 feet. This excavation would not affect the geological characteristics of the area.

5.1.4.7 Air Resources

5.1.4.7.1 Radiological Consequences. No airborne radionuclide releases from normal operations are expected to occur as a result of naval spent nuclear fuel being stored in dry storage containers. The fuel would be contained such that at least two barriers exist to prevent fission products from becoming airborne. These barriers would retain the naval spent nuclear fuel in an air-tight containment until it is moved to a permanent storage site and there would be no airborne radioactive material released from routine operations for this method of storage. The only radiation exposure would be direct radiation from the array of filled storage containers. The filled storage containers would be fenced off and shielded if necessary such that there would be no distinguishable effect on normal background radiation levels at the site perimeter.

For the alternative where naval spent nuclear fuel would be stored in a water pool, airborne radionuclide releases are expected to be less than the emissions from the Idaho National Engineering Laboratory (INEL) Expended Core Facility (ECF) because the water pool size would be smaller, no naval spent nuclear fuel inspection operations beyond visual examinations would be conducted, and no shielded cell operations would be conducted at Pearl Harbor. To conservatively estimate the radiological consequences, airborne releases based on ECF releases from 1991 are used. The radiological source term used and the detailed calculations performed to determine expected normal releases are provided in Attachment F.

The radiation exposures to human beings due to estimated radionuclide releases to the atmosphere plus direct radiation from the stored naval spent nuclear fuel at the shipyards for both the alternative involving water pool storage and the alternative involving dry storage were calculated as described in Attachment F.

A person on the shipyard boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from the stored naval spent nuclear fuel. The population data used to calculate population exposures were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F. Estimated exposures to workers were also calculated.

The hypothetical exposures calculated are based on an exposure to the estimated average effluents and the direct radiation exposure for one year from the naval spent nuclear fuel stored at the shipyard. The calculations include the external effective equivalent exposure from the ground deposition, deposition to surface water, and air immersion pathways and the 50-year committed effective equivalent exposure from internal exposure through the ingestion and inhalation pathways. All pathways were considered for persons potentially exposed, except that the ingestion pathway was omitted for the workers because they do not grow their food on-site. Solubilities which would produce the highest calculated exposures were chosen for internal exposure factors. Values for human dietary consumption patterns were taken from "Age Dependent Values of Dietary Intake for Assessing Human Exposures to Environmental Pollutants" (Rupp 1980). The hypothetical exposures calculated can be converted into a risk of fatal cancer or a risk of non-fatal health detriments (e.g., non-fatal cancers, hereditary defects) based on recommendations of the International Commission on Radiological Protection (ICRP 1991).

Attachment F summarizes the calculated exposures and fatal cancers to the worker, the maximally exposed off-site individual (MOI), nearest public access (NPA), and the population from releases of radioactivity and direct radiation exposure in one year for each location and storage mode. Section 3.7 provides a comparison of the annual number of fatal cancers calculated for the general population for each location and alternative.

The number of fatal cancers calculated is so small that there would be essentially no fatal cancers resulting from the storage of naval spent nuclear fuel during the time it could reasonably be expected to continue to be stored. Putting this into perspective, it could be stated that one member of the population might experience a fatal cancer due to incident-free storage of naval spent nuclear fuel at Pearl Harbor if operations continued for 14,300 years.

5.1.4.7.2 Non-radiological Consequences. As noted in Attachment F, no increase in non-radioactive airborne emissions would be expected to result from naval spent nuclear fuel storage facility operations. Storage facility operations would not involve use of carcinogenic toxins, criteria pollutants, or other hazardous or toxic chemicals except that small quantities of industrial cleaning agents and paint thinner may be used for housekeeping and cleanliness control and these would be the same as those already used at the shipyard. Consequently, there would be no impact on ambient air quality as a result of implementing any of the alternatives at the shipyard.

If an alternative were to be selected that required a storage facility to be constructed or renovated, fugitive dust emissions would be expected to result from excavation operations. The quantity of dust generated would be small, consistent with typical excavation activities, and controlled within local requirements for dust control.

5.1.4.8 Water Resources

5.1.4.8.1 Radiological Consequences. Naval spent nuclear fuel storage operations at Pearl Harbor would not result in discharges of radioactivity in liquid effluents during routine operation regardless of the alternative selected for storage of naval spent nuclear fuel. The health effect due to fallout of nuclides released to the air onto the surface water is included in the analysis results discussed in Section 5.1.4.7. The air fallout impact is so small that there would be no distinguishable radiation levels in the water.

Based on FIRM and topographical maps of areas approximately three miles away, the location considered for the interim storage of naval spent nuclear fuel is in the 100-year floodplain. However, the location considered for naval spent nuclear fuel is not in a high-hazard area (as defined by Title 10, Part 1022 of The Code of Federal Regulations for floodplains) which is an area where frequent flooding occurs. Since the majority of the shipyard is already developed and covered with impervious material, construction and operation of a naval spent nuclear fuel storage facility at the shipyard would produce no discernible impacts on the floodplain.

Flooding in the area where shipping and immobile dry storage containers are stored would not result in any adverse environmental consequences. These containers are completely sealed such that no radioactivity would be released from the interior even if they were completely submerged. In addition, the massive nature of these containers prevents them from floating or moving during a flood.

Since the shipyard resides in close proximity to a floodplain, the design of the facility and equipment would minimize the potential for flooding and damage to the facility. However, in the event a water pool facility would be flooded, the exchange of pool water with the flood waters could occur. As discussed in Attachment F, Section F.1.4.2.1.6.2, the radioactivity concentration in the ECF water pool is below the Nuclear Regulatory Commission limits specified in Title 10, Part 20 of The Code of Federal Regulations for liquid effluent except for Co-60 which is slightly higher (water pools used for storage or examination of naval spent nuclear fuel would be maintained to comparable concentrations). Any release of radioactivity would have to result from the exchange of floodwater with the pool water. This exchange would reduce the level of radioactivity even further.

Consequently, no adverse environmental impacts would result from flooding of water pools at naval spent nuclear fuel storage sites.

5.1.4.8.2 Non-radiological Consequences. Other than chemicals used to maintain the storage area, no hazardous wastes would be generated by the storage of naval spent nuclear fuel at Pearl Harbor. Any hazardous liquid effluents that may be generated at the storage area would be disposed of at an Environmental Protection Agency approved disposal site.

The only source for liquid discharges from the naval spent nuclear fuel storage operations to the environment consists of storm water runoff which would be consistent with the type of discharges associated with common light industrial facilities and related activities. It can be concluded that there would be no impact to the human environment due to runoff water from the naval spent nuclear fuel storage area.

The increased water usage under any of the alternatives would be negligible compared to the existing shipyard demand.

5.1.4.9 Ecological Resources

There are no threatened or endangered species known to exist within the Pearl Harbor shipyard and no major changes to the industrial environment are planned. Therefore, no major ecological impacts to the region would result from selection of any of the alternatives.

The conceptual location where naval spent nuclear fuel would be stored is illustrated in Attachment D. This location is within an existing industrial complex and is surrounded by buildings and paved areas. The industrial nature of the shipyard and the fact that the land has already been disturbed from its natural state by earlier activities mean that plant or animal species sensitive to disturbance by human activities would not be expected to be present. Therefore, there would be no ecological impacts associated with construction or operation of a spent nuclear fuel storage area at this location. The radiological controls that are in effect at the shipyard ensure that the radiation levels in the vicinity of the shipyard are maintained at or near natural background. Since these same controls would be applied to spent nuclear fuel activities, no ecological effects due to radioactive material would be expected to occur.

5.1.4.10 Noise

Pearl Harbor is an existing industrial-type environment characterized by noise from truck and automobile traffic; ship loading cranes and related diesel-powered equipment; and continuously operating transmission lines for steam, fuel, water, and related pumping systems for those and other liquids. No ambient noise level increases are expected to occur as a result of any of the alternatives. Therefore, no noise impacts would be expected to occur.

5.1.4.11 Traffic and Transportation

Shipments of radioactive materials in the Naval Nuclear Propulsion Program are required to be made in accordance with applicable regulations of the U.S. Department of Transportation, U.S. Department of Energy, and the U.S. Nuclear Regulatory Commission. The purpose of these regulations is to ensure that shipments of radioactive material are adequately controlled to protect the environment and the health and safety of the general public. These regulations are applicable to all radioactive material shipments and provide requirements for the container design, certification, and identification as applicable for the specific quantity, type, and form of radioactive material being shipped. Naval shipping container design requirements invoke shielding and integrity specifications and meet all regulatory requirements. They provide for testing of container designs, training and qualification of workers who construct containers, and quality control inspections during fabrication to ensure that the containers will meet their design requirements. A detailed description of the shipping containers used for naval spent nuclear fuel shipments is provided in Attachment A. A description of the impacts from normal and accident conditions associated with transportation of naval spent nuclear fuel is provided in Attachment A.

5.1.4.11.1 Regional Infrastructure. The alternatives under consideration are described in Section 3. The No Action alternative or the first variation of the Decentralization alternative would store the naval spent nuclear fuel on-site. This alternative would reduce the number of rail shipments from the shipyard or prototype site compared to the past practice of transporting all naval spent nuclear fuel to INEL. The second variation of the Decentralization alternative would ship about 10 percent of the naval spent nuclear fuel to Puget Sound. This would have some transportation impact, but not as much as transporting all naval spent nuclear fuel off-site. The third Decentralization alternative ships all naval spent nuclear fuel to INEL, examines it, and returns it to the original shipyard or prototype

site. This alternative involves more transportation than the previous practice of transporting naval spent nuclear fuel to INEL, since the naval spent nuclear fuel is not returned from INEL to the original site. The 1992/1993 Planning Basis alternative, the Regionalization at INEL alternative, or the Centralization at INEL alternative would involve the same transportation as has been required in the past, namely transportation to INEL and retention there. The Centralization alternative at the Hanford Site would result in more transportation impact than any of the previous alternatives, due to the distances and population distribution between Hanford and the shipyards and prototypes. The Centralization alternative at the Savannah River Site would result in the most transportation impact of naval spent nuclear fuel of any of the alternatives.

5.1.4.11.2 Site Infrastructure. The alternative associated with naval spent nuclear fuel storage at Pearl Harbor would not affect local highway traffic because any increase in the work force would represent a very small incremental increase in overall traffic to and from the shipyard. There would be no change in the internal traffic in the shipyard because naval spent nuclear fuel is held temporarily even when it is transported off-site.

5.1.4.12 Occupational and Public Health and Safety

Detailed analyses of incident-free naval spent nuclear fuel transportation and storage and handling impacts on worker and public health are described in Attachment A (transportation) and Attachment F (storage and inspection). The transportation analysis results, and the storage and handling analysis are summarized separately in the following subsections.

5.1.4.12.1 Incident-free Transportation Occupational and Public Health and Safety. The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.4.12.2 Incident-free Occupational and Public Health and Safety During Naval Spent Nuclear Fuel Storage and Handling. The public health and safety impacts of radioactivity releases and direct radiation from storage of naval spent nuclear fuel were analyzed as discussed in Section 5.1.4.7 and Attachment F. Attachment F summarizes the results of the analysis of radioactivity releases and direct radiation from stored naval spent nuclear fuel. This analysis shows that the exposure to the worker, maximally exposed off-site individual, and nearest public access from stored naval spent nuclear fuel would result in far less than one fatality per year. For perspective, it could be stated that one member of these population groups might experience a fatal cancer due to storage of naval spent nuclear fuel at Pearl Harbor if operations continued for 14,300 years.

Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

No public or occupational radiological health and safety impacts would be expected to result from naval spent nuclear fuel storage area construction activities since the construction would not involve radioactive work.

Attachment F also discusses toxic chemical issues for naval spent nuclear fuel handling and storage. Attachment F concludes that there would be no additional types or volumes of chemicals required at the shipyards or prototype site for naval spent nuclear fuel storage. Therefore, there is no incident-free non-radiological impact resulting from storage of naval spent nuclear fuel at the shipyards or prototype site.

5.1.4.12.3 Incident-free Occupational and Public Health and Safety Effects on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the management of naval spent nuclear fuel at the Pearl Harbor Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred. The wind directions at Pearl Harbor are variable, but the wind direction which occurs most frequently is toward the southwest, away from land and residential areas. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game since environmental monitoring in the vicinity of this relatively small and restricted site has shown no detectable difference in the amounts of radioactivity present in the environment from levels in similar parts of the region.

To place the impacts on environmental justice in perspective, the risk associated with routine naval spent nuclear fuel management operations under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.1.4.13 Utilities and Energy

If an alternative associated with the storage of naval spent nuclear fuel at Pearl Harbor were to be selected, construction and operation of the storage area would not be expected to require a large expenditure of utilities and energy resources. Construction activities would require quantities of water and electricity typical of any small to medium size construction project. Operation of the storage facility would likely require only small amounts of electricity for lighting and to support industrial equipment necessary to move spent nuclear fuel (e.g., cranes). Alternatives associated with water pool storage would require heating, ventilation, water, and electrical systems suitable for a work environment and to properly filter and exhaust the airborne discharges to the atmosphere. The utility and energy demands would be less than those required to operate ECF (10,000 MWh per year) (Section 5.2.13) since the water pool used for spent fuel storage would be smaller and no spent fuel operations beyond visual examinations would be conducted in the water pool.

The amount of utilities and energy expected to be consumed would be a small incremental increase in the total amount of utilities and energy used at the shipyard and would not result in any discernible environmental consequence.

5.1.4.14 Facility and Transportation Accidents

5.1.4.14.1 Facility Accidents. There has never been an accident in the history of the Naval Nuclear Propulsion Program that resulted in a significant release of radioactivity to the environment or that resulted in radiation exposure to workers in excess of abnormal occurrence limits on exposures as defined by the U.S. Nuclear Regulatory Commission. A description of potential accidents considered and a summary of the accident analyses that were conducted with regards to the storage of naval spent nuclear fuel is contained in Attachment F.

5.1.4.14.1.1 Radiological Accidents. Section 3.7.3 provides a summary of the impacts due to the most severe accidents considered for each site. The facility accident with the greatest potential impact at Pearl Harbor involves an airplane crash. An accident of this magnitude would result in a calculated 26 fatal cancers to the general population over 50 years, as described in Attachment F. The likelihood of such an accident occurring is 1×10^{-5}, which is very small. For perspective, an accident such as this would not be expected to occur unless the facility operated for about 100,000 years.

5.1.4.14.1.2 Non-radiological Accidents. As discussed in detail in Attachment F, the limiting hypothetical non-radiological accident for naval spent nuclear fuel storage in a water pool at a shipyard or prototype location would be a diesel fuel spill and fire. A catastrophic failure of a diesel fuel storage tank that might be used for an emergency diesel generator to provide backup electrical power was postulated to occur, resulting in the spilling of the entire quantity of diesel fuel with a subsequent fire. The fire would generate the following toxic chemicals:

- Carbon monoxide
- Oxides of nitrogen (90% nitric oxide and 10% nitrogen dioxide)
- Lead
- Sulfur dioxide.

Measures would be taken to reduce the health impacts of potential releases of toxic materials. These measures would involve controls to protect both workers and the general public. The naval shipyard and prototype sites have emergency planning, emergency preparedness, and emergency response programs in place to protect both workers and the public, and involve established resources such as warning communications, fire departments, and emergency command centers.

The airborne concentrations of the combustion products listed above, resulting from the fire, were calculated at the locations of the on-site individuals, an individual at the site boundary, and the general population within a 50-mile radius of the facility. Detailed results are presented in Attachment F. If the accidental fire that has been hypothesized were to actually occur, the safety measures that would be in place would ensure no adverse health impacts to the general public and minimal health impacts to the workers.

5.1.4.14.2 Transportation Accidents. Shipments of radioactive materials associated with naval spent nuclear fuel have never resulted in any measurable release of radioactivity to the environment (NNPP 1994a). There have never been any significant accidents involving release of radioactive material during shipment since the Naval Nuclear Propulsion Program began. The effects of potential transportation accidents during the various stages of transportation of naval spent nuclear fuel are presented in Attachment A.

The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.4.14.3 Other Impacts of Accidents. In addition to the possible human health effects associated with facility or transportation accidents described in the preceding sections, other effects

such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives. The analyses described in Attachment F showed that an area ranging from about 8 acres extending approximately a quarter mile (for an inadvertent criticality accident) to about 110 acres extending approximately 0.9 mile (for a large airplane crashing into a dry storage container) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, the exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. Persons who live in this area might be evacuated or otherwise experience restrictions in their daily activities for a brief period, and those who work at locations within this area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure. It should be noted that all of the affected area within about three-quarters of a mile from the spent nuclear fuel facility would be within the boundaries of the federally owned site.

An accident might result in short-term restrictions on access to a relatively small area, but there would be no enduring impacts on cultural or similar resources or concerns such as Native Hawaiian rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area impacted would vary only slightly among the alternatives considered. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with any of the alternatives would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for all alternatives considered. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. There are no endangered or threatened species unique to the area surrounding the federally owned site, so an accident would not be expected to result in destruction of any species for any of the alternatives considered. The effects of accidents related to any of the alternatives and any associated cleanup which might be performed would be localized in a small area extending only a short distance beyond the boundaries of the federally owned site and thus would not be expected to appreciably affect the potential for survival of any endangered or threatened species which might occupy wetlands or other habitat in the area. Based on these considerations, evaluation of impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.1.4.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the Pearl Harbor Naval Shipyard would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is because the consequences of any accident would depend on the random conditions in effect at the time an accident occurred. The wind directions at Pearl Harbor are variable, but the wind direction which occurs most frequently is toward the southwest, away from land and residential areas.

To place the impacts on environmental justice in perspective, the risk associated with accidents caused by naval spent nuclear fuel management under any of the alternatives considered would amount to less than one additional fatality per year in the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.1.4.15 Waste Management

The alternative in which naval spent nuclear fuel is stored at Pearl Harbor would produce limited amounts of solid municipal waste, solid low-level radioactive wastes, and hazardous wastes. In addition, no transuranic or high-level radioactive wastes would be generated by spent nuclear fuel activities at the site under any alternative. The quantity of industrial wastes generated would be small and most likely consist of industrial cleaning agents of the type normally encountered at the site. Small quantities of sanitary wastes would result from the additional work force but this volume would be small. The wastes produced from the storage of naval spent nuclear fuel would be controlled and minimized in accordance with the existing waste management programs at Pearl Harbor. The amount of additional wastes generated would be minimal compared to the existing baseline and would not cause any adverse impacts to public health and safety and the environment in the vicinity of Pearl Harbor.

5.1.4.16 Cumulative Impacts

5.1.4.16.1 Radiological Cumulative Impacts. Spent nuclear fuel storage at the site would not result in discharges of radioactivity in liquid effluents during routine operations regardless of the alternative selected. Therefore, there would be no incremental addition of radioactivity to surface or ground water as a result of normal operations for any alternative. For alternatives involving the storage of spent nuclear fuel in dry storage and shipping containers, no airborne radioactivity emissions are expected, so there would be no cumulative air quality impacts associated with these storage methods. Consequently, the only radiological cumulative impacts that would result from dry storage alternatives would be due to direct radiation exposure from the stored containers of spent nuclear fuel.

For alternatives involving the storage of naval spent nuclear fuel in water pools, there would be no discernible direct radiation exposure to the public from the fuel elements due to the shielding provided by the water in the pool. Therefore, any cumulative impacts which would result from water pool storage would be primarily due to airborne emissions, and the addition of these emissions would cause an indiscernible change in the emissions in the area (see Section 5.1.4.7). Current operations at the site are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

A summary of the cumulative radiological impacts is provided in the following section.

An overview of the historical radiological impacts from naval nuclear operations at Pearl Harbor and from transportation of naval spent nuclear fuel is provided in Section 4.1.4.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The radiological impacts associated with the alternative where naval spent nuclear fuel would be stored at Pearl Harbor are very small and are described in Section 5.1.4.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the population in the vicinity of Pearl Harbor from all of the alternatives considered would be approximately 5.6 person-rem. This means that there would be much less than one fatal cancer from these operations over the entire 40-year period evaluated. The total exposure to a theoretical maximally exposed off-site individual living at the shipyard boundary for the entire 40-year period would be 8.0×10^{-4} rem due to the alternative resulting in the largest exposure. This maximally exposed off-site individual would have a 4.0×10^{-7} risk of contracting a fatal cancer during his or her lifetime due to storage of spent nuclear fuel. When existing site radiological impacts due to naval nuclear operations are added to the impacts of the most limiting spent nuclear fuel alternative, the exposure to the population would be 6.8 person-rem and to the maximally exposed off-site individual would be 9.2×10^{-4} rem. This still results in much less than one fatal cancer in the population and the risk of the maximally exposed off-site individual contracting a fatal cancer during his or her lifetime is 4.6×10^{-7}.

The total exposure related to naval spent nuclear fuel activities to a worker assumed to be working continually 100 meters from the spent nuclear fuel under the alternative resulting in the largest exposure is 8.4×10^{-2} rem accumulated over 40 years. That corresponds to a fatal cancer risk of 3.4×10^{-5} during the worker's lifetime. The exposure to the same worker when existing site radiological impacts due to naval nuclear operations are added to the spent nuclear fuel exposure is essentially the same. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

Sections 4.1.4.14 and 5.1.4.15 describe the management of low-level radioactive waste and mixed waste at the site. The volume of low-level radioactive wastes which would be generated under the alternatives has not been calculated. However, considering the nature of radiological work that would be associated with spent nuclear fuel storage activities, the amount of low-level radioactive waste produced during spent nuclear fuel activities would be much less than 20 percent of the current site generation rate (84 m^3 per year). This additional radioactive waste would not introduce any changes to the site's waste management practices. The small amount of additional material involved would not impose any discernible additional stress on the capacity of the radioactive waste burial ground. Therefore, any cumulative impacts associated with the generation and disposal of additional low-level wastes would be very small.

Since no mixed, transuranic, or high-level radioactive wastes would be generated by spent nuclear fuel activities at this site under any alternative, there would be no cumulative impacts associated with these materials.

5.1.4.16.2 Non-radiological Cumulative Impacts. An overview of the historical non-radiological impacts from naval nuclear operations at Pearl Harbor and from transportation of naval spent nuclear fuel is provided in Section 4.1.4.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no non-radiological cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The non-radiological impacts associated with the alternative where naval spent nuclear fuel would be inspected or stored at Pearl Harbor are described in Section 5.1.4.12, with the detailed results of analyses provided in Attachment F. As summarized in Section 5.1.4.12, there would be no additional chemicals required at the shipyard for naval spent nuclear fuel storage and therefore no non-radiological impacts from normal operations. Consequently, no cumulative impacts to air quality or water resources would result since the incremental addition of chemicals at the shipyard that might result from naval spent fuel activities would be very small. There are no current environmental problems associated with these materials.

The non-radiological cumulative transportation impacts for the population from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A. The non-radiological impacts associated with the transportation and storage of naval spent nuclear fuel for all of the alternatives considered would be low.

No cumulative land use impacts would be expected to occur as a result of spent nuclear fuel storage. The land that would be dedicated for this purpose is on existing federal property and situated in an industrial setting which has already been disturbed from its natural state. The conversion of this space for storage of spent nuclear fuel would not result in the need to disturb undeveloped land or for additional land to be added to the federally owned property in the foreseeable future.

From a socioeconomic perspective, the introduction of naval spent nuclear fuel activities at the site would create a small number of additional jobs and could have a very small cumulative socioeconomic impact. The site currently employs approximately 5000 civilian personnel. No shipyard employment has been associated with spent nuclear fuel activities in the past since spent nuclear fuel activities have not been conducted at the site. An average of approximately 1 to 35 additional jobs might be added as a result of possible spent nuclear fuel activities in the future. The peak number of additional jobs created at the site in any given year would be approximately 88, which is associated with construction and operation of a water pool facility for storage of spent nuclear fuel. Considering that the regional labor force consists of approximately 407,530 workers, the additional number of added jobs under any alternative would have little or no discernible socioeconomic impact. These jobs would be filled either from within the existing site work force or from the available regional labor force without discernible effect. There are no foreseeable future projects planned at the site and no known projects planned in the region that would cause the small number of workers involved in naval spent nuclear fuel activities to become an important impact.

The cumulative impacts associated with non-radiological waste management are likewise expected to be small. As stated previously, any industrial wastes generated from naval spent nuclear fuel storage would be small and limited to industrial cleaning agents of the type normally encountered at the site. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of additional non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of waste.

5.1.4.17 Unavoidable Adverse Effects

There are no discernible unavoidable adverse effects associated with the implementation of any of the alternatives and none which would help to choose among the alternatives. The alternative in which naval spent nuclear fuel is stored at Pearl Harbor would cause the public to be exposed to small amounts of radiation, described in Section 5.1.4.12, and would result in less than one health effect in the entire population surrounding the shipyard. Similarly, continued operation of the storage facility would produce limited amounts of solid municipal waste and solid low-level radioactive waste. These amounts of waste would not produce any major impacts in the vicinity of the shipyard. There will be no changes to the ecological, cultural, geological, and aesthetic resources due to the implementation of any of the alternatives. There would also be no expected impact on ambient noise levels.

5.1.4.18 Irreversible and Irretrievable Commitments of Resources

The only irreversible and irretrievable commitment of resources that results from the alternative in which naval spent nuclear fuel would be stored at Pearl Harbor would be the money which would be spent by the federal government to construct the necessary facilities. The total cost of storing spent naval nuclear fuel at the shipyards and prototype ranges from approximately $1.5 billion to $5.7 billion. This cost represents the total cumulative cost over the 40-year period for all of the shipyards and prototype. This cost includes construction costs of the new storage facilities, and, depending on the alternative selected, the operation of a limited examination facility at Puget Sound Naval Shipyard combined with the costs associated with shutting down ECF, or the operational costs of the INEL-ECF. The major expense in the highest cost alternatives is the procurement of shipping containers. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

5.1.5 KENNETH A. KESSELRING SITE: WEST MILTON, NEW YORK

5.1.5.1 Overview of Environmental Impacts

The following sections discuss the major differences in potential environmental consequences associated with the choice of the alternatives that include storage of naval spent nuclear fuel at the Kenneth A. Kesselring Site. The environmental consequences associated with the storage of naval spent nuclear fuel at the Kesselring Site are based on the estimates of naval spent nuclear fuel that would be stored at the Kesselring Site through the year 2035 and current knowledge of the design features associated with spent fuel storage systems. The review of the environmental consequences associated with these alternatives has shown that the impact on the environment at the Kesselring Site associated with these activities is very small. There would be no impact to the environment in the vicinity of the Kesselring Site associated with any alternatives that do not involve the Kesselring Site.

5.1.5.2 Land Use

Construction of a storage area at the Kesselring Site for temporary storage of naval spent nuclear fuel would require little rearrangement of existing on-site facilities. The area is already an industrial site; therefore, there would be no impact on land use. A description of the alternate storage containers and water pools and their approximate locations is provided in Attachment D. Attachment C provides a comparison of naval spent nuclear fuel storage in water pools versus dry container storage.

No additional land within or outside the Kesselring Site would be required for fuel storage.

Native American rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.1.5.3 Socioeconomics

The calculated number of direct construction and operating jobs that would be required for the 10-year period between 1995 and 2004 for each storage alternative at the Kesselring Site is provided in Table 5.1.5-1. Since there would be no naval spent nuclear fuel storage or inspection activities at the Site under the 1992/1993 Planning Basis and Centralization alternatives, no additional jobs would be required at the Site under these alternatives.

Table 5.1.5-1. Number of construction and operating jobs created at the Kesselring Site for each alternative.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Railcar[1]	1	1	6	1	1	1	1	1	1	1
Immobile Containers on Pads[2]	1	1	1	1	2	6[3]	3	3	3	3
Shipping Containers on Pads [2]	1	1	1	1	2	6[3]	1	1	1	1
Water Pools[2]	16	16	43	66	81	58	62	24	24	24

(1) Storage mode under the No Action and Decentralization alternatives.
(2) Storage mode under the Decentralization alternative.
(3) The construction jobs would last less than one year.

The only discernible socioeconomic consequence from the alternative of storing naval spent nuclear fuel at the Kesselring Site is that a relatively small number of construction workers (ranging from a few to a maximum of several hundred would be required for construction of the storage area). The work force would consist of skilled craftsmen and unskilled laborers. This work force would be needed during the storage facility construction and would be available from within the area.

The operation of the naval spent nuclear fuel storage area using dry storage containers would require additional workers. Personnel are required to secure fuel in the storage area and to support surveillance and monitoring activities associated with naval spent nuclear fuel storage operations. For the alternative involving storing fuel in immobile dry storage containers, about 20 workers would be required to handle the spent nuclear fuel when it is placed into the storage containers. This work force would normally only be needed when fuel is being inserted into the containers. For the alternative involving shipping containers, fewer workers would be needed to handle and secure the containers in the storage area. If the alternative of storing naval spent nuclear fuel in water pools were selected, approximately 20 workers would be required. These workers would be expected to be supplied from either within the existing Kesselring Site work force or from the local work force. Considering that the Kesselring Site employs approximately 1450 workers, the addition of workers to support the alternatives would have no discernible impact on the local socioeconomic conditions of the Kesselring Site.

For the alternatives where dry storage containers would be manufactured, some additional jobs would be created in the locations where the containers are made. The process of selecting the container manufacturer is subject to federal procurement requirements and would be initiated after the Record of Decision. Consequently, the specific socioeconomic impacts from container fabrication cannot be specified. The net effect of container fabrication would be to create additional jobs and bolster the local economy of the area(s) where containers are made. It is considered unlikely that the selection of the contractor would depend on the alternative storage site selected, so the jobs associated with construction of casks provide no basis for selection of a storage site.

5.1.5.4 Cultural Resources

No site that is listed on the National Register of Historic Places (NPS 1991), any known archaeological areas, or any other cultural resources would be affected by the storage of naval spent nuclear fuel at the Kesselring Site. Therefore, there would be no impact to cultural resources from the alternative of storing naval spent nuclear fuel at the Kesselring Site.

None of the alternatives considered would impact known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.1.5.5 Aesthetic and Scenic Resources

The naval spent nuclear fuel storage area would be located in an existing area within the security perimeter of the Kesselring Site which is an existing light industrial setting. There would be minor changes to the Site resulting from the storage of spent fuel. No aesthetic or scenic resources in the vicinity of the Site or on the Site would be affected by the operation of the storage area because existing industrial use areas would be used to store the spent fuel. The visual quality of the area would not be affected since the storage area would be compatible with the landscape character of the Kesselring Site. There are no particulate air emissions associated with storage of naval spent nuclear fuel and thus no visibility impacts are expected.

5.1.5.6 Geology

The operation of the naval spent nuclear fuel storage area at the Kesselring Site is not expected to affect the geologic character or resources of the region. If an alternative were selected that required a dry container storage area to be constructed, the ground would only be excavated as necessary to prepare the surface. This would not affect the geological characteristics of the underlying layers nor the characteristics of an aquifer or vadose zone. For the alternative of storing fuel in a water pool facility, the ground surface would need to be excavated to a depth of approximately 40 feet. This excavation would not affect the geological characteristics of the area.

5.1.5.7 Air Resources

5.1.5.7.1 Radiological Consequences. If the alternative where naval spent nuclear fuel would be stored in dry storage containers were to be selected, no airborne radioactivity releases would be expected to occur as a result of normal storage operations. The naval spent nuclear fuel would be contained such that at least two barriers exist to prevent fission products from becoming airborne. These barriers would retain the naval spent nuclear fuel in an air-tight containment until it is moved to a permanent storage site and there would be no airborne radioactive material released from routine operations for this method of storage. The only radiation exposure would be direct radiation from the array of filled storage containers. The filled storage containers would be fenced off and shielded if necessary such that there would be no distinguishable effect on the current radiation readings at the site perimeter.

For the alternative where naval spent nuclear fuel would be stored in a water pool, airborne radioactivity emissions are expected to be considerably less than that identified for the Idaho National Engineering Laboratory (INEL) Expended Core Facility (ECF) because the water pool size would be smaller, no naval spent nuclear fuel inspection operations beyond visual examinations would be conducted, and no shielded cell operations would be conducted at the Kesselring Site. To conservatively estimate the radiological consequences, airborne releases based on ECF releases from

1991 are used. The radiological source term used and the detailed calculations performed to determine normal releases are provided in Attachment F.

The radiation exposures to human beings due to estimated radionuclide releases to the atmosphere and direct radiation from the stored naval spent nuclear fuel at the Kesselring Site for both the alternative involving water pool storage and the alternative involving dry storage were calculated as described in Attachment F.

A person on the Kesselring Site boundary at the location where the largest exposures would be received was used as the hypothetical maximally exposed off-site individual (MOI) for postulated releases of radioactive material from the stored naval spent nuclear fuel. The population data used to calculate population doses were taken from 1990 census data provided by the U.S. Census Bureau. Meteorology data were obtained as described in Attachment F. Estimated exposures to workers were also calculated.

The hypothetical exposures calculated are based on an exposure to the estimated average effluents and the direct radiation exposure for one year from the naval spent nuclear fuel stored at the Kesselring Site. The calculations include the external effective exposure equivalent from the ground deposition, deposition to surface water, and air immersion pathways and the 50-year committed effective exposure equivalent from internal exposure through the ingestion and inhalation pathways. All pathways were considered for the persons potentially exposed, except that the ingestion pathway was omitted for the workers at Kesselring because they do not grow their food on-site. Solubilities which would produce the highest calculated exposures were chosen for internal exposure factors. Values for human dietary consumption patterns were taken from "Age Dependent Values of Dietary Intake for Assessing Human Exposures to Environmental Pollutants" (Rupp 1980). The hypothetical exposures calculated can be converted into a risk of fatal cancer or a risk of non-fatal health detriments (e.g., non-fatal cancers, hereditary defects) based on recommendations of the International Commission on Radiological Protection (ICRP 1991).

Attachment F summarizes the calculated exposures and fatal cancers to the workers, the maximally exposed off-site individual (MOI), and the population from airborne releases of radioactivity and direct radiation exposure in one year for each location and storage mode. Section 3.7 provides a comparison of the annual number of fatal cancers calculated for the general population for each location and alternative.

The number of fatal cancers calculated is so small that there would be essentially no fatal cancers resulting from the storage of naval spent nuclear fuel during the time it could reasonably be expected to continue to be stored. Putting this into perspective, it could be stated that one member of the population might experience a fatal cancer due to incident-free storage of naval spent nuclear fuel at the Kesselring Site if operations continued for 24,400 years.

5.1.5.7.2 Non-radiological Consequences. As noted in Attachment F, no increase in non-radioactive airborne emissions would be expected to result from naval spent nuclear fuel storage area operations. Storage area operations would not involve use of carcinogenic toxins, criteria pollutants, or other hazardous toxic chemicals except for small quantities of industrial cleaning agents and paint thinner that may be used for housekeeping and cleanliness control and these would be the same as those already used at the Kesselring Site. Consequently, there would be no impact on ambient air quality as a result of implementing any of the alternatives at the Site.

If an alternative were to be selected that required a storage facility to be constructed or renovated, fugitive dust emissions would be expected to result from excavation operations. The quantity of dust generated would be small, consistent with typical excavation activities and controlled within local requirements for dust control.

5.1.5.8 Water Resources

5.1.5.8.1 Radiological Consequences. Naval spent nuclear fuel storage operations at the Kesselring Site would not result in discharges of radioactive liquid effluents during routine operation regardless of the alternative selected for storage of naval spent nuclear fuel. The health effect due to fallout of nuclides released to the air onto the surface water is included in the analysis results discussed in Section 5.1.5.7. The air fallout impact is so small that there would be no distinguishable radiation levels in the water.

The Kesselring Site does not reside in the 100 or 500 year floodplain. Consequently, the floodplain would not be impacted by spent naval nuclear fuel storage and examination activities at the Site.

5.1.5.8.2 Non-radiological Consequences. Other than chemicals used to maintain the storage area, no hazardous wastes would be generated by the storage of naval spent nuclear fuel at the Kesselring Site. Any hazardous liquid effluents that may be generated at the storage area would be disposed of at an Environmental Protection Agency approved disposal site.

The only source for liquid discharges from the naval spent nuclear fuel storage operations to the environment consists of storm water runoff which would be consistent with the type of discharges associated with common light industrial facilities and related activities. It can be concluded that there would be no impact to the human environment due to runoff water from the naval spent nuclear fuel storage area.

The increased water usage under any of the alternatives would be negligible compared to the existing Site demand.

5.1.5.9 Ecological Resources

There are no known habitats for threatened or endangered species within the Kesselring Site and no major changes to the industrial environment are planned. Therefore, no ecological impacts to the region would result from selection of any of the alternatives.

The conceptual location where naval spent nuclear fuel would be stored is illustrated in Attachment D. This location is within an existing industrial complex and is surrounded by buildings and paved areas. The industrial nature of the Kesselring Site and the fact that the land has already been disturbed from its natural state by earlier activities mean that plant or animal species sensitive to disturbance by human activities would not be expected to be present. Therefore, there would be no ecological impacts associated with construction or operation of a spent nuclear fuel storage area at this location. The radiological controls that are in effect at the Kesselring Site ensure that the radiation levels in the vicinity of the Site are maintained at or near natural background. Since these same controls would be applied to spent nuclear fuel activities, no ecological effects due to radioactive material would be expected to occur.

5.1.5.10 Noise

The Kesselring Site is an existing light industrial-type environment characterized by noise from truck and automobile traffic; diesel-powered equipment; and continuously operating transmission lines for steam, fuel, water, and related pumping systems for these and other liquids. There would be no increase in ambient noise associated with any of the alternatives. Therefore, no noise impacts would be expected to occur.

5.1.5.11 Traffic and Transportation

Shipments of radioactive materials in the Naval Nuclear Propulsion Program are required to be made in accordance with applicable regulations of the U.S. Department of Transportation, U.S. Department of Energy, and the U.S. Nuclear Regulatory Commission. The purpose of these regulations is to ensure that shipments of radioactive material are adequately controlled to protect the environment and the health and safety of the general public. These regulations are applicable to all radioactive material shipments and provide requirements for the container design, certification, and identification as applicable for the specific quantity, type, and form of radioactive material being shipped. Naval shipping container design requirements invoke shielding and integrity specifications and meet all regulatory requirements. They provide for testing of container designs, training and qualification of workers who construct containers, and quality control inspections during fabrication to ensure that the containers will meet their design requirements. A detailed description of the shipping containers used for naval spent nuclear fuel shipments is provided in Attachment A. A description of the impacts from normal and accident conditions associated with transportation of naval spent nuclear fuel is provided in Attachment A.

5.1.5.11.1 Regional Infrastructure. The alternatives under consideration are described in Section 3. The No Action alternative or the first variation of the Decentralization alternative would store the naval spent nuclear fuel on-site. This alternative would reduce the number of rail shipments from the shipyard or prototype site compared to the past practice of transporting all naval spent nuclear fuel to INEL. The second variation of the Decentralization alternative would ship about 10 percent of the naval spent nuclear fuel to Puget Sound. This would have some transportation impact, but not as much as transporting all naval spent nuclear fuel off-site. The third Decentralization alternative ships all naval spent nuclear fuel to INEL, examines it, and returns it to the original shipyard or prototype

site. This alternative involves more transportation than the previous practice of transporting naval spent nuclear fuel to INEL, since the naval spent nuclear fuel is not returned from INEL to the original site. The 1992/1993 Planning Basis alternative, the Regionalization at INEL alternative, or the Centralization at INEL alternative would involve the same transportation as has been required in the past, namely transportation to INEL and retention there. The Centralization alternative at the Hanford Site would result in more transportation impact than any of the previous alternatives, due to the distances and population distribution between Hanford and the shipyards and prototypes. The Centralization alternative at the Savannah River Site would result in the most transportation impact of naval spent nuclear fuel of any of the alternatives.

5.1.5.11.2 Site Infrastructure. The alternatives associated with storage of naval spent nuclear fuel at the Kesselring Site would have no impact on local highway traffic because any increase in the work force would represent a very small incremental increase in overall traffic to and from the Site. There would be no change in the internal traffic at the Kesselring Site because naval spent nuclear fuel is temporarily held on-site even when it is transported off-site.

5.1.5.12 Occupational and Public Health and Safety

Detailed analyses of incident-free naval spent nuclear fuel transportation and storage and handling impacts on worker and public health are described in Attachment A (transportation) and Attachment F (storage and inspection). The transportation analysis results, and the storage and handling analysis are summarized separately in the following subsections.

5.1.5.12.1 Incident-free Transportation Occupational and Public Health and Safety. The radiological and non-radiological effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.5.12.2 Incident-free Occupational and Public Health and Safety During Naval Spent Nuclear Fuel Storage and Handling. The public health and safety impacts of radioactivity releases and direct radiation from storage of naval spent nuclear fuel were analyzed as discussed in Section 5.1.5.7 and Attachment F. Attachment F summarizes the results of the analysis of radioactivity releases and direct radiation from stored naval spent nuclear fuel. This analysis shows that the exposure to the worker and maximally exposed off-site individual from stored naval spent nuclear fuel would result in far less than one fatality per year. For perspective, it could be stated that one member of these population groups might experience a fatal cancer due to storage of naval spent nuclear fuel at the Kesselring Site if operations continued for 24,400 years.

Attachment F also discusses toxic chemical issues for naval spent nuclear fuel handling and storage. Attachment F concludes that there would be no additional types or volumes of chemicals required at the shipyards or prototype site for naval spent nuclear fuel storage. Therefore, there is no incident-free non-radiological impact resulting from storage of naval spent nuclear fuel at the shipyards or prototype site.

Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

No public or occupational radiological health and safety impacts would be expected to result from naval spent nuclear fuel storage area construction activities since the construction would not involve radioactive work.

5.1.5.12.3 Incident-free Occupational and Public Health and Safety Effects on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the management of naval spent nuclear fuel at the Kesselring Site would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the Kesselring Site do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game since environmental monitoring in the vicinity of this relatively small and restricted site has shown no detectable difference in the amounts of radioactivity present in the environment from levels in similar parts of the region.

To place the impacts on environmental justice in perspective, the risk associated with routine naval spent nuclear fuel management operations under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.1.5.13 Utilities and Energy

If an alternative associated with storage of naval spent nuclear fuel at the Kesselring Site were to be selected, construction and operation of a naval spent nuclear fuel storage facility would not be expected to require a large expenditure of utilities and energy resources. Operation of the storage facility would likely require only a small amount of electricity for lighting and to support industrial equipment necessary to move spent nuclear fuel containers (cranes etc.). Construction activities would require quantities of water and electricity typical of any small to medium size construction project. Alternatives associated with water pool storage would require heating, ventilation, water, and electrical systems suitable for a work environment and to properly filter and exhaust the airborne discharges to the atmosphere. The utility and energy demands would be less than that required to operate ECF (10,000 MWh per year) (Section 5.2.13) since the water pool for naval spent nuclear fuel storage would be smaller and no inspections would be performed. The amount of utilities and energy expected to be consumed as a result of dry storage would be a small incremental increase in the total amount of utilities and energy used at the Kesselring Site and would not result in any discernible environmental consequences.

5.1.5.14 Facility and Transportation Accidents

5.1.5.14.1 Facility Accidents. There has never been an accident in the history of the Naval Nuclear Propulsion Program that resulted in a significant release of radioactivity to the environment or that resulted in radiation exposure to workers in excess of abnormal occurrence limits on exposures as defined by the U.S. Nuclear Regulatory Commission. A description of potential accidents considered and a summary of the accident analyses that were conducted with regards to the storage of naval spent nuclear fuel are contained in Attachment F.

5.1.5.14.1.1 Radiological Accidents. Section 3.7.3 provides a summary of the impacts due to the most severe accidents considered for each site. The facility accident with the greatest potential impact at the Kesselring Site involves an airplane crash. An accident of this magnitude would result in 7.5 fatal cancers to the general population over 50 years, as described in Attachment F. The likelihood of an airplane crash is 1×10^{-7}. The facility accident with the greatest risk involves accidental drainage of the water pool. The drained water pool accident would result in less than one fatality over 50 years, but the likelihood of occurrence is 1×10^{-5}.

5.1.5.14.1.2 Non-radiological Accidents. As discussed in detail in Attachment F, the limiting hypothetical non-radiological accident for naval spent nuclear fuel storage in a water pool at a shipyard or prototype location would be a diesel fuel spill and fire. A catastrophic failure of a diesel fuel storage tank that might be used for an emergency diesel generator to provide backup electrical power was postulated to occur, resulting in the spilling of the entire quantity of diesel fuel with a subsequent fire. The fire would generate the following toxic chemicals:

- Carbon monoxide
- Oxides of nitrogen (90% nitric oxide and 10% nitrogen dioxide)
- Lead
- Sulfur dioxide.

Measures would be taken to reduce the health impacts of potential releases of toxic materials. These measures would involve controls to protect both workers and the general public. The naval shipyard and prototype sites have emergency planning, emergency preparedness, and emergency response programs in place to protect both workers and the public, and involve established resources such as warning communications, fire departments, and emergency command centers.

The airborne concentrations of the combustion products listed above, resulting from the fire, were calculated at the locations of the on-site individuals, an individual at the site boundary, and the general population within a 50-mile radius of the facility. Detailed results are presented in Attachment F. If the accidental fire that has been hypothesized were to actually occur, the safety measures that would be in place would ensure no adverse health impacts to the general public and minimal health impacts to the workers.

5.1.5.14.2 Transportation Accidents. Shipments of radioactive materials associated with naval spent nuclear fuel have never resulted in any measurable release of radioactivity to the environment (NNPP 1994a). There have never been any significant accidents involving the release of radioactive material during shipment since the Naval Nuclear Propulsion Program began. The effects of potential transportation accidents during the various stages of transportation of naval spent nuclear fuel are presented in Attachment A.

The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.1.5.14.3 Other Impacts of Accidents. In addition to the possible human health effects associated with facility or transportation accidents described in the preceding sections, other effects

such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives. The analyses described in Attachment F showed that an area ranging from about 8 acres extending approximately a quarter mile (for an inadvertent criticality accident) to about 110 acres extending approximately 0.9 mile (for a large airplane crashing into a dry storage container) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. Persons who live in this area might be evacuated or otherwise experience restrictions in their daily activities for a brief period, and those who work at locations within this area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure. It should be noted that all of the affected area within about three-quarters of a mile from the spent nuclear fuel facility would be inside the boundaries of the Kesselring Site.

An accident might result in short-term restrictions on access to a relatively small area, but there would be no enduring impacts on cultural or similar resources or concerns such as Native American rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area would vary only slightly among the alternatives considered. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with any of the alternatives would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for all alternatives considered. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. There are no endangered or threatened species unique to the area surrounding the federally owned site, so an accident would not be expected to result in destruction of any species for any of the alternatives considered. The effects of any accident related to any of the alternatives and any cleanup which might be performed would be localized in a small area which extends only a short distance beyond the boundaries of the federally owned site and thus would not be expected to appreciably affect the potential for survival of endangered or threatened species which might occupy wetlands or other habitat in the Saratoga area. Consequently, evaluation of impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.1.5.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the Kesselring Site would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is because the consequences of any accident would depend on the random conditions in effect at the time an accident occurred, and the wind directions at the Kesselring Site are highly variable with no strongly dominant direction.

To place the impacts on environmental justice in perspective, the risk associated with accidents caused by naval spent nuclear fuel management under any of the alternatives considered would amount to less than one additional fatality per year for the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.1.5.15 Waste Management

The alternative in which naval spent nuclear fuel is stored at the Kesselring Site would produce limited amounts of solid municipal waste, solid low-level radioactive wastes, and hazardous wastes. In addition, no transuranic or high-level radioactive wastes would be generated by spent nuclear fuel activities at the Kesselring Site under any alternative. The quantity of industrial wastes generated would be small and most likely consist of industrial cleaning agents of the type normally encountered at the Site. Small quantities of sanitary wastes would result from the additional work force but this volume would be small. The wastes produced from the storage of naval spent nuclear fuel would be controlled and minimized in accordance with the existing waste management programs at the Kesselring Site. The amount of additional wastes generated would be minimal compared to the existing baseline and would not cause any adverse impacts to public health and safety and the environment in the vicinity of the Kesselring Site.

5.1.5.16 Cumulative Impacts

5.1.5.16.1 Radiological Cumulative Impacts. Spent nuclear fuel storage at the Kesselring Site would not result in discharges of radioactivity in liquid effluents during routine operations regardless of the alternative selected. Therefore, there would be no incremental addition of radioactivity to surface or ground water as a result of normal operations for any alternative. For alternatives involving the storage of spent nuclear fuel in dry storage and shipping containers, no airborne radioactivity emissions are expected, so there would be no cumulative air quality impacts associated with these storage methods. Consequently, the only radiological cumulative impacts that would result from dry storage alternatives would be due to direct radiation exposure from the stored containers of spent nuclear fuel.

For alternatives involving the storage of naval spent nuclear fuel in water pools, there would be no discernible direct radiation exposure to the public from the fuel elements due to the shielding provided by the water in the pool. Therefore, any cumulative impacts which would result from water pool storage would be primarily due to airborne emissions, and the addition of these emissions would cause an indiscernible change in the emissions in the area (see Section 5.1.5.7). Current operations at the site are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

A summary of the cumulative radiological impacts is provided in the following section.

An overview of the historical radiological impacts from naval nuclear operations at the Kesselring Site and from transportation of naval spent nuclear fuel is provided in Section 4.1.5.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The radiological impacts associated with the alternatives where naval spent nuclear fuel would be stored at the Kesselring Site are very small and are described in Section 5.1.5.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the population in the vicinity of the Kesselring Site from all of the alternatives considered would be approximately 3.28 person-rem. This means that there would be much less than one fatal cancer from these operations over the entire 40-year period evaluated. The total exposure to a theoretical maximally exposed off-site individual living at the shipyard boundary for the entire 40-year period would be 2.7×10^{-4} rem due to the alternative resulting in the largest exposure. This maximally exposed off-site individual would have a 1.4×10^{-7} risk of contracting a fatal cancer during his or her lifetime due to storage of spent nuclear fuel. When existing site radiological impacts due to naval nuclear operations are added to the impacts of the most limiting spent nuclear fuel alternative, the exposure to the population would be 5.6 person-rem and to the maximally exposed off-site individual would be 4.8×10^{-4} rem. This still results in much less than one fatal cancer in the population and the risk of the maximally exposed off-site individual contracting a fatal cancer during his or her lifetime is 2.4×10^{-7}.

The total exposure related to naval spent nuclear fuel activities to a worker assumed to be working continually 100 meters from the spent nuclear fuel under the alternative resulting in the largest exposure is 2.4×10^{-2} rem accumulated over 40 years. That corresponds to a fatal cancer risk of 9.6×10^{-6} during the worker's lifetime. The exposure to the same worker when existing site radiological impacts due to naval nuclear operations are added to the spent nuclear fuel exposure is 2.6×10^{-2} rem over 40 years which corresponds to a fatal cancer risk of 1.1×10^{-5} during the worker's lifetime. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

Sections 4.1.5.14 and 5.1.5.15 describe the management of low-level radioactive waste and mixed waste at the site. The volume of low-level radioactive wastes which would be generated under the alternatives has not been calculated. However, considering the nature of radiological work that would be associated with spent nuclear fuel storage activities, the amount of low-level radioactive waste produced during spent nuclear fuel activities would be much less than 20 percent of the current site generation rate (215 m^3 per year). This additional radioactive waste would not introduce any changes to the Site's waste management practices. The small amount of additional material involved would not impose any discernible additional stress on the capacity of the radioactive waste burial ground. Therefore, any cumulative impacts associated with the generation and disposal of additional low-level wastes would be very small.

Since no mixed, transuranic, or high-level radioactive wastes would be generated by spent nuclear fuel activities at the Kesselring Site under any alternative, there would be no cumulative impacts associated with these materials.

5.1.5.16.2 Non-radiological Cumulative Impacts. An overview of the historical non-radiological impacts from naval nuclear operations at the Kesselring Site and from transportation of naval spent nuclear fuel is provided in Section 4.1.5.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no non-radiological cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The non-radiological impacts associated with the alternative where naval spent nuclear fuel would be inspected or stored at the Kesselring Site are described in Section 5.1.5.12, with the detailed results of analyses provided in Attachment F. As summarized in Section 5.1.5.12, there would be no additional chemicals required at the prototype site for naval spent nuclear fuel storage and therefore no non-radiological impacts from normal operations. Consequently, no cumulative impacts to air quality or water resources would result since the incremental addition of chemicals at the Site that might result from naval spent fuel activities would be very small. There are no current environmental problems associated with these materials.

The non-radiological cumulative transportation impacts for the population from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A. The non-radiological impacts associated with the transportation and storage of naval spent nuclear fuel for all of the alternatives considered would be low.

No cumulative land use impacts would be expected to occur as a result of spent nuclear fuel storage. The land that would be dedicated for this purpose is on existing federal property and situated in an industrial setting which has already been disturbed from its natural state (about 50 acres are developed land). The conversion of this space for storage of spent nuclear fuel would not result in the need to disturb undeveloped land or for additional land to be added to the federally owned property in the foreseeable future.

From a socioeconomic perspective, the introduction of naval spent nuclear fuel activities at the Kesselring Site would create a small number of additional jobs and could have a very small cumulative socioeconomic impact. The site currently employs approximately 1450 civilian personnel. No site employment has been associated with spent nuclear fuel activities in the past since spent nuclear fuel activities have not been conducted at the site. An average of approximately 1 to 24 additional jobs might be added as a result of possible spent nuclear fuel activities in the future. The peak number of additional jobs created at the site in any given year would be approximately 81, which is associated with construction and operation of a water pool facility for storage of spent nuclear fuel. Considering that the regional labor force consists of approximately 176,600 workers, the additional number of added jobs under any alternative would have little or no discernible socioeconomic impact. These jobs would be filled either from within the existing Site work force or from the available regional labor force without discernible effect. There are no foreseeable future projects planned at the Site and no known projects planned in the region that would cause the small number of workers involved in naval spent nuclear fuel activities to become an important impact.

The cumulative impacts associated with non-radiological waste management are likewise expected to be small. As stated previously, any industrial wastes generated from naval spent nuclear fuel storage would be small and limited to industrial cleaning agents of the type normally encountered at the Kesselring Site. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of additional non-radiological wastes generated would not introduce any changes to the Site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of waste.

5.1.5.17 Unavoidable Adverse Effects

There are no discernible unavoidable adverse effects associated with the implementation of any of the alternatives and none which would help to choose among the alternatives. The alternative in which naval spent nuclear fuel is stored at the Kesselring Site would cause the public to be exposed to small amounts of radiation, described in Section 5.1.5.12, and would result in less than one health effect in the entire population surrounding the Kesselring Site. Similarly, continued operation of the storage facility would produce limited amounts of solid municipal waste and solid low-level radioactive waste. These amounts of waste would not produce any major impacts in the vicinity of the Kesselring Site. There will be no changes to the ecological, cultural, geological, and aesthetic resources due to the implementation of any of the alternatives. There would also be no expected impact on ambient noise levels.

5.1.5.18 Irreversible and Irretrievable Commitments of Resources

The only irreversible and irretrievable commitment of resources that results from the alternative in which naval spent nuclear fuel would be stored at the Kesselring Site would be the money that would be spent by the federal government to construct the necessary facilities. The total cost of storing spent naval nuclear fuel at the shipyards and prototype ranges from approximately $1.5 billion to $5.7 billion. This cost represents the total cumulative cost over the 40-year period for all of the shipyards and prototype. This cost includes construction costs of the new storage facilities, and, depending on the alternative selected, the operation of a limited examination facility at Puget Sound Naval Shipyard combined with the costs associated with shutting down ECF, or the operational costs of the INEL-ECF. The major expense in the highest cost alternatives is the procurement of shipping containers. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

5.2 IDAHO NATIONAL ENGINEERING LABORATORY

5.2.1 Overview of Environmental Impacts

The following sections discuss the potential environmental consequences at the Idaho National Engineering Laboratory (INEL) associated with the choice of alternatives for naval spent nuclear fuel management at the Expended Core Facility (ECF). The environmental consequences are based on the fact that the ECF is currently in existence and operating within the perimeter of the Naval Reactors Facility (NRF) at INEL. Volume 1, Appendix B provides an assessment of the environmental impacts at INEL resulting from the full range of spent nuclear fuel activities. This includes the impacts resulting from "ECF-related" activities, which are discussed below (i.e., the impacts resulting from the transportation, receipt, handling, and examination of naval spent nuclear fuel), as well as the impacts associated with the spent nuclear fuel operations at the Idaho Chemical Processing Plant (i.e., the storage of both naval and non-naval spent nuclear fuel and other non-naval spent nuclear fuel operations).

Review of the environmental effects of operation of the Expended Core Facility at INEL for the receipt and examination of naval spent nuclear fuel has shown that the impact on the environment associated with this work is very small. The largest effect in the vicinity of INEL associated with the selection of any alternative for examination of naval fuel is the economic impact of the jobs which are retained or lost at ECF. The differences in all other impacts in the vicinity of INEL for the available alternatives are very small or non-existent.

5.2.2 Land Use

The plan for all three naval plant prototypes at NRF is that they will all be shut down, defueled, and placed in safe storage until they are decommissioned. Operations at the ECF could continue or cease, depending upon the alternative selected. None of the prototype plants or the ECF, if operations cease, is planned to be decommissioned during the next 10 years; therefore, this land will not be available for other uses in the near future. Native American rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.2.3 Socioeconomics

Approximately 500 engineers, technicians, clerical, and maintenance personnel are employed in the receipt and examination of naval spent nuclear fuel at ECF or in direct support of these activities. Table 5.2-1 provides a summary of the direct jobs which would be associated with the ECF if an alternative is selected which closes ECF, while Table 5.2-2 provides a summary of the direct jobs associated with the continued operation of ECF. As shown in Table 5.2-1, there is an increase in workers in the first three years to handle the shipment of containers which had been in storage at the shipyards and prototype during the preparation of this Environmental Impact Statement. The number of workers then decreases steadily to a final caretaker work force of 10. The increase in work force in the first three years shown in Table 5.2-2 includes construction workers for the completion of the Dry Cell Facility in addition to the operations work force increase discussed above.

Table 5.2-1. Summary of direct jobs (closure of INEL-ECF).

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct Jobs	550	550	550	500	350	100	10	10	10	10

Table 5.2-2. Summary of direct jobs (operation of INEL-ECF).

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct Jobs	574	574	550	500	500	500	500	500	500	500

5.2.4 Cultural Resources

None of the alternatives considered would impact known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.2.5 Aesthetic and Scenic Resources

The entire Naval Reactors Facility is difficult to see from any point accessible to the public so aesthetic and scenic resources in the vicinity of INEL will not be affected by the alternative selected for receipt and handling of naval spent nuclear fuel at ECF. Even if NRF could be observed, the only action which would alter the landscape at NRF is the dry cell extension for spent fuel handling to ECF envisioned under the 1992/1993 Planning Basis alternative and this addition to the existing ECF building would be architecturally compatible with the NRF buildings.

5.2.6 Geology

The geology in the vicinity of the INEL will not be affected by the alternative selected for receipt and handling of naval spent nuclear fuel since no changes which could impact the geology would occur under any of the alternatives.

5.2.7 Air Resources

Small quantities of radioactivity are contained in the air released from ECF and prototype plant operations at NRF. The annual releases from ECF total approximately 1.1 curies, composed primarily of 0.30 curie of krypton-85, 0.70 curie of carbon-14, 0.094 curie of tritium, 0.000011 curie of combined strontium-90 and yttrium-90, and 0.0000048 curie of iodine-131. These releases at NRF would be reduced to near zero if an alternative which ends examination of naval spent nuclear fuel at ECF were selected. This reduction will occur approximately three years after the last fuel is received.

The principal sources of non-radioactive industrial gaseous effluents are air from offices, water vapor from cooling towers, and fuel combustion products from the three steam generating boilers used for heating. Since the boilers are used for generating steam for heating and it would be necessary to heat and maintain the ECF building whether naval spent nuclear fuel is shipped to INEL or not, the airborne effluents at NRF would be little affected by the alternative selected.

Asbestos-containing material is present at NRF, but, as a result of the well-controlled conditions with regard to asbestos at NRF, releases will be unaffected by the alternative selected.

5.2.8 Water Resources

No radioactive liquids are discharged to the environment at NRF. Consequently, the alternative selected would have no effect on releases of radioactive liquids at NRF.

Since the water released to the industrial waste ditch does not include any effluents from ECF, the discharges to the ditch would be unaffected by the choice of alternatives. Operation of ECF produces about 25% of the total NRF sewage discharge and the ECF discharge would be reduced to approximately zero if the people currently performing spent fuel examinations in that facility were no longer employed at NRF.

No hazardous wastes are disposed of at the NRF site and all solid and liquid hazardous wastes are transported by vendors to treatment, storage, and disposal facilities approved by the Environmental Protection Agency and operating under approvals or permits granted by state and federal regulatory agencies. The small amount of hazardous waste produced during ECF operation produces no effect on the environment in the vicinity of INEL, so the alternative selected would have no impact on water quality in this area.

Annual ECF water consumption is about 2.5 million gallons. The alternative selected would have no discernible effect on water usage, because the ground-water withdrawn for ECF operations is small in comparison to the total INEL water consumption. ECF operation has virtually no effect on surface waters.

A flood at ECF due to overflow of any surface water within the INEL boundaries is a low probability event. Flooding of the ECF building is possible should the Mackay Dam fail; however, there is adequate time following the dam break until the flood water reaches NRF to complete emergency procedure preparations. For more information refer to Attachment B.

5.2.9 Ecological Resources

Ecological resources (i.e., the terrestrial ecology, wetlands, aquatic ecology, and endangered and threatened species) in the vicinity of INEL will not be affected by any alternative selected since no additional land at the NRF site will be disturbed under any alternative.

5.2.10 Noise

The small amount of noise generated by work at ECF would cease several years after an alternative which stopped shipment of spent naval nuclear fuel were selected since ECF operations would cease. However, since this noise cannot be discerned beyond the site boundaries, the alternative selected would have no discernible impact on noise in the vicinity of INEL.

The similarly small amount of noise associated with railcar movement produced during shipment of the naval spent nuclear fuel from shipyards to ECF would cause the alternative selected to have no discernible impact on railcar noise generation. This is the case because the less than 50 railcars involved each year represent a minute fraction of the rail traffic in any area affected and the noise is indistinguishable from that produced by other rail traffic.

5.2.11 Traffic and Transportation

Traffic and transportation in the vicinity of INEL associated with naval spent nuclear fuel receipt, handling, and examination would essentially cease if an alternative which ended such operations at ECF were selected. This would cause approximately 400 truck deliveries per year to be eliminated. The reduction in personnel at ECF associated with cessation of these activities would cause approximately 22 fewer buses to be needed to transport them to and from the site each day. None of the alternatives considered would increase traffic or the need for transportation in the vicinity of INEL.

If the ECF operation continues at the INEL, routine shipments of naval spent nuclear fuel would be resumed to the site in certified shipping containers. Low-level waste generated at ECF and hazardous waste would continue to be moved from ECF to a disposal facility.

5.2.12 Occupational and Public Health and Safety

5.2.12.1 Occupational Health and Safety. Radiological and non-radiological impacts of ECF operations on occupational health and safety are assessed separately in terms of radiological and non-radiological effects.

Radiation exposures to workers at ECF have averaged approximately 100 millirem per year, compared to the limit of 5000 millirem per year specified by The Code of Federal Regulations, Title 10, Part 20. The total radiation exposure to workers at ECF makes up about 30% of the occupational exposure to radiation experienced by workers at NRF. Since only about 280 workers at ECF work in radiological areas and the health risk per worker is estimated to be approximately 0.00040 occurrences of fatal cancer per rem of exposure, less than one fatal cancer (approximately 0.45 fatal cancer estimated) could be expected among all ECF workers throughout the rest of their lives due to operation of ECF for an additional 40 years. This means that radiation effects on the health of INEL workers would be virtually unchanged by the alternative selected for examination of naval spent nuclear fuel.

Operations at ECF have resulted in fewer than 210 days of work lost to injuries in the seven years between 1987 and 1993 out of 736 total lost days of work at NRF during that period. Recordable injuries at ECF represented about 12% of the total number of such injuries at NRF during the same period. Consequently, selection of an alternative which ended operation of ECF at INEL might be expected to reduce injuries to workers at NRF by about 10% to 25% due to the reduction in work force. Operation of a replacement for ECF at another Department of Energy (DOE) site would likely result in roughly the same number of injuries to workers at that facility since the safety record at ECF is very good and similar safe working conditions could be established at the new facility.

Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

Limited quantities of some materials classified as hazardous chemicals are handled at ECF, but the precautions used during the work prevent exposure of the workers to these materials. Therefore, the alternative selected would not be expected to increase or decrease the exposure of INEL workers to potentially hazardous chemicals.

5.2.12.2 Public Health and Safety. The impact of NRF operations on public health and safety can also be assessed separately in terms of radiological and non-radiological effects.

The comprehensive INEL site radiation monitoring program (Hoff et al. 1992) shows that radiation exposure to persons who do not work at INEL resulting from all NRF operations is too small to be measured. In order to provide an estimate of the effects of radiation exposure which might be caused by INEL operations, calculations have been performed of the radiological exposures to the member of the general public who might receive the highest exposure (called the maximally exposed individual), to nearby (collocated) workers, to a worker at ECF located approximately 100 meters from the release point, and to the population surrounding the Idaho National Engineering Laboratory. These calculations include all types of radioactive particles or gases released into the atmosphere from the operation of all existing NRF facilities, including ECF. The calculation results and the analysis methods are provided in more detail in Attachment F.

The calculations indicate the risks are so small that there would be essentially no health effects resulting from radioactivity released by all operations at NRF, including ECF during the time it could reasonably be expected to operate. Putting the risk into perspective, it could be stated that one member of the population might experience a fatal cancer due to combined effects of operation of ECF if operations continued as in the past for 260 million years.

The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any health effects as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer or detrimental health effect for each alternative. The details of the transportation analysis are provided in Attachment A.

Results of all effluent monitoring confirm that the operation of NRF has no detectable impact on the environment from non-radiological releases (WECNRF 1993). Operations at NRF have had no effect on the groundwater of the Snake River Plain Aquifer, and monitoring results indicate no detectable toxic chemicals, solvents, or laboratory chemicals in the groundwater in the vicinity of NRF. No constituent measured in groundwater in the vicinity of NRF exceeds applicable drinking water standards. The alternative selected for examination of naval spent nuclear fuel would therefore have no effect on non-radiological public health and safety in the vicinity of INEL.

5.2.12.3 Incident-free Occupational and Public Health and Safety Effects on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the examination of naval spent nuclear fuel at the INEL would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of activities associated with naval spent nuclear fuel examination under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the INEL do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game because of the very small impacts associated with examination of naval spent nuclear fuel.

To place the impacts on environmental justice in perspective, the risk associated with routine operations for naval spent nuclear fuel examination under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.2.13 Utilities and Energy

Operations at ECF currently consume approximately 10,000 MWh of electricity each year. However, since the ECF building and associated facilities would have to be maintained during the period covered by this Environmental Impact Statement whether ECF is used for naval spent nuclear fuel examination or not and the spent fuel examinations do not consume particularly large amounts of energy, the consumption of electricity and other energy would not be appreciably affected by the alternative selected. None of the alternatives considered would increase the consumption of energy at INEL.

5.2.14 Facility and Transportation Accidents

5.2.14.1 Facility Accidents. There has never been an accident in the history of the Naval Nuclear Propulsion Program that resulted in a significant release of radioactivity to the environment or that resulted in radiation exposure to workers in excess of normal limits on exposure. Attachment F provides a description of radiological accidents which could occur during water pool and dry cell handling of naval spent nuclear fuel as well as accidents involving toxic chemicals used at ECF. The radiological accidents analyzed for ECF included: (1) an inadvertent criticality caused by an earthquake or similar event, (2) accidental loss of large amounts of water containing radioactive material from a water pool into the ground and then into water sources, and (3) severe damage of spent fuel if it were dropped from a crane during handling or had a heavy object dropped on it. The probability of an accident caused by an airplane crash was calculated for ECF and was determined to be less than 10^{-7}. Due to the low probability, no consequences were calculated for this accident. Calculations of the cancer fatalities which might occur as a result of all the postulated accidents are provided in Attachment F. A comparison of the accident consequences for all alternatives is provided in Section 3.7.

The most limiting of the postulated accidents at ECF was water pool drainage, ultimately resulting in fuel overheating. The exposure to the entire population from this accident is calculated to cause 0.017 cancer fatalities over 50 years, as described in Attachment F.

The exposures to collocated workers following all accidents are well below the naval and DOE 5-rem standard for occupational exposure. However, exposures to the worker located at the ECF site 100 meters from the radiation release point would exceed this standard following an accident resulting in an inadvertent criticality.

Effects from accidents at ECF involving toxic chemicals were evaluated in Attachment F. Due to the amount and types of chemicals stored at ECF, toxic chemicals do not pose a risk to the public or the maximally exposed off-site individual following any of the postulated accidents. However, following the maximum foreseeable accident analyzed (a fire transient), a number of toxic chemicals would exceed Emergency Response Planning Guideline (ERPG) values for workers at ECF. For maximum off-site individuals at INEL, ERPG-1 values for the toxic chemicals are not exceeded under 50% or 95% meteorology conditions. The concentrations of toxic chemicals following the fire transient as well as a summary of the analysis methods are provided in Attachment F.

5.2.14.2 Transportation Accidents. The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and the hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any health effects as a result of naval spent nuclear fuel and test specimen shipments since the risk estimates are much less than one fatal cancer or detrimental health effect for each alternative. However, the most severe accident, with a likelihood of occurrence greater than 1×10^{-7} events per year, is estimated to result in a maximum of approximately 2 fatalities. The details of the transportation analysis are provided in Attachment A.

5.2.14.3 Other Impacts of Accidents. In addition to the possible human health effects associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives. The analyses described in Attachment F showed that for the most severe hypothetical accidents, an area of approximately 8 to 11 acres, extending about 1/4 to 1/3 mile downwind, might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond this distance, exposures would be below 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. Persons who work at the federal facilities within this area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure.

The area affected by the hypothetical accidents would not extend beyond the boundaries of the INEL and, in fact, would not come close to approaching the boundaries. An accident might result in short-term restrictions on access to a relatively small area of the federally owned site, but it would not be expected to produce enduring impacts on cultural or similar resources or concerns such as Native American rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner and in full compliance with applicable laws and regulations. The area would vary only slightly among the alternatives considered. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with any of the alternatives would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for all alternatives considered. Similarly, since the areas which might be contaminated by chemicals or radioactive material to measurable levels during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. As previously stated, there are no endangered or threatened species unique to the area surrounding the Expended Core Facility at INEL, so an accident would not be expected to result in destruction of any species for any of the alternatives considered. The effects of accidents associated with any of the alternatives and any cleanup which might be performed would be localized within a small area extending only a short distance from the Expended Core Facility and thus would not be expected to appreciably affect the potential for survival of any species. Consequently, consideration of impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.2.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the INEL would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

To place the impacts on environmental justice in perspective, the risk from hypothetical accidents associated with naval spent nuclear fuel examination under any of the alternatives considered would amount to less than one additional fatality per year in the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.2.15 Waste Management

All non-hazardous solid wastes that cannot be recycled or used by other government agencies are transported to the INEL landfills at the Central Facilities Area. Operation of ECF makes little contribution to these wastes other than the trash associated with the approximately 500 persons who work at that facility. Therefore, the impact in this area at the INEL is little affected by the alternative selected.

The use of hazardous materials in essential applications at ECF results in the generation of some hazardous wastes, including photographic solutions, solutions containing heavy metals, organic solvents, paint-related wastes, and laboratory wastes. All hazardous wastes are transported by vendors to treatment, storage, and disposal facilities approved by the Environmental Protection Agency and operating under approvals or permits granted by state and federal regulatory agencies, and none are disposed of at INEL. When appropriate, wastes are recycled or provided to other federal agencies for use. The small amount of hazardous waste produced from ECF operation would be produced and managed in the same manner if the facility were constructed and operated at an alternate site, so the overall effect on the environment, including that in the vicinity of INEL, is essentially unchanged by the alternative selected.

Operations at ECF contribute approximately 425 cubic meters (15,000 cubic feet) of radioactive solid waste each year and this amount of solid radioactive waste would be reduced by approximately 75% after about three years if an alternative which stopped naval spent nuclear fuel examinations at INEL were selected. No high-level waste and almost no transuranic waste (less than 0.0001 cubic meter per year) are generated from current operations at ECF. None of the alternatives considered would increase the amount of radioactive waste at INEL resulting from naval spent nuclear fuel examinations. The radioactive waste from ECF examinations and related operations would be generated and managed in a similar manner if the facility were constructed and operated at an alternative site. Consequently, the overall effect on the environment is essentially unchanged by the alternative selected.

5.2.16 Cumulative Impacts

Up to this point, Section 5.2 has discussed the potential environmental consequences of operation of the ECF Project at INEL in terms of annual impacts (i.e., radiological exposures and health effects, accident risks, and quantities of wastes that would be generated during operation) based on the maximum annual capacity of the ECF Project. To determine the upper limit for the potential consequences of up to 40 years of future ECF operation (from 1995 to 2035), an evaluation of the accumulated environmental consequences and risks of operating ECF was performed.

5.2.16.1 Radiological Cumulative Impacts. Operation of the INEL-ECF does not result in discharges of radioactive liquids; therefore, there would be no changes to the surface or ground water as a result of normal operations for any alternative. There are small quantities of radioactivity in the air released from ECF which would contribute to the cumulative air quality impacts. For those alternatives where the ECF is shut down, the cumulative impacts would decrease by the amount of ECF radioactivity releases.

The radiation exposure to the general population since the beginning of operations associated with naval spent nuclear fuel is less than 2 rem, which corresponds to approximately 0.001 cancer fatality. An overview of the historical radiological impacts from naval nuclear operations at the INEL and from transportation of naval spent nuclear fuel is provided in Section 4.2.12 and detailed analyses are provided in Attachments F and A. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The annual radiological impacts associated with the alternatives where naval spent nuclear fuel would be inspected or stored at the ECF at INEL are very small and are described in Section 5.2.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the general public from transportation and from the alternatives considered involving continued operation of the ECF at INEL would be less than 3.5 person-rem. This means that there would be less than 0.0017 fatal cancers from these operations over the entire 40-year period evaluated. The exposure to the maximally exposed off-site individual is calculated to be approximately 0.01 millirem from 40 years of ECF operation. The corresponding risk of a cancer fatality to the maximally exposed off-site individual is 5.2×10^{-9} during his or her lifetime. A worker at the ECF site located 100 meters from the facility would receive less than 3 millirem over 40 years of ECF operation, which corresponds to a 1.1×10^{-6} risk of fatal cancer during the worker's lifetime. Analyses of hypothetical accidents which might occur as a result of these alternatives show that the risk of cancer fatalities is small. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

Cumulative impacts due to radioactive waste generation are expected to be minimal. Approximately 425 cubic meters of low-level waste are expected to be generated annually by ECF over the next 40 years. This is not expected to affect the INEL waste management program. Very little transuranic and mixed wastes and no high-level waste are generated from ECF operations.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

5.2.16.2 Non-radiological Cumulative Impacts. Cumulative socioeconomic impacts associated with continued operation of the ECF Project at the INEL are expected to be minor. The INEL currently employs approximately 11,000 people. The ECF operations work force of 500 people would continue to be employed over the long term at INEL if an alternative is selected which would continue naval spent nuclear fuel examination at INEL. If an alternative were selected which resulted in naval fuel no longer being examined at INEL, the reduction in ECF work force would increase the predicted future reductions in work force at INEL by 500 jobs. Considering that the labor force in the region of influence consists of almost 105,000 people, the 500 ECF jobs would be expected to have only a minor impact in the INEL area.

Continued operation of the ECF Project at INEL is not expected to result in any appreciable impacts relative to cumulative non-radiological emissions. Current operations at INEL are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

As discussed in Section 5.2.8, the withdrawal of groundwater for continued ECF operation would be a small percentage of existing water withdrawals at INEL and well within the cumulative capabilities of the local water resources. ECF discharges of non-radioactive and non-hazardous liquid effluents at INEL would not affect water quality. The volume of ECF routine liquid effluents discharged at INEL would also not discernibly increase the impact to the local ecology.

Operation of the ECF has no effect on cumulative land use impacts. NRF occupies less than 0.02% of the approximately 571,000-acre INEL site and no additional land would be disturbed. Even for the options in which ECF is shut down, there would be no cumulative land use impacts since the site would need to be decommissioned and decontaminated before releasing it for other uses and this work would extend beyond the time frame of this study.

The cumulative impacts associated with non-radiological waste management are also small. The volume of hazardous, municipal, and sanitary wastes produced by ECF has not been calculated; however, considering the nature of the work associated with ECF and the number of workers, the amount of hazardous, municipal, and sanitary waste produced has a small effect on the cumulative impacts associated with this waste. For those options in which ECF is shut down, the effect of these wastes on the cumulative impacts is even smaller.

5.2.17 Unavoidable Adverse Effects

Small amounts of radioactivity, described in Section 5.2.12, would be released as a result of spent fuel operations at ECF, resulting in less than one health effect in the entire population surrounding INEL. The effects of these small releases, combined with the other factors described in Section 5.2.16, would produce no discernible cumulative effects. Similarly, continued operation of the facility would produce limited amounts of liquid sanitary waste and solid municipal waste and solid low-level radioactive waste. These amounts of waste would not differ from those produced in the past by operation of ECF and would not produce any major impacts in the vicinity of INEL.

The most important adverse effect in the vicinity of INEL would be the loss of jobs which would occur if an alternative which shut down the Expended Core Facility were chosen. As discussed in Section 5.2.3 above, approximately 500 people at INEL would lose their jobs if such an alternative were selected.

5.2.18 Irreversible and Irretrievable Commitments of Resources

There are few irreversible or irretrievable commitments of resources, other than costs, at INEL associated with the selection of any of the alternatives considered for naval spent nuclear fuel. The total cost of operating the INEL-ECF is approximately $2.6 billion. This cost represents the total cumulative cost over the 40-year period and includes the operations costs for ECF as well as the construction costs for completing the Dry Cell Facility. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

In the event an alternative which resulted in ceasing operations at the Expended Core Facility were selected, decommissioning and decontamination of ECF would not occur immediately. Instead, the facility would be placed in a safe storage condition while the federal government decided on the proper disposition of the facility, planned the disposition, and programmed funds to carry out the disposition. Any disposition of the facility would be conducted in accordance with applicable federal and state regulations.

5.3 SAVANNAH RIVER SITE

5.3.1 Overview of Environmental Impacts

The following sections discuss the potential environmental consequences that would occur if a replacement for the Expended Core Facility (ECF) were constructed and operated at the Department of Energy's Savannah River Site (SRS) or if the Barnwell Nuclear Fuel Plant (hereafter referred to as the Barnwell Plant) that is adjacent to and contiguous with the SRS were operated for this purpose. Both of these subalternatives will be referred to as the Savannah River ECF. The two proposed sites are depicted as Site A and Site B in Figure 4.3-1. Details of receipt, handling, and examination of naval spent nuclear fuel at the SRS and the modifications to the Barnwell Plant are described in Attachment E.

The environmental consequences of locating the ECF at the SRS are based on the same radiological source terms for normal and accidental releases and the estimated ECF atmospheric emissions, liquid effluents, and solid wastes discussed in Section 5.2. Consistent with the scope of a programmatic Environmental Impact Statement, the environmental effects due to normal and accidental releases were evaluated primarily for Site A. Some variations in the exposure to off-site individuals and workers at other SRS facilities would occur for the Barnwell Plant site. The environmental consequences of locating and operating the ECF at SRS would be similar to those for the ECF at the Idaho National Engineering Laboratory (INEL), and none would be large.

5.3.2 Land Use

Construction of a Savannah River ECF Project at Site A would directly affect about 30 acres of land. The Savannah River ECF site considered and its adjacent environs are relatively diverse and contain both pine stands and mixtures of hardwoods. Construction would not disturb any critical or sensitive ecological habitats, nor would it impact wetland areas. Compared to the INEL-ECF site, however, the Savannah River ECF site is considered more ecologically diverse.

The alternative location at the Barnwell Plant is approximately 6 miles from the Site A location. Forest removal at this site has already been completed, and any additional construction is not expected to have any effect on land use.

Native American rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.3.3 Socioeconomics

The potential socioeconomic impacts associated with construction of the Savannah River ECF are expected to be equal to or less than those associated with the original ECF construction at the INEL because (1) a large movement of construction workers from other areas would not be expected for the Savannah River ECF construction due to the availability of construction craft workers within 70 miles of the SRS (Halliburton 1992); and (2) the six counties surrounding the SRS have a population much larger than the INEL area, which would provide a greater capability to absorb any temporary relocation of construction personnel.

Table 5.3-1 provides a summary of the direct jobs which would be required for the construction and operation of the Savannah River ECF during the 10-year period immediately after the Record of Decision. The greatest number of direct jobs would occur in 1999 during the peak of the construction phase. Estimates of the indirect jobs created as well as the effect on area population are included in Section 5.5.3 of Volume 1 as part of either the Regionalization or Centralization at the SRS alternatives.

Table 5.3-1. Summary of direct jobs due to the Savannah River ECF.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct Jobs	20	20	476	825	1033	894	850	500	500	500

During the Savannah River ECF construction period, operations personnel would be hired so that at the end of the construction period, most of the operations workers would be employed. When fully staffed, ECF operation at the SRS would require approximately 500 people, the same number of operating and support personnel as at the INEL-ECF. This would represent less than 3 percent of the total SRS work force. The six-county region of influence around the SRS had a 1990 population of 425,607 persons, or about twice that of the INEL. The larger population base associated with the SRS region would also provide a greater capability to absorb any personnel moving into the area during the construction period; however, the larger economic base of the SRS region (DOE 1988) would also have a greater tendency to diffuse potential economic benefits compared to the ECF Project at the INEL.

Given the small percentage increase in the number of jobs at the SRS attributable to Savannah River ECF operation, the impacts to local government services and community infrastructures are expected to be small. Volume 1 quantifies these effects. The economic benefits to the SRS region are expected to be similar to or less than those for the INEL region as the existing economic base of the SRS region is much greater and more diverse than the INEL region (DOE 1988).

5.3.4 Cultural Resources

None of the alternatives considered would impact known historical, archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.3.5 Aesthetic and Scenic Resources

The construction of the Savannah River ECF at Site A would directly affect 30 acres of land. As a result of its location and industrial characteristics, there is essentially no aesthetic or scenic impact, since the site would not be visible to the public.

No additional land would need to be cleared if the Barnwell Plant were used for an ECF. The building containing the existing water pool would need to be enlarged as part of the modifications discussed in Attachment E; however, the effect on the scenic resources would be minimal.

5.3.6 Geology

5.3.6.1 General Geology. The local geology of the SRS region determines the locations of the surface waters and groundwaters at the site described in "Reactor Operation Environmental Information Document, Volume I, Geology, Seismology and Subsurface Hydrology" (WSRC 1989). The geology of the SRS region has not been affected by operations conducted at SRS and is not expected to be affected by Savannah River ECF operations.

5.3.6.2 Geologic Resources. The geology of both sites considered has sufficient strength to support construction of the ECF structures, and operation of the Savannah River ECF is not expected to affect any geologic resources.

5.3.7 Air Resources

Toxic chemicals are used in the normal operations of an ECF. The use of these chemicals is controlled to limit the exposure of workers and the public. Airborne emissions from normal operations include the combustion gases from the boiler house, where fuel oil is burned to make steam from space heating. Emergency diesel generators, which are provided for safety, are operated periodically for test purposes and release exhaust fumes to the atmosphere. These emissions would not have any detectable environmental consequence.

The airborne releases of radioactivity for the Savannah River ECF would be the same as the INEL-ECF described in Section 5.2. The airborne release would result in no measurable exposure to on-site personnel or the general population. Details are provided in Attachment F.

5.3.8 Water Resources

5.3.8.1 Surface Water. Water required for construction of the facility would be withdrawn from the Savannah River. The small amount of water withdrawn from the Savannah River would be negligible in comparison to the approximately 4.5 million gallons-per-minute flow near the SRS. No new water intake structure would be required.

Expected surface water withdrawals of 2.5 million gallons per year from the Savannah River during Savannah River ECF operations represent small incremental increases in the amount of water currently being withdrawn by on-going SRS operations (23.2 billion gallons annually) and represent a negligible withdrawal in comparison to the average flow of the Savannah River. There would be no discharge of Savannah River ECF liquids to the Savannah River.

5.3.8.2 Groundwater. Sanitary effluents generated during construction would be treated through either the use of chemical toilets or a wastewater treatment facility. Solid waste generated during construction would be disposed of in the SRS sanitary landfill, which is operated in accordance with State of South Carolina guidelines. Mitigation and control measures for potential spills, fugitive dust, and erosion would be undertaken as part of construction activities.

Sanitary effluents generated as a result of Savannah River ECF operations would be discharged to a wastewater treatment plant. There would be no discharge of radioactive or hazardous liquid effluents to the ground at the Savannah River ECF site. Construction and operation of the Savannah River ECF is not expected to have an effect on the groundwater.

5.3.9 Ecological Resources

5.3.9.1 Terrestrial Ecology. During construction, plant and animal habitats associated with pine and hardwood vegetation communities would be lost or displaced from the construction site. Additionally, construction may have short-term impacts on wildlife beyond the immediate construction site (i.e., impact on area animals due to construction and traffic noise). However, because the affected land area is small compared to the entire SRS, the impacts on wildlife from construction are expected to be minor.

During construction and operation of the Savannah River ECF, all effluents and emissions would comply with regulatory standards. Due to the level of the emissions described in Attachment F, they are not expected to have an impact on the area wildlife. Operation of the Savannah River ECF should result in less noise and traffic than the construction phase, and no effects on terrestrial ecology are expected from Savannah River ECF operation.

5.3.9.2 Wetlands. The only wetlands located on the proposed Savannah River ECF sites are the Carolina Bays located at Site A. Because the Carolina Bays are located on the edge of the proposed site, they can be avoided during construction. Construction and operation of the Savannah River ECF would have no discernible impacts on other wetland areas and habitats at the SRS.

5.3.9.3 Aquatic Ecology. Experience has shown that SRS operations (e.g., reactor operation) can have an adverse effect on the receiving aquatic ecosystems (e.g., L-Lake, Steel Creek, Pen Branch, etc.). However, because there would be no discharge of radioactive or hazardous liquid effluents from Savannah River ECF operation, Savannah River ECF operation is expected to have no effect on the aquatic ecology.

5.3.9.4 Endangered and Threatened Species. The endangered and threatened species are described in Volume 1, Appendix C. The construction and operation of the Savannah River ECF are not expected to have any environmental impact on the endangered and threatened species found at the SRS.

5.3.10 Noise

The SRS is a large area of about 800 square kilometers (310 square miles). If the alternative involving construction of a new facility were selected, the construction of the Savannah River ECF would cause typical construction noises. There would be little or no noise accompanying normal operations of the Savannah River ECF.

5.3.11 Traffic and Transportation

Traffic and transportation would increase slightly in the SRS area if an ECF is constructed and operated at the SRS. The additional traffic would mainly be due to increased commuter traffic from construction workers and 500 operations workers as well as traffic from material shipments during the Savannah River ECF construction.

If the ECF Project were located at the SRS, routine shipments of naval spent nuclear fuel would be transported to the site in certified shipping containers. Low-level waste generated at the facility and transuranic waste would be moved from the facility to an SRS storage facility.

5.3.12 Occupational and Public Health and Safety

The health and safety assessment of normal operations at the Savannah River ECF was based on managing spent nuclear fuel for examination and storage by either of two approaches (i.e., handling in a water pool or in a dry cell). These are the same methods of spent nuclear fuel handling that have been employed or seriously considered for use at the INEL-ECF. The normal operational impacts associated with the Savannah River ECF would be similar to those for the INEL-ECF. The following sections describe the non-radiological and radiological impacts associated with the Savannah River ECF (refer to Section 5.2 for the INEL-ECF impacts).

5.3.12.1 Occupational Health and Safety. Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

During Savannah River ECF construction, workers are not expected to experience elevated background levels of radiation resulting from on-going SRS operations. The gamma radiation measured near the proposed Savannah River ECF site is similar to the radiation levels measured off-site in the SRS area (WSRC 1992). The potential exposure to a construction worker from inhalation of radionuclides released to the atmosphere from existing SRS operations is estimated to be less than 1 millirem per year, which is small compared to the external exposure. The very small exposure received by a construction worker would be well below the naval and Department of Energy (DOE) standard of 5000 millirem per year for occupationally related whole-body and internal exposures.

During operation of the Savannah River ECF, SRS personnel would be exposed to routine atmospheric emissions of radioactivity and might be exposed to potential emissions from accidents. Site A is located approximately 1 mile from the nearest SRS facility, while the Barnwell Plant is located approximately 5 miles from the nearest facility. As shown in Attachment F, no measurable exposure would be received by these collocated workers from normal Savannah River ECF operations. Exposures received by Savannah River ECF radiation workers from normal operations are expected to be similar to the exposures currently received by workers from ECF operation at the INEL, discussed in Section 5.2.12.

5.3.12.2 Public Health and Safety. The impacts of normal operation of the Savannah River ECF would be similar to those for the INEL-ECF. Normal radiological releases to the atmosphere and the quantities of radioactive and hazardous wastes that would be generated would not differ from those previously discussed for the INEL. However, the location of the project relative to the surrounding SRS population and the distances to facilities that would be involved in routine shipments of material would result in differences in potential environmental consequences. Described below are the impacts to the public associated with operation of the Savannah River ECF (refer to Section 5.2.12 for the INEL-ECF impacts).

Assessment of the normal operations of the Savannah River ECF involved two options: fuel handling in a water pool and dry cell handling of fuel for examination and storage. For both options considered, the potential annual exposures were estimated for five different types of people: a worker at the Savannah River ECF site located 100 meters from the release point, the hypothetical maximally exposed collocated worker on the SRS site, the hypothetical maximally exposed off-site individual (MOI), an individual at the nearest public access (NPA), and the population within 80 kilometers (50 miles) of the Savannah River ECF site. Three pathways were included in the analysis: airborne, waterborne, and direct radiation, as applicable.

The results indicate that either the water pool or the dry cell option would be satisfactory for normal operations since the exposure is so low. The analysis shows that the exposure to all the individuals considered (workers, collocated workers, MOI, and NPA) from Savannah River ECF operations would be much less than 1 millirem per year. For perspective, it could be stated that one member of the entire population might experience a fatal cancer due to Savannah River ECF operations if operations continued for over 50,000 years. A description of the analysis methods and more detailed results are provided in Attachment F. The impacts from normal operations for all alternatives are summarized in Section 3.7.

The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.3.12.3 Incident-free Occupational and Public Health and Safety Effects on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the examination of naval spent nuclear fuel at the SRS would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of activities associated with naval spent nuclear fuel examination under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the SRS do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game because of the very small impacts associated with examination of naval spent nuclear fuel.

To place the impacts on environmental justice in perspective, the risk associated with routine operations for naval spent nuclear fuel examination under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.3.13 Utilities and Energy

Heating, ventilation, and electrical systems appropriate to the needs of the Savannah River ECF for suitable working environments and to properly filter and exhaust the airborne discharges to the atmosphere are estimated to require approximately 10,000 MWh per year for normal operations. Emergency diesel electrical generators would provide 350 kw for life support and crucial facility services during power outages. The amount of energy consumed would be a small fraction of the total energy used at SRS, and no discernible environmental consequence is expected.

5.3.14 Facility and Transportation Accidents

The differences in the potential consequences and risks of accidents of a Savannah River ECF compared to the INEL-ECF are related to the meteorological transport of released material, the population exposure, and the distance of transport. The following sections address the potential accident consequences and risks associated with locating an ECF at the SRS.

5.3.14.1 Facility Accidents. The accident scenarios for the Savannah River ECF are the same as those considered for the existing ECF at the INEL. These include radiological accidents which could occur during water pool and dry handling of spent nuclear fuel as well as accidents involving toxic chemicals used at ECF. The general types of radiological accidents analyzed included: (1) accidental criticality, (2) water pool drainage, (3) severe mechanical damage of spent fuel, (4) partial loss of shielding, and (5) an airplane crash into the ECF. Calculations of the cancer fatalities which might occur as a result of all the postulated accidents are provided in Attachment F. A comparison of the accident consequences for all alternatives is provided in Section 3.7.

The difference in the calculated consequences for accidents at the Savannah River ECF compared to the INEL-ECF is that the exposure received by the entire population would be greater at the Savannah River ECF due to the larger population within an 80-kilometer (50-mile) radius of the Savannah River ECF project site. Although the exposure received would be greater at the Savannah River ECF, the number of health effects which would result from any of the accidents considered would be small. The most limiting of the postulated accidents for the Savannah River ECF was an airplane crash into a dry cell facility. If this accident were to occur, the exposure to the entire population from this accident is calculated to cause 4.8 cancer fatalities over 50 years, as described in Attachment F. The risk associated with the airplane crash is 0.0000096 fatal cancers per year.

The exposures to collocated workers following all accidents are below the naval and DOE 5-rem standard for occupational exposure under 50% meteorology conditions. However, exposures to the worker located at the Savannah River ECF site 100 meters from the radiation release point would exceed this standard following an accident resulting in an inadvertent criticality and following an airplane crash.

Effects from accidents at the Savannah River ECF involving toxic chemicals are similar to those described in Section 5.2.14 for the existing INEL-ECF. Due to the amount and types of chemicals stored at the ECF site, toxic chemicals do not pose a risk to the public following any of the postulated accidents. However, following the maximum foreseeable accident analyzed (a fire transient), a number of toxic chemicals would exceed Emergency Response Planning Guideline (ERPG) values for workers on the Savannah River ECF site as well as for collocated workers. For the MOI under either 50% or 95% meteorology conditions, toxic chemical levels do not exceed ERPG-2 values with the ECF at Site A and ERPG-3 values if the ECF is at the Barnwell Plant Site. The concentrations of toxic chemicals as well as a summary of the analysis methods are provided in Attachment F.

5.3.14.2 Transportation Accidents. The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any health effects as a result of naval spent nuclear fuel and test specimen shipments since the risk estimates are much less than one fatal cancer or health effect for each alternative. However, the most severe accident, with a likelihood of occurrence greater than 1×10^{-7} events per year, is estimated to result in a maximum of approximately 2 fatalities. The details of the transportation analysis are provided in Attachment A.

5.3.14.3 Other Impacts of Accidents. In addition to tbe possible buman health effects associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives. The analyses described in Attachment F showed that for the most severe hypothetical accidents, an area of between about 8 acres extending about 1/4 mile downwind (for an accidental criticality) and approximately 210 acres extending about 1 1/4 mile downwind (for a large airplane crash into the fuel examination facility) might be contaminated to the point where exposure could approach 100 millirem per year. Beyond these distances, exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. The area affected by the hypothetical facility accidents would not extend beyond the boundaries of the Savannah River Site. However, if the currently inactive Barnwell Nuclear Fuel Plant were the site of such an accident, the affected area could extend beyond the boundaries of federally owned property. Persons who live in this area might be evacuated or otherwise experience restrictions in their daily activities for a brief period, and those who work at locations within this area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure.

An accident might result in short-term restrictions on access to a relatively small area, but there would be no enduring impacts on cultural or similar resources or concerns such as Native American rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area impacted would vary only slightly among the alternatives. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with an Expended Core Facility at the Savannah River Site would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for an alternative which would relocate the Expended Core Facility to the Savannah River Site. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. As previously stated, there are no endangered or threatened species unique to the area surrounding the location considered for a replacement Expended Core Facility at the Savannah River Site, so an accident would not be expected to result in destruction of any species. The effects of accidents associated with these alternatives or any cleanup which might be performed would be localized in a small area extending only a relatively short distance from the Expended Core Facility and thus would not be expected to appreciably affect the potential for survival of any endangered or threatened species in the Savannab River area. Consequently, consideration of impacts of accidents does not help to distinguish among alternatives.

5.3.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the SRS would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

To place the impacts on environmental justice in perspective, the risk from hypothetical accidents associated with naval spent nuclear fuel examination under any of the alternatives considered would amount to less than one additional fatality per year in the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.3.15 Waste Management

During Savannah River ECF operation, non-radioactive and non-hazardous solid waste and hazardous solid waste would be generated in quantities similar to those for the INEL-ECF. Non-radioactive, non-hazardous wastes would be managed in a manner identical to that for the INEL-ECF (i.e., non-hazardous, non-radioactive solid wastes would be disposed of at a sanitary landfill). Hazardous wastes would be contained at their point of generation and stored at the SRS. Waste management practices for these wastes would produce no identifiable impact on public health and safety of the environment.

Operation of the ECF at the SRS would generate the same quantities of low-level waste, transuranic waste, and mixed wastes as the INEL-ECF. Low-level waste generated by the Savannah River ECF would be stored at the SRS. The 425 cubic meters of low-level waste generated annually by the ECF Project represents a small quantity when compared to the quantity of low-level waste disposed of at the SRS and would not impact planned disposal operations. No high-level waste would be generated.

Less than 0.0001 cubic meter of transuranic waste per year is generated by current ECF operations at the INEL. Any transuranic waste generated by the Savannah River ECF would be in addition to approximately 10,000 cubic meters currently held in storage at the SRS. Transuranic wastes generated at the Savannah River ECF would be a very small fraction of the SRS transuranic waste generated and would not impact planned SRS waste-handling operations.

Mixed wastes generated by Savannah River ECF operation would be stored at the SRS until treatment and disposal facilities are available. The amount of mixed waste generated would represent a small quantity in relation to the quantities requiring storage or disposal from past and on-going SRS operations.

5.3.16 Cumulative Impacts

Up to this point, Section 5.3 has discussed the potential environmental consequences of constructing and operating the ECF Project at the SRS in terms of annual impacts (i.e., radiological doses and health effects, accident risks, and quantities of wastes that would be generated during operation) based on the maximum expected annual throughput of the ECF Project. To determine the potential consequences for 40 years of ECF operation (from 1995 to 2035), an evaluation of the accumulated environmental consequences and risks of constructing and operating the Savannah River ECF was performed.

5.3.16.1 Radiological Cumulative Impacts. The Savannah River Site has not been used for naval spent nuclear fuel operations in the past. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

Operation of the Savannah River ECF will not result in discharges of radioactive liquids; therefore, there would be no changes to the surface or ground water as a result of normal operations for any alternative. There will be small quantities of radioactivity in the air released from ECF which would contribute to the cumulative air quality impacts.

The annual radiological impacts associated with the alternatives where naval spent nuclear fuel would be inspected or stored at SRS are very small and are described in Section 5.3.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the general public from transportation and from Savannah River ECF operations would be less than 14 person-rem. This means that there would be less than 0.0067 fatal cancers from these operations over the entire 40-year period evaluated. The exposure to the maximally exposed off-site individual would be less than 0.2 millirem from 40 years of Savannah River ECF operation at either Site A or the Barnwell Plant. The corresponding risk of a cancer fatality to the maximally exposed off-site individual is 9.6×10^{-9} at Site A and 7.6×10^{-8} at the Barnwell Plant during his or her lifetime. A worker at the Savannah River ECF site located 100 meters from the facility would receive less than 4 millirem over 40 years of Savannah River ECF operation, which corresponds to a 1.4×10^{-6} risk of fatal cancer during the worker's lifetime. These exposures and cancer risks are as a result of ECF operations only. The exposures and risks corresponding to site-wide operations (including ECF) are discussed in Volume 1, Chapter 5.

Analyses of hypothetical accidents which might occur as a result of these alternatives show that the risk of cancer fatalities is small. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

Cumulative impacts due to radioactive waste generation are expected to be minimal. Approximately 425 cubic meters of low-level waste are expected to be generated annually by the Savannah River ECF over the next 40 years. This is not expected to affect the SRS waste management program. Very little transuranic waste or mixed waste and no high-level waste will be generated from Savannah River ECF operations.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

5.3.16.2 Non-radiological Cumulative Impacts. Cumulative socioeconomic impacts associated with constructing and operating the ECF Project at the SRS are expected to be minor. The SRS currently employs over 20,000 people. In the past, no employment at the SRS has been associated with naval spent nuclear fuel operations. Savannah River ECF operations would provide long-term employment for 500 people at the SRS and would help offset predicted future reductions in the SRS work force (Halliburton 1992). The peak number of additional jobs created at the SRS in any given year would be approximately 1050, which includes both construction and operations workers during the peak of the Savannah River ECF construction effort. Considering that the labor force in the region of influence consists of 209,000 people, the additional number of jobs added from the construction and operation of the Savannah River ECF would be expected to have only a minor socioeconomic impact in the SRS area.

Construction and operation of the ECF Project at the SRS are not expected to result in any discernible impacts relative to cumulative non-radiological emissions. Construction of the ECF Project at either Site A or Site B is sufficiently remote and removed from the nearest SRS boundaries such that concentrations of fugitive emissions from construction would be well below applicable standards, as discussed in Section F.4 of Attachment F. Current operations at the SRS are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

As discussed in Section 5.3.8, the withdrawal of surface water for ECF construction and operation at the SRS would be a small percentage of existing withdrawals and well within the cumulative capabilities of the respective water resources. ECF discharges of non-radioactive and non-hazardous liquid effluents at the SRS would not affect water quality. The volume of ECF routine liquid effluents discharged at SRS would also have no measurable impact on aquatic biota or the wetland habitat.

Minimal cumulative land use impacts would be expected to occur as a result of the construction of a new ECF. The land that would be dedicated for this purpose is on existing federal property. The use of this land would not result in the need for additional land to be added to the federally owned property in the foreseeable future. The SRS occupies an area of approximately 800 square kilometers (310 square miles) with only about 5% of the land occupied by constructed facilities. No land area at the Savannah River Site has been affected by past operations involving naval spent nuclear fuel. Construction of the Savannah River ECF would affect 30 acres of land. This is less than 0.02% of the total Savannah River Site land area.

The cumulative impacts associated with non-radiological waste management are also expected to be small. The volume of hazardous waste produced by ECF has not been calculated; however, considering the nature of the work associated with ECF, the amount of hazardous waste produced would have a small effect on the cumulative impacts associated with this waste. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of wastes.

5.3.17 Unavoidable Adverse Effects

The construction of the ECF Project at the SRS would directly impact about 30 acres of land area. An estimated 30 acres of stands of loblolly pine and mixtures of hardwoods would be cleared as part of construction activities for Site A. For the Barnwell Plant, no land would need to be cleared due to the limited amount of construction required for this site. During construction at Site A, plant and animal habitats associated with pine and hardwood vegetation communities would be lost or displaced.

Construction of the Savannah River ECF would also generate liquid effluents, atmospheric emissions, and solid wastes typical of those for construction of a major industrial facility. All effluents and emissions would be below applicable environmental requirements and would not be expected to result in any major adverse impacts.

During Savannah River ECF operation, non-radioactive and non-hazardous solid waste and hazardous solid waste would be generated in quantities similar to those discussed for the INEL. Non-radioactive and non-hazardous solid waste would be disposed of in the SRS sanitary landfill and off-site in a commercial landfill. Hazardous wastes would be stored at the SRS in storage buildings or on storage pads. The Resource Conservation and Recovery Act regulates these wastes. The amount of hazardous waste generated by Savannah River ECF operation would be small in comparison to the amount of hazardous waste that is generated and currently in interim storage at the SRS. No discernible differences from normal hazardous waste management at the SRS would result from this strategy.

During Savannah River ECF operation, unavoidable radiation exposures would include occupational exposures and exposures to the public from normal atmospheric emissions of radioactive materials that would be minimal compared to criteria contained in the Environmental Protection Agency's 40CFR61 and DOE Order 5480.1B. Sanitary waste and service waste liquid discharges would be below applicable environmental standards. Solid wastes generated during operation, including transuranic, low-level, hazardous, and mixed wastes, would result in small increases in potential exposures to radioactive and hazardous materials. Freon emissions would result in a negligible increase in the risk of skin cancer; substitutes will be used when available.

In general, the unavoidable adverse impacts would be few and limited, and none have been identified that would have a detectable effect on public health and safety. The difference in the impacts between the ECF alternative at SRS and the other DOE sites (INEL, Hanford, Oak Ridge, Nevada Test Site) is not discernible.

5.3.18 Irreversible and Irretrievable Commitments of Resources

During operation of the Savannah River ECF, additional fuel oil would be burned to supply steam for heat. The fuel is not in short supply. The water to be used for the Savannah River ECF would be withdrawn from the Savannah River and would be a negligible amount. No new water intake structure would be required, and no observed impacts have resulted from previous withdrawals. Total consumption of water attributable to water pool operations and consumption of potable water by operating personnel represent less than one-thousandth of a percent of the Savannah River average annual flow.

The total cost of locating a new ECF at Savannah River is approximately $3.5 billion. This cost represents the total cumulative costs over the 40-year period and includes construction and operations costs of the new ECF as well as the costs associated with shutting down the INEL-ECF. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives. This cost would be reduced if the Barnwell Plant were selected.

As is the case with the INEL-ECF, construction and operation of the Savannah River ECF would not require the use or consumption of scarce resources.

5.4 HANFORD SITE

5.4.1 Overview of Environmental Impacts

The following sections discuss the potential environmental consequences that would arise if a facility to replace the Idaho National Engineering Laboratory Expended Core Facility (INEL-ECF) were to be constructed and operated at the Department of Energy (DOE) Hanford Site (Hanford ECF). Two options exist at Hanford: build a new ECF between the 200 West and the 200 East Areas, or modify the existing Fuels and Materials Examination Facility (FMEF) in the 400 Area (see Figure 4.4-1). Details of the receipt, handling, and examination of naval spent nuclear fuel at Hanford and the modifications to the FMEF are described in Attachment E. A detailed discussion of the potential environmental consequences of other actions and alternatives at Hanford is contained in Volume 1, Appendix A.

The environmental consequences of constructing and operating the Hanford ECF are based on the same radiological source terms for normal and accidental releases and the estimated atmospheric emissions, liquid effluents, and solid wastes for the INEL-ECF discussed in Section 4.2.

The environmental consequences for the Hanford ECF would be similar to those for the INEL-ECF (see Section 5.2), and none would be large.

5.4.2 Land Use

The Hanford ECF would use essentially the same land area as that which was affected by construction of the INEL-ECF. The structure itself would occupy approximately 5 acres, and the total affected land area would be approximately 30 acres. The higher elevation of the Hanford ECF location relative to a Probable Maximum Flood would reduce the amount of grading and the resulting atmospheric emissions from construction activities.

The land area that would be affected at the Hanford Site has been dedicated through previous operations as a nuclear materials handling area. The land area affected by construction is of the sagebrush vegetation community typical of the arid Hanford Site region. Land areas disturbed by construction but not affected during operation would revert to the natural sagebrush community.

Native American rights and interests may be affected by construction or operations associated with alternatives that involve construction or modification of facilities at the Hanford Site. DOE is assisting Native Americans who have expressed an interest in renewing their use of some Hanford land-use resources, in accordance with the Treaty of 1855. Details are provided in Volume 1, Appendix A.

5.4.3 Socioeconomics

If the Hanford ECF were to be constructed, the potential socioeconomic impacts associated with construction of the facility are expected to be equal to or less than those that were associated with constructing the existing INEL-ECF because: (1) as at the INEL, a large migration of construction workers into the area would not be expected for constructing the project at the Hanford Site due to the availability of construction craft workers who were formerly involved in construction work at the Hanford Site; and (2) the existing population base within 80 kilometers (50 miles) of the Hanford Site is larger than that surrounding the INEL and would provide a larger capability to absorb the incoming construction workers. The estimates of the social and economic requirements of the operational work force expected to be employed during the construction period are small and similar to those estimated for the INEL. Details are available in Volume 1, Appendix A.

Table 5.4-1 provides a summary of the direct jobs which would be required for the construction and operation of the Hanford ECF during the 10-year period immediately after the Record of Decision. The greatest number of direct jobs would occur in 1999 during the peak of the construction phase. Estimates of the indirect jobs created as well as the effect on area population are included in Section 5.5.1 of Volume 1 as part of either the Regionalization or Centralization at Hanford alternatives.

Table 5.4-1. Summary of direct jobs due to the Hanford ECF.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct Jobs	20	20	476	825	1033	894	850	500	500	500

During the construction period, operations personnel would be hired so that at the end of the construction period, most of the workers required for operation and support would be employed. When fully staffed, operation of the Hanford ECF would require approximately 500 people, the same number of operating and support personnel as operation of the INEL-ECF. The total operating work force would represent about 3 percent of the Hanford Site employment. The potential economic benefits to the area are expected to be similar to those for the INEL area. The benefits would result from the new jobs that would be created and the associated jobs that would become reinforced (DOE 1986a).

With the small percentage increase in the number of jobs at the Hanford Site attributable to Hanford ECF operations, the impacts to local government services and community infrastructures are expected to be small. Volume 1 quantifies these effects. The beneficial economic impacts to the region are expected to be similar to the economic benefits for the INEL region.

5.4.4 Cultural Resources

Construction at this site would neither impact any known archaeological and historic sites nor disturb any known habitats for rare or endangered species. None of the alternatives considered would impact known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.4.5 Aesthetic and Scenic Resources

The Hanford Site is in a semi-arid region of southeastern Washington. Since 1943, when the site was selected to become the facility for the production of plutonium for the Manhattan Project, the site has been devoted to research, development, and production activities. As a result of its isolated location, its industrial characteristics are not readily visible to the public. The architecture is compatible with the current industrial setting.

5.4.6 Geology

5.4.6.1 General Geology. The local geology of the Hanford region determines the locations of the surface waters and groundwaters at the site. The geology of the Hanford region is not expected to be affected by the Hanford ECF construction or operations.

5.4.6.2 Geologic Resources. Two geological resources are of particular relevance to the Hanford Site and to its utility as a location for the Hanford ECF. The water table is located several hundred feet beneath the site. The region between the surface and the water table is an unsaturated zone; it provides an effective barrier between the large aquifer in the groundwater below and the radiological work conducted above. No radiological or hazardous liquid effluent from the Hanford ECF would be discharged to the ground. The operation of the Hanford ECF is not expected to alter the character of the unsaturated zone or the aquifer under the Hanford Site.

5.4.7 Air Resources

The meteorology of the Hanford region is described in Section 4.4.7. There is no potential for the construction and operation of the Hanford ECF to have any impacts on the meteorology of the region.

Consideration of general weather parameters in the Hanford region indicates a high potential for air pollution due to frequent low rates of turbulence or mixing in the atmosphere. The lowest rates of mixing in an atmospheric layer are found in thermally stable layers. Thermally stable conditions occur at Hanford about 44 percent of the time, on the average. Neutral conditions (moderate mixing) occur about 31 percent of the time. The highest rates of mixing (thermally unstable) occur only about 25 percent of the time.

The stagnation that results from low mixing permits an abnormally high concentration of pollutants to accumulate from sources within the region. This applies to ordinary pollutants, such as smoke and other exhaust fumes from regional sources, as well as to airborne emissions from Hanford and a Hanford ECF. The normal emissions from a Hanford ECF would be low enough that the increase that might be accumulated during an inversion would not have any discernible environmental consequence. Less than 1 percent of the total calculated number of fatal cancers in the 80-kilometer (50-mile) population would be due to the normal operations of a Hanford ECF.

Some of the chemicals that are used in the normal operations of an ECF are classified as toxic chemicals. The use of these chemicals is controlled to limit the exposure of workers and the public. Airborne emissions from normal operations include the combustion gases from the boiler house, where fuel is burned to make steam for space heating. Emergency diesel generators are provided for safety, are operated periodically for test purposes, and release exhaust fumes to the atmosphere.

The airborne release of radioactivity for the Hanford ECF would be the same as the INEL-ECF described in Section 5.2. The airborne releases would result in no measurable exposure to on-site personnel or the general public. Details are provided in Attachment F.

Experience with construction activities at Hanford indicates that fugitive dust concentrations at the nearest point of public access and at the site boundaries would be less than the Washington State limits. Standard control techniques such as applying water to the disturbed ground could be used to limit the dust emissions at the construction site.

5.4.8 Water Resources

5.4.8.1 Surface Water. Water required for construction would be withdrawn from the Columbia River. The amount of water withdrawn from the Columbia River would be negligible in comparison with the 3400 cubic meters per second (120,000 cubic feet per second) annual average flow rate of the river at the Hanford Site. No new water withdrawal intake structure would be required.

Expected surface water withdrawals from the Columbia River during Hanford ECF operations represent small incremental increases in the amount of water currently being withdrawn by on-going Hanford operations and represent a negligible withdrawal in comparison to the average flow of the Columbia River. There would be no discharge of liquids from the Hanford ECF to either the Columbia or Yakima River.

5.4.8.2 Groundwater. The groundwater at the potential Hanford ECF site is several hundred feet beneath the surface. This distance provides an ample buffer between the surface operations and the aquifer.

There would be no discharge of radioactive or hazardous liquid effluents from the Hanford ECF to the ground. The existence of contamination in the groundwater due to previous operations at the Hanford Site is discussed in Section 4.4.8.

Sanitary effluents generated during construction would be treated through the use of a septic tank and drain field. Solid non-radioactive and non-hazardous waste resulting from construction would be disposed of on-site at a sanitary landfill. Mitigative and control measures for potential spills and fugitive dust emissions would be undertaken as required.

Sanitary effluents generated as a result of Hanford ECF operations would be discharged to a septic tank located outside of the protected-area fence. Effluent from the septic tank would then be discharged to a sanitary tile field. Other liquid effluents, such as process steam condensate that would be within the limits of DOE and federal standards (DOE 1986b; CFR 1991; CFR 1992a), would be monitored and discharged to a tile field. Liquid effluents meeting these standards and requirements would not result in contamination of groundwater resources.

5.4.9 Ecological Resources

The largest impacts would result from the Centralization alternative. It requires the construction and operation of the Hanford ECF. It is expected that these impacts would be small and similar to those already experienced at Hanford from the construction and operation of other facilities of similar size and scope of operations. The expected impacts are discussed in the following subsections.

5.4.9.1 Terrestrial Ecology. Construction of the Hanford ECF would disturb approximately 30 acres of land, and would permanently occupy 5 acres of land. The remaining land would be revegetated with native grasses. There would be some adverse effect on animal populations, especially the less-mobile animals that might be destroyed during land clearing, but the larger ones would move to another location. The small quantities of radioactivity that would be released are expected to have no effect on man, and are expected to have no effect on the terrestrial organisms. Further discussion is provided in Volume 1, Appendix A.

5.4.9.2 Wetlands. Due to the semi-arid nature of the Hanford environment, there are few affected wetland areas. They are found along the Columbia River and in local areas at the edges of ponds where the growth of various plants is enhanced. Hanford ECF operations would not have any adverse impact on these areas. Additional information is provided in Volume 1, Appendix A.

5.4.9.3 Aquatic Ecology. There are no aquatic habitats at the potential site for the Hanford ECF. Hence, there would be no impact on aquatic resources due to construction or operation of the Hanford ECF. Aquatic resources are discussed further in Volume 1, Appendix A. Experience has shown that Hanford operations have not adversely affected its aquatic ecology. The Hanford ECF alternatives are expected to have no adverse impact.

5.4.9.4 Endangered and Threatened Species. Construction and operation of the Hanford ECF would remove approximately 30 acres of sagebrush habitat until it was revegetated and reestablished after construction. This would impact some members of the species that nest and breed there. Similarly, there would be some impact on vegetation and less-mobile animals, but in general the impacts would be local and the affected animals would be expected to relocate to another suitable habitat on the site. Further discussion and mitigation measures are provided in Volume 1, Appendix A.

5.4.10 Noise

The Hanford Site is a very large area, about 1450 square kilometers (560 square miles), but only about 6 percent of the area is occupied by constructed facilities. Other than the normal noises associated with sparsely spaced industrial facilities and air, rail and road traffic, there is essentially no detectable noise on the site. Construction of the Hanford ECF would cause typical construction noises during the construction period. There would be little or no noise accompanying the normal operations of the Hanford ECF.

5.4.11 Traffic and Transportation

Traffic and transportation would increase slightly in the Hanford area if an ECF is constructed and operated at Hanford. The increased traffic would be mainly due to material shipments during Hanford ECF construction and additional commuter traffic from the construction workers and the operations workers.

The Hanford ECF site would be served by railway and roads. Naval spent nuclear fuel and any irradiated test specimens would be shipped by railway in shielded shipping containers from the shipyard, prototype, or test reactor to the Hanford ECF. There they would be examined and prepared for storage at a DOE facility. Stored fuel and scrap specimens would be stored until they would be shipped to a designated site for disposition. Solid, low-level waste from Hanford ECF handling would be transported by roadway to a Hanford shallow land burial site.

5.4.12 Occupational and Public Health and Safety

The health and safety assessment of normal operations at the Hanford ECF is based on handling spent nuclear fuel for examination and storage by either of two approaches: handling in a water pool or handling in a shielded dry cell. These are the same methods of spent nuclear fuel handling that have been used or were seriously considered for use at the INEL-ECF.

The normal operational impacts associated with the Hanford ECF would be similar to those for the INEL-ECF. The following sections describe the non-radiological and radiological impacts associated with the Hanford ECF (refer to Section 5.2 for the INEL-ECF impacts).

5.4.12.1 Occupational Health and Safety. Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

During construction of the Hanford ECF at the Hanford Site, construction personnel would be exposed to a slightly elevated background level of radioactivity resulting from ongoing Hanford Site operations. The maximum additional annual exposure from ongoing operations at the Hanford Site for a construction worker in the vicinity of the 200-East Area would be approximately 2 to 3 millirem if he or she spent 2000 hours per year (40 hours per week for 50 weeks per year) at the Site. This annual exposure of approximately 2 to 3 millirem to a construction worker at the Hanford Site would be well below the DOE standard of 5000 millirem per year for occupational exposure.

During operation of the Hanford ECF, other Hanford personnel would be exposed to routine atmospheric emissions of radioactivity and to potential emissions from accidents. The radiological exposure received by on-site personnel would be below the DOE standard for occupationally related external and internal exposure. Approximately 3000 workers are employed in the 200-East Area within a 1.6-kilometer (1-mile) radius of the Hanford ECF site. Fewer workers are employed near the 400 Area (alternative FMEF site for the Hanford ECF). As shown in Attachment F, the health effects due to exposures received by the collocated worker from normal Hanford ECF operation would be small. Exposures received by Hanford ECF workers are expected to be similar to the exposures that have been received by workers from recent ECF operations at the INEL, discussed in Section 5.2.12.

5.4.12.2 Public Health and Safety. Radiological releases to the atmosphere during normal operations and the quantities of radioactive and mixed wastes normally generated would be approximately the same as those previously discussed for the INEL. However, the location of the Hanford ECF relative to the surrounding Hanford Site population and the distances to other facilities that would be involved in routine shipments of material would result in small differences in potential environmental consequences.

Assessment of the normal operations of the Hanford ECF involved two options: fuel handling in a water pool or dry cell for examination and storage. For both options considered, the potential annual exposures were estimated for five different types of people: a worker at the Hanford ECF site located 100 meters from the release point, the hypothetical maximally exposed collocated worker on the Hanford Site, the hypothetical maximally exposed off-site individual (MOI), an individual at the nearest public access (NPA), and the population within 80 kilometers (50 miles) of the Hanford ECF site. Three pathways were included in the analysis: airborne, waterborne, and direct radiation, as applicable.

The results indicate that either the water pool or the dry cell option would be satisfactory for normal operations since the exposure is so low. The analysis shows that the exposure to all the individuals considered (workers, collocated workers, MOI, and NPA) from Hanford ECF operations would be much less than 1 millirem per year. For perspective, it could be stated that one member of the entire population might experience a fatal cancer due to Hanford ECF operations if operations continued for over 200,000 years. A description of the analysis methods and more detailed results are provided in Attachment F. The impacts from normal operations for all alternatives are summarized in Section 3.7.

The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.4.12.3 Incident-free Occupational and Public Health and Safety Effects on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the examination of naval spent nuclear fuel at the Hanford Site would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of activities associated with naval spent nuclear fuel examination under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the Hanford Site do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game because of the very small impacts associated with examination of naval spent nuclear fuel.

To place the impacts on environmental justice in perspective, the risk associated with routine operations for naval spent nuclear fuel examination under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.4.13 Utilities and Energy

Heating, ventilation, and electrical systems appropriate to the needs of the Hanford ECF for suitable working environments and to properly filter and exhaust the airborne discharges to the atmosphere are estimated to require approximately 10,000 MWh per year for normal operations. Emergency diesel electrical generators would provide 350 kw for life support and crucial facility services during power outages. The increase in electrical power needs might create the demand for additional capacity. The amount of energy consumed would be a small fraction of the total energy used at the Hanford Site, and no discernible environmental consequence is expected.

5.4.14 Facility and Transportation Accidents

The potential consequences and risks of accidents for the Hanford ECF compared to the INEL-ECF are related to the meteorological transport of released material, the population exposed, and (for the transport of naval spent nuclear fuel and any test specimens) the distance of transport. The following sections address the major potential accident consequences and risks associated with the Hanford ECF compared to the INEL-ECF.

5.4.14.1 Facility Accidents. The accident scenarios for the Hanford ECF are the same as those considered for the existing ECF at the INEL. These include radiological accidents which could occur during water pool and dry handling of spent nuclear fuel as well as accidents involving toxic chemicals used at ECF. The radiological accidents analyzed included: (1) an inadvertent criticality caused by an earthquake or similar catastrophic event, (2) accidental loss of large amounts of water containing radioactive material from a water pool into the ground and then into water sources, and (3) severe damage of spent fuel if it were dropped from a crane during handing or had a heavy object dropped on it. The probability of an accident caused by an airplane crash was calculated for the Hanford ECF and was determined to be less than 10^{-7}. Due to the low probability, no consequences were calculated for this accident. Calculations of the cancer fatalities which might occur as a result of all the postulated accidents are provided in Attachment F. A comparison of the accident consequences for all alternatives is provided in Section 3.7.

The difference in the calculated consequences for accidents at the Hanford ECF compared to the INEL-ECF is that the exposure received by the entire population tended to be greater at the Hanford ECF due to the larger population within an 80-kilometer (50-mile) radius of the Hanford ECF project site. Although the exposure received was greater at the Hanford ECF, it is unlikely that any health effects would result from any of the accidents considered. As was the case with the INEL-ECF, the most limiting of the postulated accidents for the Hanford ECF was water pool drainage, ultimately resulting in fuel overheating. The exposure to the entire population from this accident is calculated to cause 0.047 cancer fatalities over 50 years, as described in Attachment F. This amounts to an approximately 5-percent chance of one cancer fatality in 50 years from this potential accident.

The exposures to collocated workers following any accident are well below the naval and DOE 5-rem standard for occupational exposure. However, exposures to the worker located at the Hanford ECF site 100 meters from the radiation release point would exceed this standard following an accident resulting in an inadvertent criticality.

The effects from accidents involving the use of toxic chemicals at the Hanford ECF are similar to those described in Section 5.2.14 for the INEL-ECF. The same amount and types of chemicals stored and used at the INEL-ECF would be used at the Hanford ECF, so toxic chemicals would not pose a risk to the public following any of the postulated accidents. However, following the maximum foreseeable accident analyzed (a fire transient), a number of toxic chemicals would exceed the Emergency Response Planning Guideline (ERPG) values for workers on the Hanford ECF site as well as collocated workers. For the maximum off-site individual (MOI), EPRG-1 values for the toxic chemicals are not exceeded under 50-percent or 95-percent meteorology conditions. The concentrations of toxic chemicals following the fire transient and a summary of the analysis methods are provided in Attachment F.

5.4.14.2 Transportation Accidents. The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancer as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. However, the most severe accident with a likelihood of occurrence greater than 1×10^{-7} events per year is estimated to result in a maximum of approximately 2 cancer fatalities. The details of the transportation analysis are provided in Attachment A.

5.4.14.3 Other Impacts of Accidents. In addition to the possible human health effects associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives. The analyses described in Attachment F showed that for the most severe hypothetical accidents, an area of between about 8 acres extending about 1/4 mile downwind (for an accidental criticality) and approximately 210 acres extending about 1 1/4 mile downwind (for a large airplane crash into the fuel examination facility) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, the exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. Persons who work at locations within this area might be prevented from going to their jobs at the federally owned facilities until measures had been taken to reduce the potential for exposure.

The area affected by the hypothetical accidents would not extend beyond the boundaries of the federally owned Hanford Site. An accident might result in short-term restrictions on access to a relatively small area, but it would not be expected to produce any enduring impacts on cultural or similar resources or concerns such as Native American rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area would vary only slightly among alternatives. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with an Expended Core Facility at the Hanford Site would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for an alternative which would relocate the Expended Core Facility to the Hanford Site. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, any effects on the ecology would be limited to small areas. As previously stated, there are no endangered or threatened species unique to the area surrounding the location considered for a replacement Expended Core Facility at the Hanford Site, so an accident would not be expected to result in destruction of any species. The effects of accidents related to any of the alternatives and any cleanup which might be performed would be localized in a small area which would not extend beyond a relatively short distance from the Expended Core Facility and thus would not be expected to appreciably affect the potential for survival of endangered or threatened species in the Hanford area. Based on these considerations, evaluation of impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.4.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the Hanford Site would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

To place the impacts on environmental justice in perspective, the risk from hypothetical accidents associated with naval spent nuclear fuel examination under any of the alternatives considered would amount to less than one additional fatality per year in the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.4.15 Waste Management

During Hanford ECF operations, non-radioactive and non-hazardous solid waste and hazardous solid waste would be generated in quantities similar to those for the INEL-ECF. These wastes would be managed in a manner identical to that for the INEL-ECF (that is, non-hazardous, non-radioactive solid wastes would be disposed of at a sanitary landfill, and hazardous wastes would be contained at their point of generation and transported off-site to an approved treatment, storage, and disposal facility). During normal waste management practices for these wastes, no identifiable impact on public health and safety or the environment would occur.

Operation of the Hanford ECF would generate essentially the same quantities of low-level waste, transuranic waste, and mixed wastes as discussed for the INEL. Additional information on materials and waste management at Hanford is provided in Volume 1, Appendix A.

5.4.16 Cumulative Impacts

The potential environmental consequences of constructing and operating the Hanford ECF are discussed above in terms of annual impacts (that is, radiological exposures and health effects, accident risks, and quantities of wastes that would be generated during operation) based on the evaluation of operating experiences at the INEL-ECF. This section provides a discussion of the potential consequences of up to 40 years of operation of the Hanford ECF (from 1995 to 2035).

5.4.16.1 Radiological Cumulative Impacts. Operation of the Hanford ECF would not result in discharges of radioactive liquids; therefore, there would be no changes to the surface or ground water as a result of normal operations for any alternative. There would be small quantities of radioactivity in the air released from the Hanford ECF which would contribute to the cumulative air quality impacts. The Hanford Site has not been used for naval spent nuclear fuel operations in the past. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The annual radiological impacts associated with the alternatives where naval spent nuclear fuel would be inspected or stored at Hanford Site are very small and are described in Section 5.4.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the general public from transportation and from Hanford ECF operations would be about 5 person-rem. This means that there would be about 0.0025 fatal cancers from these operations over the entire 40-year period evaluated. The exposure to the maximally exposed off-site individual would be less than 0.02 millirem from 40 years of Hanford ECF operation at either the 200 Area or the FMEF. The corresponding risk of a cancer fatality to the maximally exposed off-site individual is 4.8×10^{-9} at the 200 Area and 8.8×10^{-9} at the FMEF during his or her lifetime. A worker at the Hanford ECF site located 100 meters from the facility would receive less than 4 millirem over 40 years of Hanford ECF operation, which corresponds to a 1.4×10^{-6} risk of fatal cancer during the worker's lifetime. These exposures and cancer risks are as a result of ECF operations only. The exposures and risks corresponding to site-wide operations (including ECF) are discussed in Volume 1, Chapter 5. Analyses of hypothetical accidents which might occur as a result of these alternatives show that the risk of cancer fatalities is small. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

Cumulative impacts due to radioactive waste generation are expected to be minimal. Approximately 425 cubic meters of low-level waste are expected to be generated annually by the Hanford ECF over the next 40 years. This is not expected to affect the Hanford waste management program. Very little transuranic waste or mixed waste and no high-level waste will be generated from Hanford ECF operations.

5.4.16.2 Non-radiological Cumulative Impacts. The cumulative socioeconomic impacts associated with constructing and operating the Hanford ECF are expected to be small. The Hanford Site currently employs over 18,000 people. In the past, no employment at the Hanford Site has been associated with naval spent nuclear fuel operations. Hanford ECF operations would provide long-term employment for 500 people at the Hanford Site. The peak number of additional jobs created at the Hanford Site in any given year would be approximately 1050, which includes both construction and operations workers during the peak of the Hanford ECF construction effort. Considering that the labor force in the region of influence consists of approximately 88,000 people, the additional number of jobs added from the construction and operation of the Hanford ECF would be expected to have only a minor socioeconomic impact in the Hanford area.

Construction and operation of the Hanford ECF are not expected to result in any impacts from cumulative hazardous or toxic emissions. Construction would be sufficiently remote from the nearest site boundaries such that concentrations of any fugitive construction emissions would be well below applicable standards, as discussed in Section F.4 of Attachment F. Current operations at the Hanford Site are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

As discussed in Section 5.4.8, the withdrawal of surface water for construction and operation of the Hanford ECF would be a small percentage of existing withdrawals and well within the cumulative capabilities of the respective water resources. Discharges of ECF non-radioactive and non-hazardous liquid effluents to tile fields at the Hanford Site are not expected to impact groundwater quality (that is, either of itself or on a cumulative basis).

Minimal cumulative land use impacts would be expected to occur as a result of the construction of a new ECF at Hanford. The land that would be dedicated for this purpose is on existing federal property. The use of this land would not result in the need for additional land to be added to the federally owned property in the foreseeable future. The Hanford Site occupies an area of approximately 1450 square kilometers (560 square miles) with only about 6% of the land occupied by constructed facilities. No land area at the Hanford Site has been affected by past operations involving naval spent nuclear fuel. Construction of the Hanford ECF would affect 30 acres of land. This is less than 0.01% of the total Hanford Site land area.

The cumulative impacts associated with non-radiological waste management are expected to be small. The volume of hazardous waste produced by ECF has not been calculated; however, considering the nature of the work associated with ECF, the amount of hazardous waste produced would have a small effect on the cumulative impacts associated with this waste. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of wastes.

5.4.17 Unavoidable Adverse Effects

Construction of the Hanford ECF would directly impact a total of about 120,000 square meters (30 acres) of land area previously dedicated to the handling of nuclear materials, and approximately 400,000 square meters (100 acres) outside the protected site area for the construction of a transmission line and tile field. During construction, plant and animal habitats associated with a sagebrush vegetation community would be lost or displaced from areas not previously disturbed. None of the land area outside the protected site area associated with the construction of the transmission line and less than half of the land area within the protected site area would be affected by operation; the rest would revert to a sagebrush vegetation community through natural plant succession. Modification of the FMEF would have lesser impacts because the construction work would be less extensive. Refer to Attachment E for details.

Construction of the Hanford ECF would also generate liquid effluents, atmospheric emissions, and solid wastes typical of those for construction of a major industrial facility. All effluents and emissions would be below applicable environmental requirements and would not be expected to result in any adverse impact.

During operation of the Hanford ECF, unavoidable radiation exposures would include occupational exposures and exposures to the public from normal atmospheric emissions of radioactive materials that would be minimal compared to the criteria imposed by the "Environment, Safety, and Health Program for Department of Energy Operations" (DOE 1986b) and the "National Emission Standard for Hazardous Air Pollutants" (CFR 1992b). Sanitary and service waste liquid discharges that would eventually be discharged to the soil column through tile fields would all be below applicable environmental standards, including radioactivity standards for drinking water. Solid wastes generated during operation, including transuranic, low-level, hazardous, and mixed wastes, would result in small increases in potential exposures to radioactive and hazardous materials. Freon emissions would be controlled, but might result in a negligible increase in the risk of skin cancer; substitutes would be used when available.

In general, the unavoidable adverse impacts would be few and limited, and none have been identified that would affect public health and safety.

5.4.18 Irreversible and Irretrievable Commitments of Resources

During operation of the Hanford ECF, additional fuel would be burned to supply steam, similar to the levels experienced at the INEL-ECF. The water to be used for the Hanford ECF would be withdrawn from the Columbia River. The amount of water that would be withdrawn from the Columbia River would be negligible. No new water withdrawal intake structure would be required and no observed impacts have resulted from previous withdrawals. Total consumption of water attributable to water pool operations and consumption of potable water by operating personnel represent less than one-thousandth of a percent of the Columbia River average flow rate.

The total cost of locating a new ECF at Hanford would be approximately $3.4 billion. This cost represents the total cumulative cost over the 40-year period and includes construction and operations costs of the new ECF as well as the cost associated with shutting down the INEL-ECF. If the FMEF were to be modified for use as the Hanford ECF, the cost would be less. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

Construction and operation of the Hanford ECF would not require the use or consumption of scarce resources. Expected withdrawals of surface water and groundwater during construction and operation would represent small incremental increases in the amounts of water being withdrawn by ongoing Hanford operations.

5.5 OAK RIDGE RESERVATION

5.5.1 Overview of Environmental Impacts

The following sections discuss the potential environmental consequences that would occur if a replacement for the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) were constructed and operated at the Department of Energy's Oak Ridge Reservation (ORR). This replacement will be referred to as Oak Ridge ECF. The new ECF would be sited near the K-25 Site which is located on the western portion of the ORR (see Figure 4.5-1 of Section 4.5).

The environmental consequences of locating and operating the ECF at ORR are based on the same radiological source terms for normal and accidental releases and the estimated atmospheric emissions, liquid effluents, and solid wastes discussed in Section 5.2 for the ECF at INEL. The environmental consequences of locating and operating the ECF at ORR would be similar to those for the ECF at INEL, and none would be large.

5.5.2 Land Use

Construction of an ECF at ORR would directly affect about 30 acres of land near the already highly developed K-25 Site area. Site preparation for construction would disturb areas of natural vegetation cover which primarily include oak/hickory forest land. The direct loss of terrestrial habitat would be minimized to the extent practical. Following completion of construction, the grounds around the ECF would be landscaped with trees and shrubbery in a manner consistent with other facilities in the K-25 Site area. The affected land area is very small compared to the entire ORR. Native American rights and interests would not be modified by construction or operation of the Oak Ridge ECF.

5.5.3 Socioeconomics

The potential socioeconomic impacts associated with construction of the ECF at ORR are expected to be equal to or less than those associated with the original ECF construction at INEL because (1) a large movement of construction workers from other areas would not be expected for the

Oak Ridge ECF construction due to the availability of construction craft workers in the ORR region and (2) the existing population base within 80 kilometers (50 miles) of the ORR is larger than that surrounding the INEL area and would provide a greater capability to absorb the incoming construction personnel.

Table 5.5-1 provides a summary of the direct jobs which would be associated with construction and operation of the Oak Ridge ECF during the 10-year period immediately following the Record of Decision. The greatest number of direct jobs would occur in 1999 during the peak of the construction phase. Estimates of the indirect jobs created as well as the effect on area population are included in Chapter 5 of Volume 1 for Regionalization at the ORR and for Centralization at the ORR.

Table 5.5-1. Summary of direct jobs due to Oak Ridge ECF construction and operation.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct Jobs	20	20	476	825	1033	894	850	500	500	500

During the Oak Ridge ECF construction period, operations workers would be hired so that at the end of the construction period, most of the 500 operations personnel would be employed. The percentage of operations workers expected to move into the area from other areas varies based on skill requirements. Overall, approximately 20 percent are estimated to move into the ORR area. The four-county region of influence around the ORR had a 1990 population of 489,230 persons, or more than twice that of the INEL.

ECF operations at the ORR would require essentially the same number of operations personnel as at the INEL. This would represent less than 3 percent of the total ORR work force. Given an average family size of 2.6 persons per household for operations personnel moving into the area, the expected population increase attrihutable to operations personnel would represent about 14 percent of the average annual growth rate from 1980 to 1990 in the ORR's four-county region of influence. This percentage of population increase attributahle to Oak Ridge ECF operations in relation to normal population increases in the ORR region might have a short-term, minor impact on local government services and community infrastructures. The economic benefits to the ORR region are expected to be similar to or less than those for the INEL region since the existing economic base of the ORR region is greater and more diverse than that of the INEL region.

5.5.4 Cultural Resources

Construction or operation of the Oak Ridge ECF would not impact known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.5.5 Aesthetic and Scenic Resources

Construction of the Oak Ridge ECF would directly affect 30 acres of land. The proposed facility would be seen from Bear Creek Road as being completely surrounded by undeveloped areas. The forested ridges to the northwest and southeast of this area reduce its visibility from privately owned lands, so that impacts to aesthetic and scenic resources would be minor.

5.5.6 Geology

5.5.6.1 General Geology. Although some ripping or blasting of limestone, dolomite, or quartz layers could be necessary to construct the ECF, no unique geological features would be affected. There are no mining activities in this vicinity that could be impacted by ECF construction or operation. Previously disturbed areas would be regraded to accommodate the new ECF. Sediment runoff from such land disturbances would be minimized by implementation of soil erosion and sediment control measures.

5.5.6.2 Geologic Resources. Since no extensive or unique geologic or mineral resources are known to occur near the K-25 Site, impacts to such resources from ECF construction or operation would not be expected.

5.5.7 Air Resources

Minor short-term emissions of fugitive dust and exhaust from heavy equipment would be possible during Oak Ridge ECF construction. The use of toxic chemicals during ECF normal operations is controlled to limit the exposure of workers and the public. Airborne emissions from normal operations would include the combustion gases from the boiler house, where fuel would be burned to make steam for space heating. Emergency diesel generators, which would be provided for safety, would be operated periodically for test purposes and release exhaust fumes to the atmosphere. The environmental impacts of these emissions would be negligible.

The airborne releases of radioactivity for the ECF at ORR would be the same as for the ECF at INEL described in Section 5.2. The airborne release would result in no measurable exposure to on-site personnel or the general population. Details are provided in Attachment F.

5.5.8 Water Resources

5.5.8.1 Surface Water. Water required for construction of the Oak Ridge ECF would be withdrawn from the Clinch River. The small amount of water withdrawn would be negligible in comparison to the approximately 1.29×10^{10} liters (3.40×10^{9} gallons) per day flow at the Melton Hill Dam. No new water intake structure would be required.

The 2.5 million gallons per year additional surface water withdrawal from the Clinch River during Oak Ridge ECF operations would represent a very small increase in the 6.93×10^{7} liters (1.83×10^{7} gallons) per day currently being withdrawn by ongoing ORR operations and represent a negligible withdrawal in comparison to the average flow of the Clinch River.

Liquid discharges from the Oak Ridge ECF would be treated by a wastewater treatment plant which would be built to service the new DOE spent nuclear fuel facilities. Discharges of treated wastewater to area receiving waters would be in accordance with applicable National Pollutant Discharge Elimination System effluent limits. These discharges would have a negligible impact on the receiving water system. Design controls would render spills and leaks that could contaminate surface or groundwater unlikely.

The Oak Ridge ECF would not be located within the 500-year floodplain.

5.5.8.2 Groundwater. No groundwater would be used for construction and operation of the Oak Ridge ECF, given the plentiful surface water supplies. Therefore, no impact on groundwater levels or quantity is expected. Because there would be no direct discharge of process water to groundwater, and because wastewater would be treated prior to a National Pollutant Discharge Elimination System-permitted discharge to surface waters, no impacts on groundwater are expected.

5.5.9 Ecological Resources

5.5.9.1 Terrestrial Ecology. Areas of natural vegetation cover which primarily include oak/hickory forest land would be disturbed for the Oak Ridge ECF. The loss of terrestrial habitats would be minimized to the extent practical. Construction and traffic noise might have a short-term, minor impact on wildlife beyond the immediate construction site.

During construction and operation of the Oak Ridge ECF, all effluents and emissions would comply with regulatory standards and are not expected to have an impact on the area wildlife. Operation of the Oak Ridge ECF should result in less noise and traffic than the construction phase, and no effects on terrestrial ecology are expected from Oak Ridge ECF operations.

5.5.9.2 Wetlands. Construction of the Oak Ridge ECF may displace forested wetlands adjacent to tributaries of Grassy Creek flowing near the proposed site. This displacement of wetlands would be accomplished in accordance with Corps of Engineers and Tennessee Water Quality Control Administration requirements.

5.5.9.3 Aquatic Ecology. Aquatic habitat would be affected by the rechanneling of tributaries to Grassy Creek during construction of the Oak Ridge ECF. Minor increases in water withdrawal from the Clinch River and water discharged to its tributaries would not greatly affect the aquatic ecology of these water bodies. All wastewater would be discharged in compliance with National Pollutant Discharge Elimination System permit limitations.

5.5.9.4 Endangered and Threatened Species. No known terrestrial or aquatic areas potentially providing habitat to federally listed or state listed threatened or endangered species are found in the construction area; consequently, impacts to threatened and endangered species are not expected to be a concern.

5.5.10 Noise

Noises generated on the ORR do not propagate off-site at levels that impact the general population. Noise increases outside the ORR due to the Oak Ridge ECF would be limited to those produced by truck, car, and train traffic on roads and railroads approaching the ORR. These increases would not be large enough to be objectionable to the communities bordering the roads and railroads.

5.5.11 Traffic and Transportation

Traffic and transportation would increase slightly in the ORR area if an ECF were constructed and operated at ORR. The additional traffic would mainly be due to increased commuter traffic from construction workers and 500 operations workers as well as traffic from material shipments during Oak Ridge ECF construction and operation.

If the Oak Ridge ECF were established, naval spent nuclear fuel would be routinely transported to the ORR in certified shipping containers. Various types of wastes generated at the ECF would be dispositioned on-site and off-site. Following examination, most of the spent nuclear fuel would be transferred to the spent fuel storage location at ORR until the time that permanent geologic storage becomes available.

5.5.12 Occupational and Public Health and Safety

The health and safety assessment of normal operations at the Oak Ridge ECF was based on handling and examination of naval spent nuclear fuel either in a water pool or in a dry cell. These are the same methods of spent nuclear fuel handling that have been employed or seriously considered for use at the ECF at INEL. The normal operational impacts associated with the ECF at ORR would be similar to those for the ECF at INEL. The following sections describe the non-radiological and radiological impacts associated with the ECF at ORR (refer to Section 5.2 for the ECF at INEL impacts).

5.5.12.1 Occupational Health and Safety. Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

During Oak Ridge ECF construction, workers are not expected to experience elevated background levels of radiation resulting from ongoing ORR operations. The potential exposure to a construction worker from inhalation of radionuclides released to the atmosphere from existing ORR operations is expected to be small compared to the external exposure. The exposure received by a construction worker would be well below the naval and Department of Energy (DOE) standard of 5000 millirem per year for occupationally related whole-body and internal exposures.

During operation of the Oak Ridge ECF, ORR personnel would be exposed to routine atmospheric emissions of radioactivity and might be exposed to potential emissions from accidents. The Oak Ridge ECF site is located approximately 1 mile from the nearest ORR facility. As shown in Attachment F, no measurable exposure would be received by these collocated workers from normal Oak Ridge ECF operations. Exposures received by radiation workers from normal operation of the ECF at ORR are expected to be similar to the exposures currently received by workers from normal operation of the ECF at INEL, discussed in Section 5.2.12.

Exposures, injuries, and potential fatalities to workers at the Oak Ridge ECF could also occur as a result of accidents during ECF operations. However, the safety record of the ECF at INEL is very good, and similar safe working conditions could be established at the new facility.

5.5.12.2 Public Health and Safety. The impacts of normal operation of the ECF at ORR would be similar to those for the ECF at INEL. Normal radiological releases to the atmosphere and the quantities of radioactive and hazardous wastes that would be generated would not differ from those previously discussed for the INEL. However, location of the ECF relative to the surrounding ORR population and the distances to facilities that would be involved in routine shipments of material would result in differences in potential environmental consequences. Described below are the impacts to the public associated with operation of the ECF at ORR (refer to Section 5.2.12 for the ECF at INEL impacts).

Assessment of normal operation of the Oak Ridge ECF involved handling and examination of spent fuel either in a water pool or in a dry cell. For both cases, the potential annual exposures were estimated for five different types of people: a worker at the Oak Ridge ECF site located 100 meters from the release point, the hypothetical maximally exposed collocated worker on the ORR site, the hypothetical maximally exposed off-site individual, an individual at the nearest public access, and the population within 80 kilometers (50 miles) of the Oak Ridge ECF site. Three pathways were included in the analysis: airborne, waterborne, and direct radiation, as applicable.

The results indicate that handling and examination of spent fuel either in a water pool or in a dry cell would be satisfactory for normal operations since the exposure is so low. The analysis shows that the exposure to all the individuals considered (workers, collocated workers, and off-site individuals) from Oak Ridge ECF operations would be much less than 1 millirem per year. For perspective, it could be stated that one member of the entire population might experience a fatal cancer due to Oak Ridge ECF operations if operations continued for 20,000 years. A description of the analysis methods and more detailed results are provided in Attachment F. The impacts from normal operations for all alternatives are summarized in Section 3.7.

The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens have been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.5.12.3 Incident-free Occupational and Public Health and Safety Effects on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the examination of naval spent nuclear fuel at the ORR would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of activities associated with naval spent nuclear fuel examination under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the ORR do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game because of the very small impacts associated with examination of naval spent nuclear fuel.

To place the impacts on environmental justice in perspective, the risk associated with routine operations for naval spent nuclear fuel examination under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.5.13 Utilities and Energy

Heating, ventilation, and electrical systems appropriate to the needs of the Oak Ridge ECF for suitable working environments and to properly filter and exhaust the airborne discharges to the atmosphere are estimated to require approximately 10,000 MWh per year for normal operations. Emergency diesel electrical generators would provide 350 kw for life support and crucial facility services during power outages. The amount of energy consumed would be a small fraction of the total energy used at ORR and no discernible environmental consequence is expected.

5.5.14 Facility and Transportation Accidents

The differences in the potential consequences and risks of accidents at the ECF at Oak Ridge compared to the ECF at INEL are related to the meteorological transport of released material, the population exposure, and the distance of transport. The following sections address the potential accident consequences and risks associated with locating an ECF at the ORR.

5.5.14.1 Facility Accidents. A number of hypothetical accidents were evaluated for the Oak Ridge ECF. These included radiological accidents involving naval spent nuclear fuel during water pool storage, dry storage, and dry cell operations as well as accidents involving toxic chemicals used at ECF. Calculations of the cancer fatalities which might occur as a result of all the postulated accidents are provided in Attachment F. A comparison of the accident consequences for all alternatives is provided in Section 3.7.

The difference in the calculated consequences for accidents at the ECF at ORR compared to the ECF at INEL is that the exposure received by the entire population would be greater at the Oak Ridge ECF due to the larger population within an 80-kilometer (50-mile) radius of the Oak Ridge ECF site. Although the exposure received was greater at the Oak Ridge ECF, the number of health effects which would result from any of the accidents considered would be small. The most limiting of the postulated accidents for the ECF at Oak Ridge would be an airplane crash into a dry cell facility. The exposure to the entire population from this accident is calculated to cause 8.4 cancer fatalities over 50 years, as described in Attachment F. The risk associated with the airplane crash would be approximately 0.000008 fatal cancers per year.

Effects from two accidents at the ECF at Oak Ridge involving toxic chemicals were evaluated in Attachment F. The first accident was a chemical spill and fire; the second was a fire involving diesel fuel. Both accidents could expose the public to various toxic chemicals at concentrations which exceed Emergency Response Planning Guidelines (ERPG) level 3 limits. Both accidents could also expose workers at the Oak Ridge ECF to various toxic chemicals at concentrations which exceed ERPG-3 limits. In both cases, however, it is expected that actual toxic chemical exposures would be much less due to the mitigative measures that would be implemented. A summary of the analysis methods, the toxic chemical concentrations, and a discussion of the mitigative measures for toxic chemicals are provided in Attachment F.

5.5.14.2 Transportation Accidents. The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any health effects as a result of naval spent nuclear fuel and test specimen shipments since the risk estimates are much less than one fatal cancer or health detriment for each alternative. However, the most severe accident, with a likelihood of occurrence greater than 1×10^{-7} events per year, is estimated to result in a maximum of 2.1 fatalities. The details of the transportation analysis are provided in Attachment A.

5.5.14.3 Other Impacts of Accidents. In addition to the possible human health effects associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives. The analyses described in Attachment F showed that for the most severe hypothetical accidents, an area of between about 8 acres extending about 1/4 mile downwind (for an accidental criticality) and approximately 210 acres extending about 1 1/4 mile downwind (for a large airplane crash into the fuel examination facility) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, the exposure would be less than 100 millirem per year, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. The area which might be affected by one of these hypothetical accidents could extend slightly beyond the boundaries of the Oak Ridge Reservation, so some people who live in the affected area might be evacuated or otherwise experience restrictions in their daily activities, and those who work at locations within the affected area might be prevented from going to their jobs until measures had been taken to reduce the potential for exposure.

An accident might result in short-term restrictions on access to a relatively small area, but it would not be expected to produce any enduring impacts on cultural or similar resources or concerns such as Native American rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area would vary only slightly among the alternatives. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with an Expended Core Facility at the Oak Ridge Reservation would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for an alternative which would relocate the Expended Core Facility to the Oak Ridge Reservation. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, effects on the ecology should be limited to small areas. As previously stated, there are no endangered or threatened species unique to the area surrounding the location considered for an Expended Core Facility at the Oak Ridge Reservation, so an accident would not be expected to result in destruction of any species. The effects of accidents related to any of the alternatives and any cleanup which might be performed would be localized within a small area which would extend only a relatively short distance from the Expended Core Facility and thus would not be expected to appreciably affect the potential for survival of endangered or threatened species in the vicinity. Based on these considerations, evaluation of the impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.5.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the ORR would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

To place the impacts on environmental justice in perspective, the risk from hypothetical accidents associated with naval spent nuclear fuel examination under any of the alternatives considered would amount to less than one additional fatality per year in the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.5.15 Waste Management

During Oak Ridge ECF operations, non-radioactive and non-hazardous waste and hazardous waste would be generated in quantities similar to those for the ECF at INEL. Solid sanitary and industrial wastes would be disposed of at an on-site landfill. Hazardous solid wastes would be contained at their point of generation and transported off-site to an approved disposal facility. Waste management practices for these wastes would produce no identifiable impact on public health or safety of the environment.

Operation of the ECF at ORR would generate the same quantities of radioactive low-level waste, transuranic waste, and mixed wastes as the ECF at INEL. Low-level waste generated by the Oak Ridge ECF would be stored on-site pending a future disposal action. The 425 cubic meters (556 cubic yards) of low-level waste generated annually by the ECF at INEL represents a small fraction of the low-level waste managed at ORR. No high-level waste would be generated.

Less than 0.0001 cubic meter of transuranic waste per year is generated by current ECF operations at the INEL. Any transuranic waste generated by the Oak Ridge ECF would be a very small fraction of the transuranic waste at ORR and would not impact planned waste handling operations. Much of the newly generated and retrievably stored transuranic waste at ORR will be treated and certified for eventual disposal at the DOE Waste Isolation Pilot Project.

Any mixed waste generated by Oak Ridge ECF operations would be stored on-site pending a future disposal action. This would represent a very small fraction of the mixed waste at ORR from past and ongoing operations requiring disposition.

5.5.16 Cumulative Impacts

Up to this point, Section 5.5 has discussed the potential environmental consequences of constructing and operating the ECF at the ORR in terms of annual impacts (i.e., radiological doses and health effects, accident risks, and quantities of wastes that would be generated during operations) based on the maximum expected annual workload of the ECF. To determine the potential consequences for 40 years of ECF operation (from 1995 to 2035), an evaluation of the accumulated environmental consequences and risks of constructing and operating the Oak Ridge ECF was performed.

5.5.16.1 Radiological Cumulative Impacts. Operation of the Oak Ridge ECF would not result in discharges of radioactive liquids; therefore, there would be no changes to the surface or ground water as a result of normal ECF operations. There would be small quantities of radioactivity in the air released from ECF which would contribute to the cumulative air quality impacts.

The Oak Ridge Reservation has not been used for naval spent nuclear fuel operations in the past. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

The annual radiological impacts associated with the alternatives where naval spent nuclear fuel would be inspected or stored at ORR are very small and are described in Section 5.5.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure to the general public from transportation and from Oak Ridge ECF operations would be approximately 15 person-rem. This means that there might be 0.0075 fatal cancers from these operations over the entire 40-year period evaluated. The exposure to the maximally exposed off-site individual would be 4 millirem from 40 years of Oak Ridge ECF operation. The corresponding risk of a cancer fatality to the maximally exposed off-site individual is

2.0×10^{-6} during his or her lifetime. A worker at the Oak Ridge ECF site located 100 meters from the facility would receive less than 5 millirem over 40 years of Oak Ridge ECF operation, which corresponds to a 1.9×10^{-6} risk of fatal cancer during the worker's lifetime. These exposures and cancer risks are as a result of ECF operations only. The exposures and risks corresponding to site-wide operations (including ECF) are discussed in Volume 1, Chapter 5. Analyses of hypothetical accidents which might occur as a result of these alternatives show that the risk of cancer fatalities is small. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

Cumulative impacts due to radioactive waste generation are expected to be minimal. Approximately 425 cubic meters (556 cubic yards) of low-level waste are expected to be generated annually by the Oak Ridge ECF over the next 40 years. This is not expected to affect the ORR waste management program. Very little transuranic waste or mixed waste and no high-level waste will be generated from Oak Ridge ECF operations.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

5.5.16.2 Non-radiological Cumulative Impacts. The cumulative socioeconomic impacts associated with constructing and operating the Oak Ridge ECF are expected to be minor. The Oak Ridge Reservation employs over 17,000 people. In the past, no employment at the ORR has been associated with naval spent nuclear fuel operations. Oak Ridge ECF operations would provide long-term employment for 500 people at the ORR. The peak number of additional jobs created at the ORR in any given year would be approximately 1050, which includes both construction and operations workers during the peak of the Oak Ridge ECF construction effort. Considering that the labor force in the region of influence consists of over 292,000 people, the additional number of jobs added from the construction and operation of the Oak Ridge ECF would be expected to have only a minor socioeconomic impact in the Oak Ridge area.

Construction and operation of the Oak Ridge ECF are not expected to result in any discernible impacts relative to cumulative non-radiological emissions. Construction of the ECF is sufficiently remote and removed from the nearest ORR boundaries such that concentrations of fugitive emissions from construction would be well below applicable standards, as discussed in Section F.4 of Attachment F. Current operations at the Oak Ridge Reservation are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

The withdrawal of surface water for ECF construction and operation at the ORR would be a small percentage of existing withdrawals and well within the cumulative capabilities of the respective water resources. Discharges of ECF non-radioactive and non-hazardous liquid effluents at the ORR would have no measurable impact on water quality or aquatic ecology.

Minimal cumulative land use impacts would be expected to occur as a result of the construction of a new ECF. The land that would be dedicated for this purpose is on existing federal property. The use of this land would not result in the need for additional land to be added to the federally owned property in the foreseeable future. The Oak Ridge Reservation occupies an area of approximately 140 square kilometers (54 square miles) with only about 8% of the land occupied by the Y-12 Plant, K-25 Site, and Oak Ridge National Laboratory. No land area at the Oak Ridge Reservation has been affected by past operations involving naval spent nuclear fuel. Construction of the Oak Ridge ECF would affect 30 acres of land. This is less than 0.09% of the total Oak Ridge Reservation land area.

The cumulative impacts associated with non-radiological waste management are also expected to be small. The volume of hazardous waste produced by ECF has not been calculated; however, considering the nature of the work associated with ECF, the amount of hazardous waste produced would have a small effect on the cumulative impacts associated with this waste. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the.number of additional workers added, and this small incremental increase would not be discernible. The amount of non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of wastes.

5.5.17 Unavoidable Adverse Effects

Construction of an ECF at ORR would directly affect about 30 acres of land area. Site preparation for construction would disturb areas of natural vegetation cover which primarily include oak/hickory forest land. The direct loss of terrestrial habitat would be minimized to the extent practical.

Construction of the Oak Ridge ECF would also generate liquid effluents, atmospheric emissions, and solid wastes typical of those for construction of a major industrial facility. All effluents and emissions would be below applicable environmental requirements and would not be expected to result in any major adverse impacts.

During Oak Ridge ECF operations, non-radioactive and non-hazardous waste and hazardous waste would be generated in quantities similar to those discussed for the INEL. Solid sanitary and industrial wastes would be disposed of in an ORR landfill. Hazardous wastes would be contained at their point of generation and transported off-site to an approved disposal facility. The amount of hazardous waste generated by Oak Ridge ECF operations would be small in comparison to the amount of hazardous waste that is generated at the ORR. No discernible differences from normal hazardous waste management at the ORR would result from this strategy.

During Oak Ridge ECF operations, unavoidable radiation exposures would include occupational exposures and exposures to the public from normal atmospheric emissions of radioactive materials that would be small compared to criteria contained in 40CFR Part 61.92 and DOE Order 5480.1B. Sanitary waste and service waste liquid discharges would be below applicable environmental standards. Solid wastes generated during operations, including transuranic, low-level, hazardous, and mixed wastes, would result in small increases in potential exposures to radioactive and hazardous materials.

Construction and operation of the Oak Ridge ECF would not require the use or consumption of scarce resources. Expected surface water withdrawals during construction and operation would represent small incremental increases in the amount of water being withdrawn by ongoing ORR operations. In general, the unavoidable adverse impacts would be few and limited, and none have been identified that would have a detectable effect on public health and safety. The difference in the impacts between the ECF alternative at ORR and the other DOE sites (INEL, Savannah River, Hanford, Nevada Test Site) is not discernible.

5.5.18 Irreversible and Irretrievable Commitments of Resources

During operation of the Oak Ridge ECF, additional fuel would be burned to supply steam for heat. The fuel is not in short supply. The water to be used for the Oak Ridge ECF would be withdrawn from the Clinch River and would be a small amount. No new water intake structure would be required, and no observed impacts have resulted from previous withdrawals. Total consumption of water attributable to water pool operations and consumption of potable water by operations personnel represent less than one-thousandth of a percent of the Clinch River average annual flow.

The total cost of locating a new ECF at Oak Ridge is approximately $3.5 billion. This cost represents the total cumulative cost over the 40-year period and includes construction and operation costs of the new ECF as well as the cost associated with shutting down the ECF at INEL. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

As is the case with the ECF at INEL, construction and operation of the ECF at ORR would not require the use or consumption of scarce resources.

5.6 NEVADA TEST SITE

5.6.1 Overview of Environmental Impacts

The following sections discuss the potential environmental consequences that would occur if a replacement for the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) were constructed and operated at the Department of Energy's Nevada Test Site (NTS). This facility will be referred to as the Nevada ECF. The affected environment for the proposed site, depicted on Figure 4.6-1, is discussed briefly in Section 4.6 and in greater detail in Volume 1, Appendix F.

The environmental consequences of locating and operating the ECF at NTS are based on the same radiological source terms for normal and accidental releases and the estimated atmospheric emissions, liquid effluent, and solid wastes discussed in Section 5.2 for the ECF at INEL. The environmental consequences of locating and operating the Nevada ECF would be similar to those for the ECF at INEL, and none would be large.

5.6.2 Land Use

Over 40.5 square kilometers (10,000 acres) of land exists in the area being considered as a location for the proposed Nevada ECF. This is in the same general area being considered for the proposed spent nuclear fuel storage facility discussed in Volume 1, Appendix F. Construction of an ECF at NTS would directly affect about 30 acres of land. This would result in only a minimal reduction in the available land base of the NTS. Located next to Mercury Highway, the proposed area would support construction and maintenance of an ECF, railcar holding facilities, and necessary support facilities. The ECF facilities would be compatible with all existing and presently foreseeable NTS facilities. The affected land area is small compared to the entire NTS. Native American rights and interests would not be modified by construction or operations associated with any of the alternatives considered.

5.6.3 Socioeconomics

The potential socioeconomic impacts associated with construction of the Nevada ECF are expected to be equal to or less than those associated with the original ECF construction at the INEL because (1) a large movement of construction workers from other areas would not be expected for the Nevada ECF construction due to the availability of construction craft workers in the Las Vegas area; and (2) the counties surrounding the NTS have a population adequate to absorb any temporary relocation of construction personnel.

Table 5.6-1 provides a summary of the direct jobs which would be required for the construction and operation of the Nevada ECF during the 10-year period immediately after the Record of Decision. The greatest number of direct jobs would occur in 1999 during the peak of the construction phase. Estimates of the indirect jobs created as well as the effect on area population are included in Section 5.5.6 of Volume 1 as part of either the Regionalization or Centralization at the Nevada Test Site alternatives.

Table 5.6-1. Summary of direct jobs due to the Nevada ECF.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct Jobs	20	20	476	825	1033	894	850	500	500	500

During the Nevada ECF construction period, operations personnel would be hired so that at the end of the construction period, most of the operations workers would be employed. The percentage of operations workers expected to move into the area from other areas varies based on skill requirements. Overall, approximately 20 percent are estimated to move into the NTS area. The Las Vegas Metropolitan Service Area, which constitutes the major portion of the population in the region of influence, had a 1990 population of 735,000 and an estimated population of 900,000 as of August 1993.

The Nevada ECF operation would require essentially the same number of operations personnel (500) as at the INEL. This would represent a relatively small percentage of the total NTS work force. Given the 20-percent estimate for immigration and an average family size of 2.6 persons per household for operations personnel moving into the area, the expected population increase attributable to the operating personnel would be 260 persons.

Given the small percentage of population increase attributable to Nevada ECF operations in relation to normal population increases in the NTS region, no major adverse impacts to local government services and community infrastructures are expected. The economic benefits to the NTS region are expected to be similar to those for the INEL region.

5.6.4 Cultural Resources

Construction at the site considered for the Nevada ECF would not impact any known archaeological or Native American sites. Procedures which comply with all applicable laws and regulations would be implemented to protect previously undetected archaeological and cultural sites.

5.6.5 Aesthetic and Scenic Resources

The construction of the Nevada ECF would directly affect approximately 30 acres of land. As a result of its location and industrial characteristics, there is essentially no aesthetic or scenic impact since the site would not be visible to the public.

5.6.6 Geology

5.6.6.1 General Geology. The local geology of the NTS region has been impacted as a result of past nuclear testing. This impact has been in the form of surface faulting. Because construction and operation of the Nevada ECF would not produce forces near the magnitude of those produced from past nuclear tests, it is highly unlikely that this activity would cause additional faulting.

5.6.6.2 Geologic Resources. Precious metals may exist in certain carbonate rocks and volcanic or sedimentary rocks at the NTS. The Nevada ECF would not be located within a mining district and the site will likely remain closed to mining operations so the impact to any precious metal deposits that may exist at the NTS will not change if the proposed facility is sited there.

5.6.7 Air Resources

Minor short-term emissions of fugitive dust and exhaust from heavy equipment would be possible during Nevada ECF construction. The use of toxic chemicals during ECF normal operations would be controlled such that the exposure levels of workers and the public would be negligible. Airborne emissions from normal operations would include the combustion gases from the boiler house, where fuel would be burned to make steam for space heating. Emergency diesel generators, which would be provided for safety, would be operated periodically for test purposes and release exhaust fumes to the atmosphere. These emissions would not have any detectable environmental consequence.

The airborne releases of radioactivity for the ECF at NTS would be the same as for the ECF at INEL described in Section 5.2. The airborne release would result in no measurable exposure to on-site personnel or the general population. Details of the analyses supporting this conclusion are provided in Attachment F.

5.6.8 Water Resources

5.6.8.1 Surface Water. As stated in Section 4.6.8, with the exception of short periods of runoff from spring discharges, there is no perennial surface water at the NTS. As such, the daily water supply required to operate the Nevada ECF could not be obtained from local surface waters. In fact, the NTS currently derives its complete water supply from the groundwater aquifers. Therefore, the construction and operation of the Nevada ECF would have no impact on the quantity and quality of surface water in the area.

There are no National Pollutant Discharge Elimination System permits for the NTS, as there are no wastewater discharges to on-site and off-site surface waters. NTS wastewaters are discharged to sewage lagoons. Therefore, all wastewaters associated with the construction and operation of the Nevada ECF would likely be discharged into the on-site lagoon system along with the other wastewaters generated at the NTS. Thus, surface water quantity and quality in the NTS area would not be expected to be impacted.

5.6.8.2 Groundwater. The NTS currently extracts groundwater from aquifers within two hydrographic subbasins: Alkali Flat-Furnace Creek Ranch and Ash Meadows. These subbasins, along with their specific hydrographic areas and NTS well locations, are described in Section 5.8 of Volume 1, Appendix F. The 2.5 million gallons per year additional withdrawal of water from these aquifers required for operation of an ECF represents less than a 3-percent increase over the present rate at which water is withdrawn for use in Area 6 and less than 0.5 percent of the total NTS usage rate.

5.6.9 Ecological Resources

5.6.9.1 Terrestrial Ecology. During construction and operation of the Nevada ECF, all effluent and emissions would comply with regulatory standards and are not expected to have an impact on the area wildlife. Operation of the Nevada ECF should result in less noise and traffic than the construction phase, and no effects on terrestrial ecology are expected from Nevada ECF operations.

5.6.9.2 Wetlands. National Wetland Inventory maps of the NTS have not been prepared, nor have wetlands been delineated on the site. However, available information indicates that wetlands on the NTS are limited in distribution and extent. Small areas of wetlands could be present in or on the margins of the surface drainages, playas, and reservoirs on the NTS. It is expected that construction and operation of the Nevada ECF would have negligible impact on any wetlands.

5.6.9.3 Aquatic Ecology. Because there would be no discharge of radioactive or hazardous liquid effluent from Nevada ECF operation, these operations are expected to have no effect on the aquatic ecology.

5.6.9.4 Endangered and Threatened Species. The endangered and threatened species are described in Section 4.6.9. The desert tortoise is the only federally listed species that could be affected by the construction of an ECF facility. Forty-five percent of the total known desert tortoise habitat is located in the Yucca Mountains. The area that could be affected directly by the proposed ECF are Frenchman Flat and the southern bajada of Control Point Hills.

Construction and maintenance of roads, utility and communication lines, buildings, water pipelines, sewage lagoons, and other facilities could result in harm or harassment of desert tortoises and loss of habitat. Tortoises could become injured by falling into open trenches or other temporary construction excavations and might not be able to escape. They could become submerged in water storage ponds, wastewater lagoons, and other impoundments not fenced to exclude them.

5.6.10 Noise

Noises generated on the NTS do not propagate off-site at levels that impact the general population. Noise increases outside the NTS due to the Nevada ECF would be limited to those produced by truck, car, and train traffic on roads and railroads approaching the NTS. These increases would not be large enough to be objectionable to the areas bordering the roads and railroads.

5.6.11 Traffic and Transportation

Traffic and transportation would increase in the area if an ECF is constructed and operated at the NTS. The additional traffic would mainly be due to increased commuter traffic from construction workers and 500 operations workers as well as traffic from material shipments during the Nevada ECF construction.

If the Nevada ECF were established, naval spent nuclear fuel would be routinely transported to the site in certified shipping containers. Various types of wastes generated at the facility would be dispositioned on-site and off-site. Following examination, most of the naval spent nuclear fuel would be transferred to the spent fuel storage location on the NTS until the time that permanent geologic storage becomes available.

5.6.12 Occupational and Public Health and Safety

The health and safety assessment of normal operations at the Nevada ECF was based on handling and examination of spent nuclear fuel either in a water pool or in a dry cell. These are the same methods of spent nuclear fuel handling that have been employed or seriously considered for use at the ECF at INEL. The normal operational impacts associated with the Nevada ECF would be similar to those for the ECF at INEL. The following sections describe the non-radiological and radiological impacts associated with the ECF at NTS (refer to Section 5.2 for the ECF at INEL impacts).

5.6.12.1 Occupational Health and Safety. Projections of the number of occupational accidents that might occur during construction and operation of naval spent nuclear fuel storage and examination facilities have been made for each alternative. These projections are presented in Attachment F. Based on the results of these projections, it is concluded that the number of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations would be very small for any alternative.

During Nevada ECF construction, workers are not expected to experience elevated background levels of radiation resulting from on-going NTS operations. The gamma radiation measured near the proposed Nevada ECF site is similar to the radiation levels measured off-site in the NTS area. The potential exposure to a construction worker from inhalation of radionuclides released to the atmosphere from previous and current NTS operations is expected to be small compared to the external exposure. The exposure received by a construction worker would be well below the naval and Department of Energy (DOE) standard of 5000 millirem per year for occupationally related whole-body and internal exposures.

During operation of the Nevada ECF, NTS personnel would be exposed to routine atmospheric emissions of radioactivity and might be exposed to potential emissions from accidents. The Nevada ECF site is located approximately 3 miles from the Radioactive Waste Management Facility, which is the nearest existing NTS facility. As shown in Attachment F, no measurable exposure would be received by these collocated workers from normal Nevada ECF operations. Exposures received by radiation workers from normal operation of the ECF at NTS are expected to be similar to the exposures currently received by workers from normal operation of the ECF at INEL, discussed in Section 5.2.12.

Exposures, injuries, and potential fatalities to workers at the Nevada ECF could also occur as a result of accidents during ECF operations. However, the safety record of the ECF at INEL is very good, and similar safe working conditions could be established at the new facility.

5.6.12.2 Public Health and Safety. The impacts of normal operation of the Nevada ECF would be similar to those for the ECF at INEL. Normal radiological releases to the atmosphere and the quantities of radioactive and hazardous wastes that would be generated would not differ from those previously discussed for the INEL. However, the location of the project relative to the surrounding NTS population and the distances to facilities that would be involved in routine shipments of material would result in differences in potential environmental consequences. Described below are the impacts to the public associated with operation of the ECF at NTS (refer to Section 5.2.12 for the ECF at INEL impacts).

Assessment of the normal operations of the Nevada ECF involved handling and examination of spent fuel either in a water pool or in a dry cell. For both cases, the potential annual exposures were estimated for five different types of people: a worker at the Nevada ECF site located 100 meters from the release point, the hypothetical maximally exposed collocated worker on the NTS site, the hypothetical maximally exposed off-site individual, an individual at the nearest public access, and the population within 80 kilometers (50 miles) of the Nevada ECF site. Three pathways were included in the analysis: airborne, waterborne, and direct radiation, as applicable.

The results indicate that handling and examination of spent fuel either in a water pool or in a dry cell would be satisfactory for normal operations since the exposure is so low. The analysis shows that the exposure to all the individuals considered (workers, collocated workers, and off-site individuals) from Nevada ECF operations would be much less than one millirem per year. For perspective, it could be stated that one member of the entire population might experience a fatal cancer due to Nevada ECF operations if operations continued for over 11 million years. A description of the analysis methods and more detailed results are provided in Attachment F. The impacts from normal operations for all alternatives are summarized in Section 3.7.

The radiological and non-radiological health effects associated with the incident-free transportation of naval spent nuclear fuel and test specimens bave been assessed for the general population, transportation workers, and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any fatal cancers as a result of naval spent nuclear fuel and test specimen shipments since the estimates are much less than one fatal cancer for each alternative. The details of the transportation analysis are provided in Attachment A.

5.6.12.3 Incident-free Occupational and Public Health and Safety Effects on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from normal operations associated with the examination of naval spent nuclear fuel at the NTS would be small under any of the alternatives considered. For example, it is unlikely that a single fatal cancer would occur as a result of activities associated with naval spent nuclear fuel examination under any alternative. Since the potential impacts due to normal operations or accident conditions for any of the alternatives considered present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects would be expected for any particular segment of the population, minorities and low-income groups included.

The conclusion that there would be no disproportionately high and adverse impacts on human health or the environment is not affected by the prevailing winds or direction of surface or subsurface water flow. This is true for normal operations because the effects of routine operations are so small. It is also true for accident conditions because the consequences of any accident would depend on the random conditions at the time it occurred, and the wind directions at the NTS do not display any strongly dominant direction. Similarly, the conclusion is not affected by concerns related to subsistence consumption of fish or game because of the very small impacts associated with examination of naval spent nuclear fuel.

To place the impacts on environmental justice in perspective, the risk associated with routine operations for naval spent nuclear fuel examination under any of the alternatives considered would be less than one fatality per year for the entire population. For comparison, in 1990 there were approximately 510,000 cancer deaths in the United States population and there were about 64,000 cancer deaths among people of color in the U. S. Even if all of the impacts associated with one of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would be unlikely to experience a single additional cancer fatality in any year. Therefore, the cancer risk for that population from naval spent nuclear fuel management would not constitute a disproportionately high and adverse impact on human health or the environment. The same conclusion can be drawn for low-income groups.

5.6.13 Utilities and Energy

Heating, ventilation, and electrical systems appropriate to the needs of the Nevada ECF for suitable working environments and to properly filter and exhaust the airborne discharges to the atmosphere are estimated to require approximately 10,000 MWh per year for normal operations. This would represent about a 4-percent increase in NTS electrical consumption and may require transmission line upgrades. Emergency diesel electrical generators would provide 350 kW for crucial facility services during power outages.

5.6.14 Facility and Transportation Accidents

The differences in the potential consequences and risks of accidents at the ECF at NTS compared to the ECF at INEL are related to the meteorological transport of released material, the population exposure, and the distance of transport. The following sections address the potential accident consequences and risks associated with locating an ECF at the NTS.

5.6.14.1 Facility Accidents. A number of hypothetical accidents were evaluated for the Nevada ECF. These included radiological accidents involving naval spent nuclear fuel during water pool storage, dry storage, and dry cell operations, as well as accidents involving toxic chemicals used at ECF. Calculations of the cancer fatalities which might occur as a result of all the postulated accidents are provided in Attachment F. A comparison of the accident consequences for all alternatives is provided in Section 3.7.

The difference in the calculated consequences for accidents at the Nevada ECF compared to the ECF at INEL is that the exposure received by the entire population would be less at the Nevada ECF due to a different population distribution within an 80-kilometer (50-mile) radius of the site. The most limiting of the postulated accidents for the Nevada ECF would be an airplane crash into a dry cell facility. The exposure to the entire population from this accident is calculated to cause 0.18 cancer fatalities over 50 years, as described in Attachment F.

The exposures to collocated workers following all accidents are well below the naval and DOE standard of 5 rem per year for occupational exposure. However, exposures to the worker located at a Nevada ECF site 100 meters from the radiation release point could exceed this standard following an accident resulting in an inadvertent criticality or an airplane crash into a dry cell.

Effects from accidents at the Nevada ECF involving toxic chemicals are similar to those described in Section 5.2.14 for the existing ECF at INEL. Due to the amount and types of chemicals stored at the ECF site, toxic chemicals do not pose a risk to the public following any of the postulated accidents. However, following the maximum foreseeable accident analyzed (a fire transient), a number of toxic chemicals would exceed Emergency Response Planning Guideline (ERPG) values for workers on the Nevada ECF site. For the maximum off-site individual, ERPG-2 values for the toxic chemicals are not exceeded under either 50% meteorology or 95% meteorology conditions. The concentrations of toxic chemicals as well as a summary of the analysis methods are provided in Attachment F.

5.6.14.2 Transportation Accidents. The health effects associated with accidents during shipments of naval spent nuclear fuel and test specimens have been assessed for the general population and hypothetical maximum exposed individual for each alternative. As summarized in Section 3.7, it is unlikely that there will be any health effects as a result of naval spent nuclear fuel and test specimen shipments since the risk estimates are much less than one fatal cancer or detrimental health effect for each alternative. However, the most severe accident, with a likelihood of occurrence greater than 1×10^{-7} events per year, is estimated to result in a maximum of 2.1 fatalities. The details of the transportation analysis are provided in Attachment A.

5.6.14.3 Other Impacts of Accidents. In addition to the possible human health effects associated with facility or transportation accidents described in the preceding sections, other effects such as the impacts on socioeconomics and land use in the area and the costs of cleanup have been estimated in order to develop a perspective and to evaluate potential differences among alternatives. The analyses described in Attachment F showed that for the most severe hypothetical accidents, an area of between about 8 acres extending about 1/4 mile downwind (for an accidental criticality) and approximately 210 acres extending about 1 1/4 mile downwind (for a large airplane crash into the fuel examination facility) might be contaminated to the point where exposure could exceed 100 millirem per year. Beyond these distances, the exposure would be less than 100 millirem, the Nuclear Regulatory Commission's standard for protection of the general population from radiation. The area affected by the hypothetical accidents would not extend beyond the boundaries of the Nevada Test Site. Persons who work at locations within this area might be prevented from going to their jobs at the federally owned facilities until measures had been taken to reduce the potential for exposure.

An accident might result in short-term restrictions on access to a relatively small area, but it would not be expected to produce any enduring impacts on cultural or similar resources or concerns such as Native American rights or interests, partially because the area involved would be small and partly because all remedial actions would be conducted in a careful, controlled manner in full compliance with applicable laws and regulations. The area would vary only slightly among the alternatives. Overall, the risks are small so these considerations do not assist in distinguishing among alternatives.

Facility or transportation accidents associated with an Expended Core Facility at the Nevada Test Site would not have an appreciable effect on the ecology of the area, considering the potential for human health effects and the amount of land which might be affected, as described in earlier parts of this section. There is little consensus among scientists on methods for estimating the effects of radiation on ecological resources such as plant or animal life, but since human health effects for all the accidents analyzed are small and most plants and animals are not thought to be more sensitive to radiation than human beings, the small impacts on human health provide an indication that the impacts on animal and plant species in the area would also be small for an alternative which would relocate the Expended Core Facility to the Nevada Test Site. Similarly, since the areas which might be contaminated to measurable levels by chemicals or radioactive material during the hypothetical accidents would be relatively small, effects on the ecology should be limited to small areas. As previously stated, there are no endangered or threatened species unique to the area surrounding the location considered for an Expended Core Facility at the Nevada Test Site, so an accident would not be expected to result in destruction of any species. The effects of accidents related to any of the alternatives and any cleanup which might be performed would be localized within a small area which would extend only a relatively short distance from the relocated Expended Core Facility and thus would not be expected to appreciably affect the survival potential of endangered or threatened species in the vicinity. Based on these considerations, evaluation of the impacts of accidents on ecological resources does not help to distinguish among alternatives.

5.6.14.4 Effects of Accidents on Environmental Justice Due to Naval Spent Nuclear Fuel Storage and Handling. As discussed in the preceding paragraphs, the impacts on human health or the environment resulting from facility or transportation accidents associated with the management of naval spent nuclear fuel at the NTS would be small under any of the alternatives considered. For example, it is unlikely that a single additional fatal cancer would occur as a result of naval spent nuclear fuel management activities under any alternative. Since the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the surrounding population, no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any particular segment of the population, minorities and low-income groups included.

To place the impacts on environmental justice in perspective, the risk from hypothetical accidents associated with naval spent nuclear fuel examination under any of the alternatives considered would amount to less than one additional fatality per year in the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident involving any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience less than one additional fatal cancer per year. The same conclusion can be drawn for low-income groups.

5.6.15 Waste Management

During Nevada ECF operation, non-radioactive and non-hazardous solid waste and hazardous solid waste would be generated in quantities similar to those for the ECF at INEL. These wastes would be managed in a manner identical to that for the ECF at INEL (i.e., non-hazardous, non-radioactive solid wastes would be disposed of at a sanitary landfill and hazardous solid wastes would be contained at their point of generation and transported off-site to an approved disposal facility). Waste management practices for these wastes would produce no identifiable impact on public health and safety of the environment.

Operation of the ECF at NTS would generate the same quantities of low-level waste, transuranic waste, and mixed wastes as the ECF at INEL. Low-level waste generated by Nevada ECF would be disposed of at the NTS. The 425 cubic meters (556 cubic yards) of low-level waste generated annually by the ECF at INEL represents a small fraction of the low-level waste managed at the NTS and would not impact planned disposal operations. No high-level waste would be generated.

Less than 0.0001 cubic meter of transuranic waste per year is generated by current ECF operations at the INEL. Any transuranic waste generated by the Nevada ECF would be added to the Nevada Test Site's transuranic waste storage cell, and would not impact planned waste handling operations. Any mixed wastes generated by Nevada ECF operation would be stored on-site pending a future disposal action.

5.6.16 Cumulative Impacts

Up to this point, Section 5.6 has discussed the potential environmental consequences of constructing and operating the ECF Project at the NTS in terms of annual impacts (i.e., radiological doses and health effects, accident risks, and quantities of wastes that would be generated during operations) based on the maximum expected annual workload of the ECF. To determine the potential consequences for 40 years of ECF operation (from 1995 to 2035), an evaluation of the accumulated environmental consequences and risks of constructing and operating the Nevada ECF was performed.

5.6.16.1 Radiological Cumulative Impacts. The Nevada Test Site has not been used for naval spent nuclear fuel operations in the past. Prior to this time, naval spent nuclear fuel inspections and storage operations have been conducted only at INEL. Therefore, no cumulative impacts have resulted from previous naval spent nuclear fuel inspection and storage operations at any alternate site except for INEL.

Operation of the Nevada ECF will not result in discharges of radioactive liquids; therefore, there would be no changes to the surface or ground water as a result of normal operations for any alternative. There will be small quantities of radioactivity in the air released from ECF which would contribute to the cumulative air quality impacts.

The annual radiological impacts associated with the alternatives where naval spent nuclear fuel would be inspected or stored at the NTS are very small and are described in Section 5.6.12, with the detailed results of analyses provided in Attachment F. In order to calculate cumulative impacts for the period between 1995 and 2035, the annual radiological impacts associated with each location and alternative were summed over 40 years. The results of this summation are tabulated in Tables 3-5 and 3-6 of Section 3.

The cumulative transportation impacts for the population groups from naval spent nuclear fuel transportation activities since the beginning of the Naval Nuclear Propulsion Program also have been calculated and are very small. In addition, the cumulative impacts from transportation of naval spent nuclear fuel over the 40-year period between 1995 and 2035 for each alternative have been assessed. The detailed results of these calculations are presented in Attachment A and summarized in Section 3.7.4.

The total exposure (from operations and transportation) to the general public from Nevada ECF operation would be approximately 6 person-rem. This means that there would be less than 3×10^{-3} fatal cancers from these operations over the entire 40-year period evaluated. The exposure to the maximally exposed off-site individual would be less than 1 millirem from 40 years of Nevada Test

Site ECF operation. The corresponding risk of a cancer fatality to the maximally exposed off-site individual is 6.8×10^{-9} during his or her lifetime. A worker at the Nevada Test Site ECF located 100 meters from the facility would receive less than 2 millirem over 40 years of Nevada Test Site ECF operation, which corresponds to a 7.2×10^{-7} risk of fatal cancer during the worker's lifetime. These exposures and cancer risks are as a result of ECF operations only. The exposures and risks corresponding to site-wide operations (including ECF) are discussed in Volume 1, Chapter 5. Analyses of hypothetical accidents which might occur as a result of these alternatives show that the risk of cancer fatalities is small. The impacts associated with transportation of naval spent nuclear fuel for all of the alternatives considered would be similarly low.

Cumulative impacts due to radioactive waste generation are expected to be minimal. Approximately 425 cubic meters of low-level waste are expected to be generated annually by the Nevada ECF over the subject 40-year period. This is not expected to affect the NTS waste management program. Very little transuranic waste or mixed waste and no high-level waste will be generated from Nevada ECF operations.

No contribution to cumulative impacts from accidents involving naval spent nuclear fuel has been included in the analyses presented in this Environmental Impact Statement because there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity which had a significant effect on the environment.

5.6.16.2 Non-radiological Cumulative Impacts. The cumulative socioeconomic impacts associated with constructing and operating the Nevada ECF are expected to be minor. The Nevada Test Site currently employs over 8,500 people. In the past, no employment at the NTS has been associated with naval spent nuclear fuel operations. Nevada Test Site ECF operations would provide long-term employment for 500 people at the NTS. The peak number of additional jobs created at the NTS in any given year would be approximately 1050, which includes both construction and operations workers during the peak of the Nevada Test Site ECF construction effort. Considering that the labor force in the region of influence is expected to reach 792,309 people by 2004, the additional number of jobs added from the construction and operation of the Nevada Test Site ECF would be expected to have only a minor socioeconomic impact in the NTS area.

Construction and operation of the Nevada ECF are not expected to result in any discernible impacts relative to cumulative non-radiological emissions. Construction of the ECF is sufficiently remote and removed from the nearest NTS boundaries such that concentrations of fugitive emissions from construction would be well below applicable standards, as discussed in Section F.4 of Attachment F. Current operations at the Nevada Test Site are in compliance with Title 40, Code of Federal Regulations, Part 61, "National Emission Standards for Hazardous Air Pollutants." Cumulative air emissions would not threaten to exceed any applicable air quality requirement or regulation, either federal, state, or local in radiological and non-radiological categories.

Minimal cumulative land use impacts would be expected to occur as a result of the construction of a new ECF. The land that would be dedicated for this purpose is on existing federal property. The use of this land would not result in the need for additional land to be added to the federally owned property in the foreseeable future. The Nevada Test Site occupies an area of approximately 3,500 square kilometers (1,350 square miles) of which only about 0.55% is developed. No land area at the Nevada Test Site has been affected by past operations involving naval spent nuclear fuel. Construction of the Nevada Test Site ECF would affect 30 acres of land. This is less than 0.004% of the total Nevada Test Site land area.

The cumulative impacts associated with non-radiological waste management are also expected to be small. The volume of hazardous waste produced by ECF has not been calculated; however, considering the nature of the work associated with ECF, the amount of hazardous waste produced would have a small effect on the cumulative impacts associated with this waste. The volume of municipal solid wastes and sanitary wastes which would be generated is expected to be proportional to the number of additional workers added, and this small incremental increase would not be discernible. The amount of non-radiological wastes generated would not introduce any changes to the site's waste management practices and would not impose any additional stress on the capacity of on-site or off-site waste disposal or treatment facilities. Therefore, any cumulative impacts associated with the generation and disposal of additional wastes would be very small. There are no current environmental problems associated with these types of wastes.

5.6.17 Unavoidable Adverse Effects

Construction of an ECF at NTS would directly affect about 30 acres of land area. The direct loss of terrestrial habitat would be minimal.

Construction of the Nevada ECF would also generate liquid effluents, atmospheric emissions, and solid wastes typical of those for construction of a major industrial facility. All effluents and emissions would be below applicable environmental requirements and would not be expected to result in any major adverse impacts.

During Nevada ECF operations, non-radioactive and non-hazardous solid waste and hazardous solid waste would be generated in quantities similar to those discussed for the INEL. Non-radioactive and non-hazardous solid waste would be disposed of in the NTS sanitary landfill. Hazardous wastes would be contained at their point of generation and transported off-site to an approved disposal facility. The amount of hazardous waste generated by Nevada ECF operation would be small in comparison to the amount of hazardous waste that is generated and currently in interim storage at the NTS. No discernible differences from normal hazardous waste management at the NTS would result from this strategy.

During Nevada ECF operations, unavoidable radiation exposures would include occupational exposures and exposures to the public from normal atmospheric emissions of radioactive materials that would be minimal compared to criteria contained in 40CFR Part 61.92 and DOE Order 5480.1B. Sanitary waste and service waste liquid discharges would be below applicable environmental standards. Solid wastes generated during operations, including transuranic, low-level, hazardous, and mixed wastes, would result in small increases in potential exposures to radioactive and hazardous materials. Freon emissions would result in a negligible increase in the risk of skin cancer; substitutes will be used when available.

Construction and operation of the Nevada ECF would not require the use or consumption of scarce resources. Expected groundwater withdrawals during construction and operation would represent small incremental increases in the amount of water being withdrawn by ongoing NTS operations. In general, the unavoidable adverse impacts would be few and limited, and none have been identified that would have a detectable effect on public health and safety. The difference in the impacts between the ECF alternative at the NTS and the other DOE sites (INEL, Savannah River, Hanford, Oak Ridge) is not discernible.

5.6.18 Irreversible and Irretrievable Commitments of Resources

During operation of the Nevada ECF, additional fuel would be burned to supply steam for heat. The fuel is not in short supply. The water to be used for the Nevada ECF would be withdrawn from the groundwater aquifers. No new water wells are expected to be required, and no observed impacts have resulted from previous withdrawals. Total consumption of water attributable to water pool operations and consumption of potable water by operating personnel would represent only a small percentage of the supply available by aquifer recharge.

The total cost of locating a new ECF at the Nevada Test Site is approximately $3.5 billion. This cost represents the total cumulative cost over the 40-year period and includes construction and operation costs of the new ECF as well as the cost associated with shutting down the ECF at INEL. Refer to Section 3.7 for a comparison of the total cumulative costs among alternatives.

As is the case with the ECF at INEL, construction and operation of the Nevada ECF would not require the use or consumption of scarce resources.

5.7 RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Implementation of any of the alternatives for the Navy will commit and utilize some environmental resources shortly after the implementation date. In general, up to an additional 30 acres of land could be committed to support naval spent nuclear fuel management activities; it should be noted however that the land at the Naval Reactors Facility at the Idaho National Engineering Laboratory is already committed to this purpose and implementation of the Preferred Alternative would not require the commitment of any additional land. The spent nuclear fuel management activities are expected to require up to 2.5 million gallons of water per year and up to 10,000 megawatt-hours of electrical energy per year depending on the alternative selected. As discussed throughout this Appendix, the normal operations associated with naval spent nuclear fuel management will result in some radioactive releases and releases of some toxic chemicals and other pollutants; however, due to the types of operations involved and the stringent controls that would be in place, these releases would be extremely small and would not affect long-term productivity of any site.

Commitment of these resources is necessary to support long-term safe handling, storage, and examination of naval spent nuclear fuel.

5.8 POTENTIAL MITIGATION MEASURES

As stated earlier, all of the environmental impacts associated with implementation of any of the alternatives would be small. However, measures will be taken to reduce these small effects to the lowest possible levels. Consistent with existing Naval Nuclear Propulsion Program policies and historical practices, actions would be taken to prevent pollution, and to mitigate the impacts of naval spent nuclear fuel management facility construction, operations and potential accidents. These measures are summarized below; additional discussion is provided in Attachment F.

5.8.1 Pollution Prevention

Extensive environmental control programs and procedures are in place at all naval sites in order to minimize any environmental and public safety and health impacts that might result from radiological and non-radiological operations. A summary of some of these controls is provided in the following sections.

5.8.1.1 Radiological Pollution Prevention Actions. The policy of the U.S. Navy is to reduce to the minimum practicable the amounts of radioactivity released to the environment. This policy is implemented at shipyards and prototype sites through procedures that are consistent with the recommendations of the National Council on Radiation Protection and Measurements and the standards issued by the U.S. Environmental Protection Agency, International Commission on Radiation Protection, International Atomic Energy Agency, National Academy of Science - National Research Council, U.S. Nuclear Regulatory Commission, and U.S. Department of Energy.

The principal source of radioactivity in liquid effluents is trace amounts of corrosion and wear products from reactor plant metal surfaces in contact with reactor cooling water. Concentrations of radioactive fission products are normally not a consideration for waste disposal because these fission products remain within spent nuclear fuel elements, which are not handled as waste. Radioactive liquids that are generated at shipyard and prototype sites are collected in containers, processed to remove most of the radioactivity, and reused rather than intentionally discharged to the environment.

Radiological work facilities are designed to ensure that there are no appreciable discharges of radioactivity in airborne exhausts. Radiological controls are exercised in radiological work facilities to preclude exposure of workers to airborne radioactivity exceeding limits specified in Title 10, Code of Federal Regulations, Chapter 20. These controls include performing work involving radioactive materials inside plastic bags or glove boxes which are completely sealed off from the environment. Air exhausted from radiological work facilities is passed through high efficiency particulate air filters which remove more than 99.9 percent of all particles from air, and is monitored during discharge to verify the effectiveness of the control measures.

Sources of radiation are controlled at shipyards and prototypes. Radiological work facilities are designed to minimize radiation exposure to personnel who perform work in the facility and to ensure that exposure to personnel outside the facility is negligible. Ambient radiation is measured with sensitive devices outside the boundaries of areas where radiological work is performed in order to confirm that radiological operations result in no measurable increase in exposure to the general public.

Shipyards and prototypes are not permitted to dispose of radioactive waste on their sites. All solid radioactive wastes are packaged in strong, tight containers, shielded as necessary, and shipped to burial sites that are either licensed by the U.S. Nuclear Regulatory Commission or a state under agreement with the U.S. Nuclear Regulatory Commission or are authorized for radioactive waste disposal by the U.S. Department of Energy. The volume of waste that is generated and shipped is minimized through use of work procedures that limit the amount of material that becomes contaminated during work on radioactive systems and reactor components. Workers periodically receive training specifically intended to help them minimize the production of radioactive waste.

Personnel who work with radioactive materials receive specific training regarding the potential hazards associated with radioactive materials, the general and specific radiological aspects which he or she might encounter, and his or her responsibility to the Navy and the public for safe handling of radioactive materials. More details regarding the scope of this training are provided in Naval Nuclear Propulsion Program Reports NT-94-2 and NT-94-3 (NNPP 1994b and NNPP 1994c).

5.8.1.2 Non-radiological Pollution Prevention Actions. Naval shipyards and prototype sites follow applicable federal, state, and local requirements for the prevention of release of non-radiological pollutants to the environment. Procedures are in place at each location that ensure that operations at the shipyard or prototype comply with environmental requirements and that the operations do not have an adverse effect on the workers, the public, and the environment.

Shipyards and prototype sites are subject to regulation under the Clean Air Act. All sites follow Environmental Protection Agency, state, and local regulations regarding air pollution prevention. Permits are secured as required for operation of facilities which might emit criteria, toxic, or hazardous air pollutants. Equipment is designed and operated in order to comply with the National Emission Standards for Hazardous Air Pollutants and National Ambient Air Quality Standards for the region. Procedures are also in place at shipyard and prototype sites to ensure that the facilities comply with federal, state, and local requirements regarding asbestos emissions, open burning, vehicle emissions, and use of ozone depleting substances. When appropriate, air emissions are treated in order to achieve compliance with requirements and to ensure that the emissions will not degrade ambient air quality.

Shipyard and prototype sites also must comply with the requirements of the Clean Water Act. The Navy policy is to reduce or eliminate the need for wastewater treatment by minimizing or eliminating pollutants at the source. Permits are secured as required for all point source discharges to navigable waters and corrective measures are taken to comply with the terms of these permits. For cases where Publicly Owned Treatment Works are used for industrial wastewater discharges, measures are taken by the site to ensure that the discharges are in accordance with federal, state, and local requirements.

Each site has an active program for evaluating equipment and chemicals proposed for purchase to minimize or eliminate environmental, safety, and health hazards. These evaluations also help to minimize the amount of hazardous waste that is generated by ensuring that the types and quantities of hazardous materials procured are kept to a minimum. Each site has an active program to investigate the replacement of toxic or hazardous materials with other materials and, when possible, substitutions are made in order to avoid the use of chemicals that would result in the generation of hazardous waste. The procurement program includes approval by appropriate safety and health organizations at the site. Hazardous wastes and other toxic substances, such as polychlorinated biphenyls, are handled and disposed of in accordance with applicable Environmental Protection Agency, state, and local requirements. Personnel who handle hazardous materials, hazardous wastes, and other potentially hazardous substances receive training regarding the specific hazards of the materials that they are expected to handle and the methods for safely handling those materials. This training is conducted in accordance with applicable requirements such as those mandated by the Occupational Safety and Health Administration, the Department of Transportation, and the Environmental Protection Agency. Non-hazardous solid wastes are handled and disposed of in accordance with applicable federal, state, and local requirements. When practicable and economically feasible, materials are recycled or recovered.

Naval designs also consider the effects of the life-cycle of components, including the ultimate disposal. For example, stainless steel fittings are frequently used in equipment in place of brass or bronze fittings, which contain lead, and which can allow lead to leach out of the metal alloys. Similarly, solvents chosen for naval work in recent years have been selected to avoid volatile substances and complex organic chemicals.

Contingency plans exist at shipyard and prototype sites to respond to all accidental discharges and hazardous substance (radiological and non-radiological) releases. These plans have been developed in accordance with the applicable federal, state, and local requirements and are intended to ensure that workers, the public, and the environment would be protected in the event of an accidental release.

5.8.1.3 Prevention of Mixed Wastes. Mixing of radioactive and chemically hazardous materials is avoided; compounding the intrinsic hazards of radioactivity with the chemical hazards of other materials creates a complex regulatory and occupational safety and health situation that impairs the execution of the work. For example, hazardous materials which could give rise to hazardous wastes listed under the Resource Conservation and Recovery Act (such as acetone) are precluded from use in radiological work. Other materials such as alcohol are used instead. The success of Program efforts in avoiding the creation of mixed radioactive and hazardous waste is reflected by the fact that in 1993, Program sites, naval shipyards, and Program DOE laboratories and prototypes produced less than 30 m^3 of mixed waste and hold a current inventory of less than 100 m^3.

5.8.2 Construction

In the event that implementation of an alternative requires construction of a new facility, the location will be selected to avoid impacts on the cultural, archaeological, aesthetic, or scenic resources of the area and to ensure that the rights and interests of Native American or Native Hawaiian groups are not infringed. Ecologically sensitive areas such as those in the vicinity of threatened or endangered species, and sites listed in the National Register of Historical Places would be avoided.

If upon implementation of an alternative, it is determined that construction of a naval spent nuclear fuel management facility would appreciably impact some resources, then actions to minimize those impacts would be taken. These actions could include, but would not be necessarily limited to, items such as: archaeological data collection prior to construction, education of workers about cultural resources and unauthorized artifact collection, involvement of Native Americans or Native Hawaiians in the selection of a mitigation strategy, and memorandums of agreement between the DOE and concerned parties. Preactivity surveys would be conducted to identify any plant or animal species that could be affected. As needed, mitigation measures and recovery plans would be developed; agencies such as the U.S. Fish and Wildlife Services and the Corps of Engineers would be consulted. The potential for soil erosion could be reduced through methods such as control of storm water runoff, including sediment catch basins. Fugitive dust emissions would be minimized by periodically wetting exposed soils. Traffic concerns could be controlled by widening of roads and traffic demand management. Workers in the construction environment would be protected by the use of hard hats and ear plugs and other safety equipment as needed.

5.8.3 Normal Operations

As has been the policy of the Naval Nuclear Propulsion Program, normal work practices at any naval spent nuclear fuel management facility would be designed to minimize releases and therefore mitigate the impacts on the environment. Releases as a result of normal operations would be minimized through a variety of measures, including: closely controlling the generation of contaminated waste, using total containment devices for certain work that could result in a radioactive release, filtering the ventilation exhaust from radiological facilities, and recycling and treating water used in contaminated systems. All radiological workers at naval facilities are trained in these mitigation principles and in other methods of minimizing radiation exposure. Mitigative measures for the use of toxic or hazardous materials make use of administrative controls, training, and safety equipment to provide personnel protection and emergency response. For personnel protection, controls involve safety review committees for planned activities that establish requirements, safe work permits and procedures, and the use of required clothing such as rubber boots, gloves, face shields, and eye protection that mitigate the effects associated with use of toxic or hazardous materials. Procedures may also require provisions for positioning mitigative devices such as eyewash stations and emergency showers before work is allowed to commence. All of the facilities being evaluated would employ emergency response programs to mitigate impacts of potential toxic chemical accidents to workers and the public.

5.8.4 Accidents

Although a serious accident involving naval spent nuclear fuel is highly unlikely, emergency plans are in place at all nuclear naval facilities to mitigate the impacts of a facility or transportation accident. These plans include activation of emergency control organizations throughout the Naval Nuclear Propulsion Program to provide on-scene response as well as support for the on-scene response team. Realistic training exercises are conducted periodically to ensure that the response organizations maintain a high level of readiness, and to ensure that coordination and communication lines with local authorities and other federal and state agencies are effective. In addition, naval fuel is designed to resist corrosion and damage due to accident conditions; this rugged construction would also have an important mitigative effect on the impacts of an accident involving naval spent nuclear fuel.

Emergency response measures include provisions for immediate response to any emergency at any naval site, identification of the accident conditions, and communications with civil authorities providing radiological data and recommendations for any appropriate protective actions. In the event of an accident involving radioactive or toxic materials, workers in the vicinity of the accident would promptly evacuate the immediate area. This evacuation can typically be accomplished within minutes of the accident and would reduce the hazard to workers.

For members of the general public residing at the site boundary and beyond, action would be taken to prevent the public from exceeding certain limits on exposure to radiation or other hazards if needed. Individuals that reside or work on site, or those that may be traversing the site in a vehicle would be evacuated from the affected area within 2 hours. Security personnel and appropriate local officials at all locations would oversee the removal of residents, workers, and travelers in a safe and efficient manner. Periodic training and evaluation of the emergency response personnel is conducted to ensure that correct actions are taken during an actual casualty. Therefore, exposure of residents, workers, and travelers to any hazard, including the potential for ingestion and inhalation of contamination, would be limited, as much as possible. Upon stabilization of the situation, recovery and remediation actions would be implemented as soon as practicable.

5.9 REFERENCES

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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
Appendix D
Part B

Naval Spent Nuclear Fuel Management

April 1995

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

ATTACHMENT A - TRANSPORTATION OF NAVAL SPENT NUCLEAR FUEL

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ATTACHMENT A

TRANSPORTATION OF NAVAL SPENT NUCLEAR FUEL

A.1 PURPOSE AND SCOPE

This attachment provides an evaluation of the radiological and non-radiological risks associated with the transportation of naval spent nuclear fuel and test specimens that originate from Navy and commercial shipyards, prototypes, and related Department of Energy laboratories. This evaluation covers all past shipments through May 1995 and shipments planned in the 40-year period from June 1995 through the end of 2035. This attachment evaluates the radiological risks associated with the five alternatives described in Section 3.

A.2 BACKGROUND

The transportation of naval spent nuclear fuel and test specimens covered in this attachment falls into the following four categories:

- Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes
- Transfers of Naval Spent Nuclear Fuel to Storage Following Examination
- Transfers of Naval Test Specimen Assemblies Between the Examination Facility and the Test Reactor Area
- Shipments of Naval Test Specimens to Examination and Testing Facilities.

Each category is described in more detail below.

A.2.1 Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes

Since 1956, spent nuclear fuel has been removed from Navy nuclear-powered ships and prototypes as a routine part of their operational cycle. The spent nuclear fuel has been transported to the Expended Core Facility (ECF) for examination and evaluation. ECF is part of the Naval Reactors Facility (NRF) within the Idaho National Engineering Laboratory (INEL). The examinations of the spent nuclear fuel and irradiated test specimens have provided and will continue to provide engineering data for materials and designs used in technology development for naval nuclear reactors.

In the past, shipments have originated from two prototype sites, nine shipyard locations, and the Shippingport Atomic Power Station (SAPS), located in Shippingport, Pennsylvania. The two prototype locations are the Kenneth A. Kesselring Site (KSO), located in West Milton, New York and the Windsor Site Operation (WSO), located in Windsor, Connecticut. The nine shipyard locations are Newport News Shipbuilding (NNS), located in Newport News, Virginia; the Norfolk Naval Shipyard (NOR), located in Portsmouth, Virginia; the Pearl Harbor Naval Shipyard (PHNS), located in Pearl Harbor, Hawaii; the Portsmouth Naval Shipyard (PNS), located in Kittery, Maine; the Puget Sound Naval Shipyard (PSNS), located in Bremerton, Washington; the Charleston Naval Shipyard (CNS), located in Charleston, South Carolina; the Mare Island Naval Shipyard (MINS), located in Vallejo, California; the Electric Boat Division of General Dynamics (EB), located in Groton, Connecticut, and Ingalls Shipbuilding (INGL), located in Pascagoula, Mississippi. Figure A-1 provides a map of the United States showing the transportation origins for naval spent nuclear fuel. No future shipments from the Electric Boat Division, Ingalls Shipbuilding, and Shippingport Atomic Power Station facilities are planned. The Mare Island Naval Shipyard, Charleston Naval Shipyard, and Windsor Site Operations facilities are being phased out.

The naval spent nuclear fuel has been shipped in M-130, M-140, M-160, and S2W/S2Wa shipping containers. Only the M-130, M-140, and M-160 shipping containers will be used in the future. A detailed description of the shipping containers to be used for naval spent nuclear fuel shipments from shipyards and prototype sites is provided in Section A.4.1.

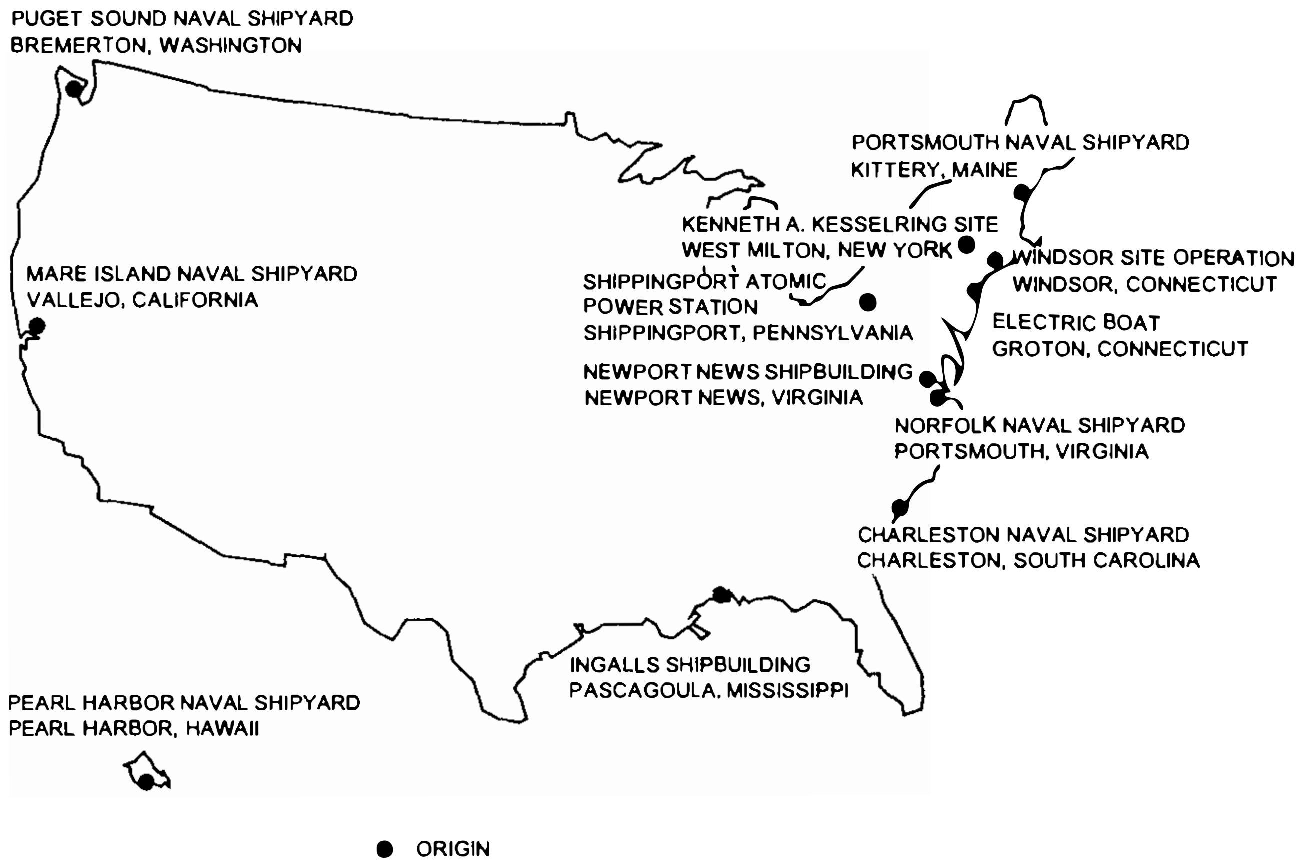

Figure A-1. Transportation origins for naval spent nuclear fuel.

The naval spent nuclear fuel is primarily shipped by rail. However, for the two prototype sites, rail spurs to the sites are not available. Therefore, the shipping containers are transported by heavy-lift transporter to a nearby commercial rail line where the containers are then transported by rail. For the Pearl Harbor Naval Shipyard, the containers are transported by ship to the Puget Sound Naval Shipyard where the containers are then transported to ECF by rail. Since 1956, 599 containers of naval spent nuclear fuel have been shipped to ECF. An additional 16 containers of spent nuclear fuel were shipped (12 from Shippingport Atomic Power Station to Hanford and 4 from ECF to Hanford); however, these shipments are covered by the DOE historic shipment calculations in Appendix I, Volume 1 of this Environmental Impact Statement. Table A-1 provides a list of these shipments made by year and originating facility.

A.2.2 Transfers of Naval Spent Nuclear Fuel to Storage Following Examination

In the past, following examinations at ECF, the spent nuclear fuel has been prepared and transferred to the Idaho Chemical Processing Plant (ICPP), also located on the INEL. A detailed description of the operations performed in the Expended Core Facility is provided in Attachment B. Naval spent nuclear fuel is currently being held at ICPP until permanent disposition becomes possible.

Since 1956, approximately 5400 transfers of naval spent nuclear fuel have been made from ECF to ICPP in shipping casks transported by truck dedicated to performing only such shipments (exclusive-use). For alternatives involving continued transfers to storage, the transfers would be made in the NFS-100, Peach Bottom, and Large Cell casks, in exclusive-use trucks. A detailed description of the shipping casks used for naval spent nuclear fuel transfers to storage is provided in Section A.4.2.

A.2.3 Transfers of Naval Test Specimen Assemblies Between the Examination Facility and the Test Reactor Area

In addition to naval spent nuclear fuel from ships and prototypes, irradiated test specimen assemblies (fuel and non-fuel) have also been transported to ECF for examination. Test specimens, which are constructed of plant materials, reactor structural materials, and fuels used in naval reactor

Table A-1. Number of past naval spent nuclear fuel containers shipped to ECF by origin.

	Origin												
Year	EB	SAPS	KSO	MINS	PHNS	PSNS	NNS	PNS	CNS	WSO	NOR	INGL	TOTAL
1957	1												1
1958			1										1
1959	1							1					2
1960													0
1961	1	2	2										5
1962	5			1	1								7
1963		3		1	1								5
1964	2	1	2										5
1965	2	1		2			33	1	2		1		42
1966	4	2		1	1			1		1			10
1967	2		1			2	8	3	3		4		23
1968	2			4		4	2	3	2				17
1969	8		2	3	1	2	4		2				22
1970	4			7		2	32	2	2				49
1971	4			2		8	4	2					20
1972	2			4		2	2		4		1		15
1973	2	1	1	2	1	6	4	2	2				21
1974	2	1		6		6	2	3				2	22
1975	2		1	4	1	4	2		2	1		2	19
1976	4		3	7			2	4	2			2	24
1977				4	1	2	2	2	2			2	15
1978		2		3	1	4	4		2			2	18
1979				1		2			2				5
1980				2		6	4	1	1				14

Table A-1 (Cont).

	Origin												
Year	EB	SAPS	KSO	MINS	PHNS	PSNS	NNS	PNS	CNS	WSO	NOR	INGL	TOTAL
1981					1		4		3				8
1982					1		6		3				10
1983		3		2		6	4		2	1			18
1984		7			1	6	4	2					20
1985						2	2	2	2				8
1986				2	1	4	4	2	2				15
1987				1		4		2	6				13
1988				4	1	5		3	4				17
1989				4	1	7		2	4				18
1990			3	4		10	4	4	3				28
1991				4	2	4		1	7				18
1992			3	3	2	7			4		4		23
1993					2	8	12						22
1994[(1)]			2	4		1	5		4				16
1995[(1)]				2		1							3
TOTAL	48	23	21	84	20	115	150	43	72	3	10	10	599

EB = Electric Boat Division of General Dynamics
SAPS = Shippingport Atomic Power Station
KSO = Kenneth A. Kesselring Site Operations
MINS = Mare Island Naval Shipyard
PHNS = Pearl Harbor Naval Shipyard
PSNS = Puget Sound Naval Shipyard
NNS = Newport News Shipbuilding
PNS = Portsmouth Naval Shipyard
CNS = Charleston Naval Shipyard
WSO = Windsor Site Operations
NOR = Norfolk Naval Shipyard
INGL = Ingalls Shipbuilding

[(1)] Shipments in these years cover those authorized by the court injunction.

plants are tested and qualified to characterize their performance for the lifetime of the plant. Part of this qualification program is to perform various irradiation tests of the materials for lifetime effects prior to certification. Along with those tests are pre- and post-examinations that provide the necessary data for subsequent analysis of the material in question. This work is considered a fundamental requirement for the design and safe operation of naval reactor plants. Therefore, the transfers of test specimen assemblies to the examination facility and shipments of the test specimens to the test facilities are included in the transportation evaluation. The test specimens have been assembled into test specimen assemblies and irradiated at the Test Reactor Area (TRA) on the INEL. The irradiated test specimen assemblies are returned to ECF for disassembly and examination.

Since 1956, approximately 3600 transfers of naval test specimen assemblies have been made between ECF and TRA in shipping casks transported by exclusive-use truck. For alternatives involving future transfers of this type, the transfers would be made in the NR-1, ATR-2, NR-3, NR-4, and Test Train casks. A detailed description of the shipping casks used to transfer irradiated test specimen assemblies is provided in Section A.4.3.

A.2.4 Shipments of Naval Irradiated Test Specimens to Examination and Testing Facilities

Following disassembly and examination of the test specimen assemblies at ECF, some specimens are shipped to off-site facilities for further testing or examination. These tests and examinations are generally very specialized and ECF does not have the capability to perform them or cannot perform them in a timely manner due to other examination priorities. Specimens are also shipped back to ECF for examination or further irradiation at TRA.

Test specimen shipments have been shipped to or from several laboratories and test facilities. They are the Bettis Atomic Power Laboratory (Bettis), located in West Mifflin, Pennsylvania; the Knolls Atomic Power Laboratory (KAPL), located in Niskayuna, New York; the Oak Ridge National Laboratory (ORNL), located in Oak Ridge, Tennessee; the Argonne National Laboratory (ANL)-East, located in Argonne, Illinois; the Battelle Memorial Institute, located in Columbus, Ohio; the Chalk River Nuclear Laboratories, located in Chalk River, Ontario, Canada (1 shipment only); the Hanford Site, located in Richland, Washington; and the ANL-West, Central Facilities Area (CFA), TRA, and ICPP facilities, all located on the INEL. Based on current schedules, Bettis and KAPL will be the only origins for future shipments. Figure A-2 provides a map of the United States showing the transportation origins and destinations for the test specimen shipments.

Since 1956, approximately 850 shipments of naval test specimens have been made between ECF and on- and off-site testing and examination facilities, in shipping containers transported by exclusive-use truck. The shipments have been made in NRBK-41, -42, -43, and -44 shipping containers and the WAPD-39 and -40 shipping containers. For alternatives involving future shipments of this type, the shipments would be made in the NRBK-41 and WAPD-40 shipping containers. A detailed description of the shipping containers used to ship irradiated test specimens between off-site facilities and the examination facility is provided in Section A.4.4.

A.3 ALTERNATIVES TO BE EVALUATED

A detailed description of the alternatives is provided in Section 3. The specific impacts on each of the four types of naval shipments (described in Section A.2) are described below for each alternative.

A.3.1 Alternative 1 - No Action

Under this alternative, after implementation, there would be no further shipments of naval spent nuclear fuel from the shipyards and prototypes. The Expended Core Facility would be shut down. Naval spent nuclear fuel would be stored at a facility at the site where it was removed during reactor servicing, with the exception of naval spent nuclear fuel removed at Newport News Shipbuilding, a commercial shipyard, which would be transported to Norfolk Naval Shipyard for storage. All naval spent nuclear fuel currently at ECF would be transferred to ICPP prior to the start of the 40-year period with the exception of the fuel saved for future examinations, referred to as reference specimens. The reference specimens and the naval spent nuclear fuel which originated at the prototype sites at NRF would be shipped from ECF to ICPP sometime during the 40-year period. The TRA facility would perform any work associated with the assembly, disassembly, and routine examination of the test train assemblies; therefore, no transfers would be required. Specimens shipped off-site would remain at the destination following examination. Table A-2 summarizes the shipments for the No Action alternative.

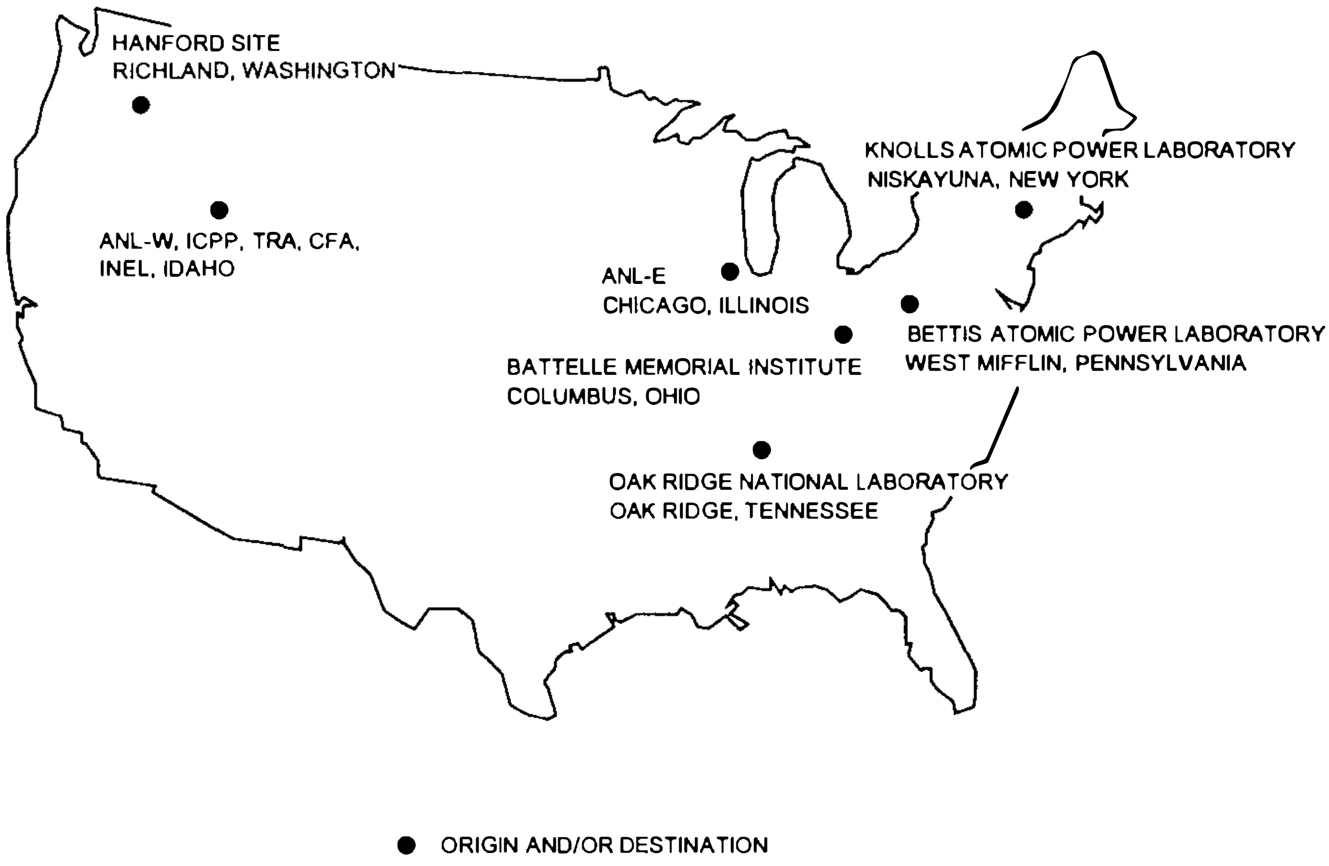

Figure A-2. Transportation origins and destinations for test specimen shipments.

Table A-2. Summary of shipments for the No Action alternative.

Type of Shipment	
Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes	
- Shipyards and Prototypes to ECF	None
- Newport News to Norfolk	Yes
Transfers of Naval Spent Nuclear Fuel from ECF to ICPP	Reference Specimens and Prototype Only
Transfers of Naval Test Specimen Assemblies Between ECF and TRA	None
Shipments of Irradiated Test Specimens Between Off-Site Facilities and ECF	
- Shipments from ECF	Yes
- Shipments back to ECF	None

A.3.2 Alternative 2 - Decentralization

As described in Section 3.4, this alternative also involves storage of the naval spent nuclear fuel near the point of origin. An evaluation of each of the three subalternatives defined in Section 3 was performed. The impact of the transportation related to each subalternative is briefly described below.

A.3.2.1 Alternative 2a - Store Naval Spent Nuclear Fuel at or Close to Locations Where Removed Without Examination. From the standpoint of transportation, this subalternative is equivalent to the No Action alternative.

A.3.2.2 Alternative 2b - Examine a Limited Amount of Naval Fuel in the Puget Sound Naval Shipyard Water Pit Facility and Store All Naval Fuel at Navy Facilities. For this alternative, the Expended Core Facility at NRF would be shut down and only high priority spent nuclear fuel would be transported to the Puget Sound Naval Shipyard for examination. For the naval spent nuclear fuel, approximately 10 percent of the total spent nuclear fuel for the 40-year period would be shipped. Following examination, the fuel would remain at Puget Sound Naval Shipyard. As in the No Action alternative, only the reference specimens would remain at ECF after June 1995. Ten percent of the reference specimens would be transferred from ECF to Puget Sound Naval Shipyard. The remainder of the reference specimens and the naval spent nuclear fuel which originated at the prototype sites at NRF would be transferred to ICPP. The TRA facility would perform any work associated with the assembly, disassembly, and routine examination of the test specimen assemblies; therefore, no transfers would be required. Shipments of test specimens to off-site facilities for specialized examinations would continue. Test specimens shipped off-site would remain at the destination following examination. Table A-3 summarizes the shipments.

Table A-3. Summary of shipments for the Decentralization - Limited Inspection alternative.

Type of Shipment	
Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes	
- Shipyards and Prototypes to Puget Sound	Approximately 10% of spent fuel
- Newport News to Norfolk	Yes
Transfers of Naval Spent Nuclear Fuel from ECF to ICPP	Reference Specimens and Prototype Only
Transfers of Naval Test Specimen Assemblies Between Puget Sound and TRA	None
Shipments of Irradiated Test Specimens to Off-Site Facilities	
- Shipments from TRA	Yes
- Shipments back to TRA	None

A.3.2.3 Alternative 2c - Examine All Naval Spent Nuclear Fuel at the INEL and Return to Navy Facilities for Storage. For this alternative, all naval spent nuclear fuel would be shipped to ECF and examined as it has been in the past. Only non-destructive examinations would be performed. The spent nuclear fuel would be returned in the same condition as originally shipped. Following examination, the fuel would be returned to the originating shipyard or prototype site for storage in the same type of container with the exception that naval spent nuclear fuel which originated at Newport News Shipbuilding would be shipped to Norfolk Naval Shipyard for storage. New equipment would have to be designed and procured to handle the spent nuclear fuel which returns to the shipyard. As in the No Action alternative, only reference specimens would remain at ECF after June 1995. The naval spent nuclear fuel which originated in the prototype sites at NRF (A1W and S5G) would be transferred to ICPP. Transfers of the irradiated test specimen assemblies would continue, along with the shipments of test specimens from ECF to off-site testing or examination facilities. Specimens shipped off-site would remain at the destination following examination. Table A-4 summarizes the planned shipments for this alternative.

Table A-4. Summary of shipments for the Decentralization - Full Examination alternative.

Type of Shipment	
Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes	
- Shipyards and Prototypes to ECF	Yes
- Newport News to Norfolk	To Norfolk from ECF
Transfers of Naval Spent Nuclear Fuel from ECF to ICPP	NRF Prototypes
Transfers of Naval Test Specimen Assemblies Between ECF and TRA	Yes
Shipments of Irradiated Test Specimens to Off-Site Facilities	
- Shipments from ECF	Yes
- Shipments back to ECF	None

A.3.3 Alternative 3 - 1992/1993 Planning Basis

This alternative plans on making the same types of shipments described in Section A.2 of this attachment. The only difference is that some of the historical origins of naval spent nuclear fuel and some destinations for the test specimen shipments will not be used. Table A-5 summarizes the planned shipments for this alternative.

Table A-5. Summary of shipments for the 1992/1993 Planning Basis alternative.

Type of Shipment	
Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes	
- Shipyards and Prototypes to ECF	Yes
- Newport News to Norfolk	No
Transfers of Naval Spent Nuclear Fuel from ECF to ICPP	Yes
Transfers of Naval Test Specimen Assemblies Between ECF and ATR	Yes
Shipments of Irradiated Test Specimens to Off-Site Facilities	
- Shipments from ECF	Yes
- Shipments back to ECF	Yes

A.3.4 Alternative 4 - Regionalization

As described in Section 3.4, this alternative would distribute existing and new spent nuclear fuel between various sites either on the basis of the fuel type or on the basis of dividing storage between the eastern and western parts of the United States. An evaluation of each of the options for this alternative described in Section 3.4 was performed. The impact of the transportation related to each option under this alternative is briefly described below.

A.3.4.1 Alternative 4a - Regionalization Using Storage at Three Sites. From the standpoint of transportation of naval spent nuclear fuel and test specimens, this alternative is equivalent to the 1992/1993 Planning Basis alternative.

A.3.4.2 Alternative 4b - Regionalization Using Storage at Two Sites. This alternative would utilize an existing DOE site in the eastern part of the United States and another existing DOE site in the western part of the country for storage of spent nuclear fuel. From the standpoint of transportation of naval spent nuclear fuel and test specimens, this alternative is equivalent to the Centralization alternative at each of the DOE sites because the Navy would operate a facility for examining naval spent nuclear fuel at only one of the DOE sites and the naval spent nuclear fuel would be stored at the same site where it was examined.

A.3.5 Alternative 5 - Centralization

This alternative considers consolidating all naval spent nuclear fuel and test specimens at the INEL, Hanford Site, Savannah River Site, Oak Ridge Reservation, or Nevada Test Site. Centralization at INEL is identical to the 1992/1993 Planning Basis alternative. For the other centralization sites, the type and number of shipments would be identical to the 1992/1993 Planning Basis alternative with the only difference being the destination. The naval spent nuclear fuel will be shipped to the centralization site for examination and subsequently transferred to a storage facility at the centralization site which would be equivalent to ICPP. Naval spent nuclear fuel shipments from Newport News Shipbuilding to Norfolk Naval Shipyard would not be necessary. As in the No Action alternative, only reference specimens would remain at ECF after June 1995. All reference specimens would be shipped to the centralization site. The naval spent nuclear fuel which originated in the prototype sites at NRF would also be transferred to the centralization site. The test specimen assembly shipments would be shipped between TRA and the alternate site. The test specimen shipments would originate at the centralization site and all specimens would ultimately return to that site for storage.

A.4 GENERAL DESCRIPTIONS

The following general information is common to all of the alternatives evaluated.

A.4.1 Spent Nuclear Fuel Shipping Containers

For naval spent nuclear fuel, the M-130, M-140, and M-160 shipping containers would be used for all alternatives. The shipping containers are primarily transported by railcars used only for this purpose as part of general-use freight trains. Section A.2.1 describes the special circumstances where the shipping containers are transported by ship or heavy-lift transporter. A brief description of each shipping container follows.

A.4.1.1 M-130 Shipping Container. The M-130 shipping container is a large, lead-lined, steel-shelled shipping container that is transported in the vertical position on a depressed center railcar (Figure A-3). The major components of the M-130 shipping container include the shielded container, closure head, and dust cover. Module holders are installed inside the container to hold the irradiated fuel modules in place and can be modified to accept different sized fuel modules. The container is shipped dry with the exception of a small amount of residual water. Cooling fins on the outside of the container are designed to dissipate the heat generated by the spent nuclear fuel.

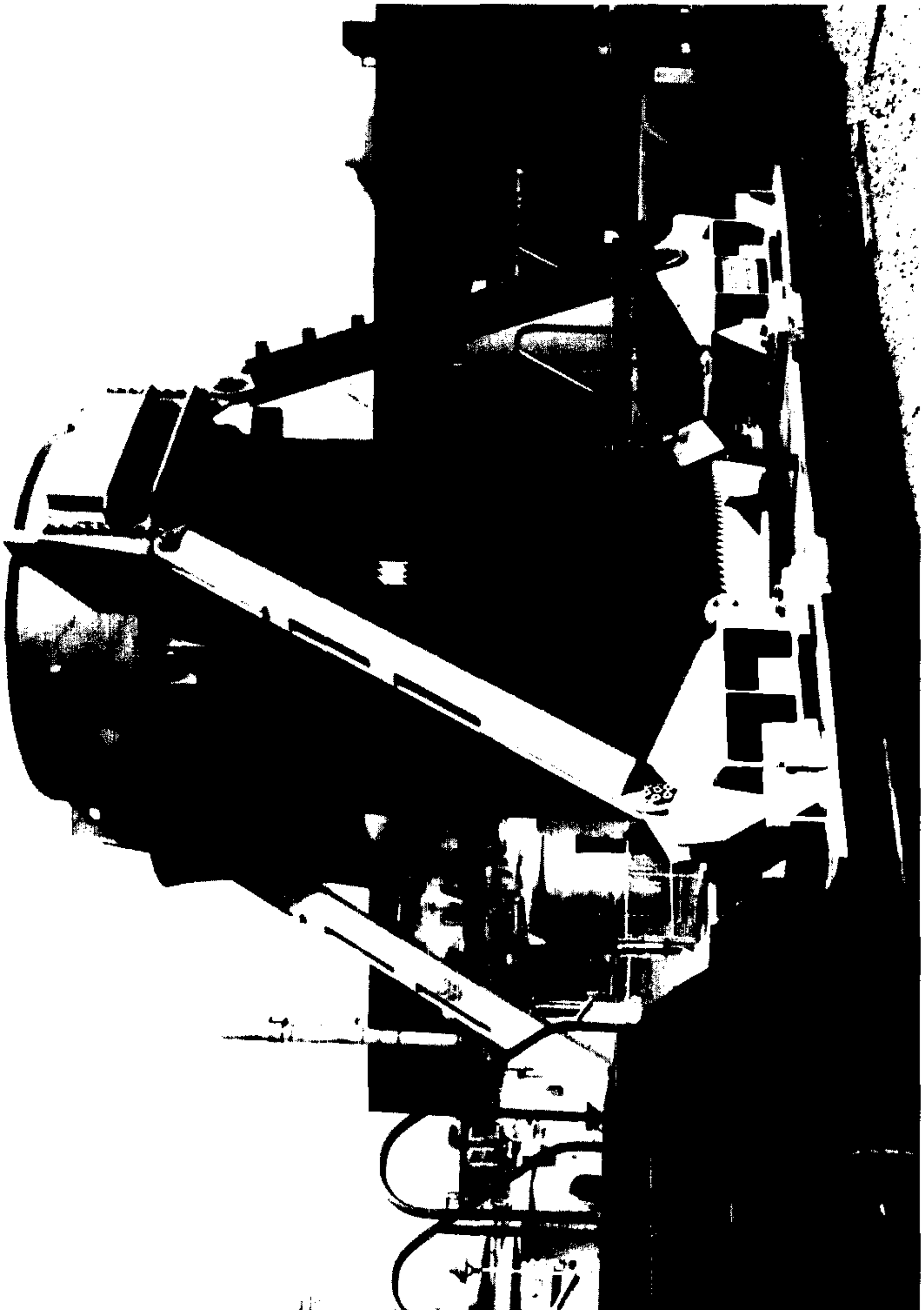

Figure A-3. M-130 shipping container mounted on railcar.

The M-130 shipping container weighs approximately 214,500 pounds in the standard loaded configuration. The container is approximately 13 feet tall and 7 feet in diameter. The container is a closed bottom cylindrical lead shell that is covered both on the inside and the outside with a 1-inch thick layer of steel. The lead on the cylindrical sides is about 10 inches thick and is a minimum of 9.5 inches thick on the bottom. In the standard configuration, the closure head at the top of the container is primarily constructed of 5.25 inches of lead and 7 inches of steel.

A.4.1.2 M-140 Shipping Container. The M-140 shipping container is a large, stainless steel shipping container that is transported in the vertical position on a specially designed well-type railcar (Figure A-4). The major components of the M-140 shipping container include the shielded container, closure head, and protective dome. Module holders are installed inside the container to hold the irradiated fuel modules in place and can be modified to accept different sized fuel modules. The container is shipped dry with the exception of a small amount of residual water. Cooling fins on the outside of the container are designed to dissipate the heat generated by the fuel.

The M-140 shipping container weighs approximately 375,000 pounds in the loaded condition. The container is approximately 16 feet tall with a maximum diameter of 10.5 feet. The container body is made from stainless steel forgings with 14-inch thick walls and a 12-inch thick bottom. The closure head and protective dome have a total thickness of 17.5 inches of stainless steel.

A.4.1.3 M-160 Shipping Container. The M-160 shipping container is a large, lead-lined, steel-shelled shipping container that is transported in a horizontal position on a support structure mounted on a modified flat bed railcar (Figure A-5). The major components of the M-160 shipping container include the shielded container, closure head, and dust cover. Module holders are installed inside the container to hold the irradiated fuel modules in place. The container is shipped dry with the exception of a small amount of residual water. Cooling fins on the outside of the container are designed to dissipate the heat generated by the fuel.

Figure A-4. M-140 shipping container mounted on railcar.

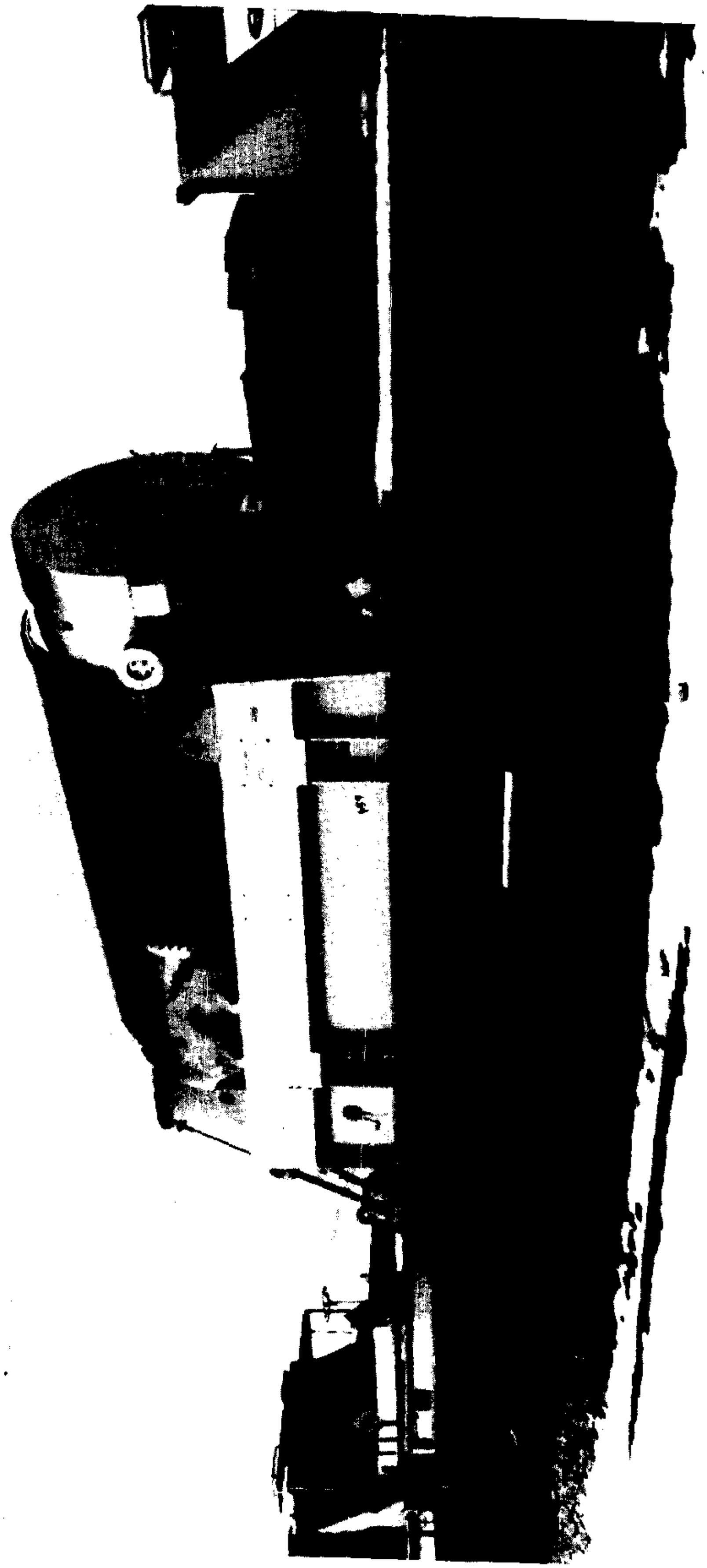

Figure A-5. M-160 shipping container mounted on railcar.

The M-160 shipping container weighs approximately 235,500 pounds in the loaded condition. The container is approximately 16.5 feet long and 6.5 feet in diameter. The container consists of two concentric bottom closed steel cylinders with a 9.4-inch annulus between the cylinders that is filled with lead. The outer shell is made from 1.5-inch thick steel, and the inner shell is made from 1-inch thick steel. The bottom plate is approximately 7 inches thick, and the closure head is approximately 15 inches thick.

A.4.1.4 Government Escorts for Spent Nuclear Fuel. Commercial railroads, exclusive-use heavy-lift transporters, or exclusive-use ships are used to transport the naval spent nuclear fuel from the prototypes and shipyards. The specific routes used to transport the spent nuclear fuel are selected by the rail or shipping companies. All naval spent nuclear fuel shipments are accompanied by government escorts. The escorts perform the duties necessary to ensure the safe, expeditious transportation of the naval spent nuclear fuel.

The government escorts receive specialized training in shipment safety procedures, radiological controls, security, and emergency response. Routine shipment escort procedures involve processing of authorization and shipping documentation, pre-shipment inspections, tracking shipment progress and schedules, enroute inspections, shipment observation and surveillance, and periodic communication checks. The government escorts have been trained to use and are equipped with the necessary radiological monitoring equipment to verify the shipping container integrity.

A large amount of the government escorts' training involves emergency response. This training involves emergency procedures for notification of technical and safeguards support personnel. The government escorts are equipped to immediately notify emergency assistance personnel, immediately assess the containment status of the shipping container, and communicate this information to emergency support personnel. Depending on the situation, the technical and support personnel may activate various emergency control centers that are prepared to provide the government escorts with the necessary support to quickly and safely bring an emergency situation under control. All railroads, which handle escorted shipments, also have specific emergency response procedures to safely expedite recovery for shipments that are involved in a rail line accident. Continually manned railroad operation centers maintain the capability to contact personnel from a combination of resources which provide appropriate equipment and manpower at the accident scene.

A.4.2 Spent Nuclear Fuel Shipping Casks for Transfers to Storage Following Examination

For naval spent nuclear fuel being transferred from the examination facility to storage (e.g., ECF to ICPP), the Nuclear Fuel Services Model 100 cask (NFS-100), Peach Bottom cask, and the Large Cell cask will be used for all alternatives. These shipping containers are transported by exclusive-use truck. A brief description of each cask follows.

A.4.2.1 NFS-100 Cask. The NFS-100 cask is a large, lead-lined, steel-shelled shipping cask that is transported in the horizontal position on a skid assembly attached to a tandem axle trailer (Figure A-6). The major components of the NFS-100 cask include the shielded cask and closure head. A fuel holding insert is installed inside the cask to hold the irradiated fuel modules in place. The container is shipped dry with the exception of a small amount of residual water. The cask is enclosed on the truck by a metal cover during shipment.

The NFS-100 cask weighs approximately 110,000 pounds in the loaded configuration. The cask is approximately 10.5 feet tall and 7 feet in diameter. The cask is a closed bottom cylinder of lead with a 0.375-inch thick steel inner shell and a 2-inch thick outer shell. The lead on the cylindrical sides is about 8.75 inches thick and the lead on the bottom is 8.8 inches thick. The closure head at the top of the cask is constructed of 9.75 inches of lead and 2 inches of steel.

A.4.2.2 Peach Bottom Cask. The Peach Bottom cask is a large, lead-lined, steel-shelled shipping cask that is transported in the horizontal position on a skid assembly attached to a tandem axle trailer (Figure A-7). The major components of the Peach Bottom cask include the shielded cask and closure heads. A fuel holding insert is installed inside the cask to hold the irradiated fuel modules in place. The cask is shipped dry with the exception of a small amount of residual water. The cask is enclosed on the truck by a metal cover during shipment.

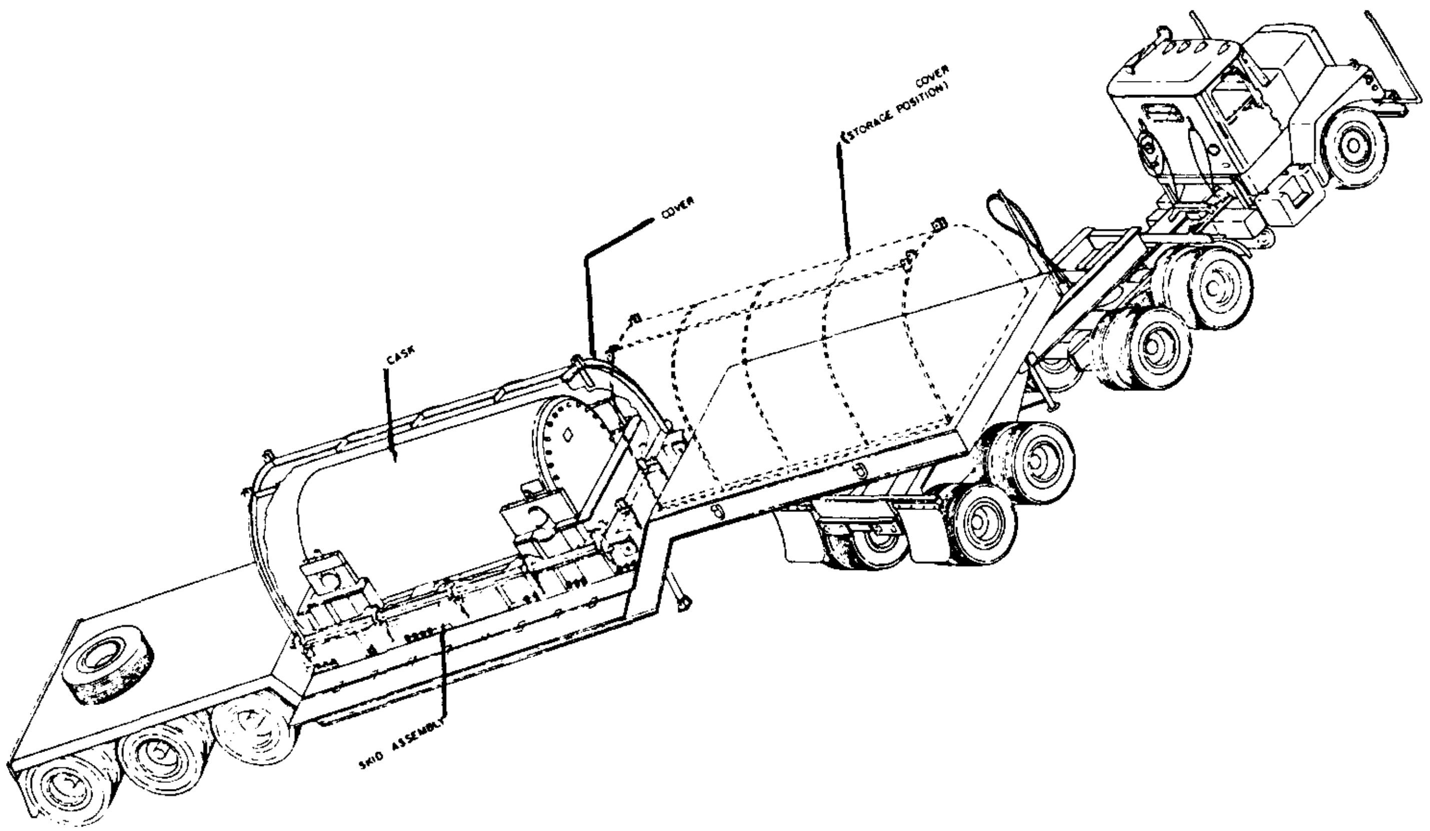

Figure A-6. NFS-100 cask mounted on truck.

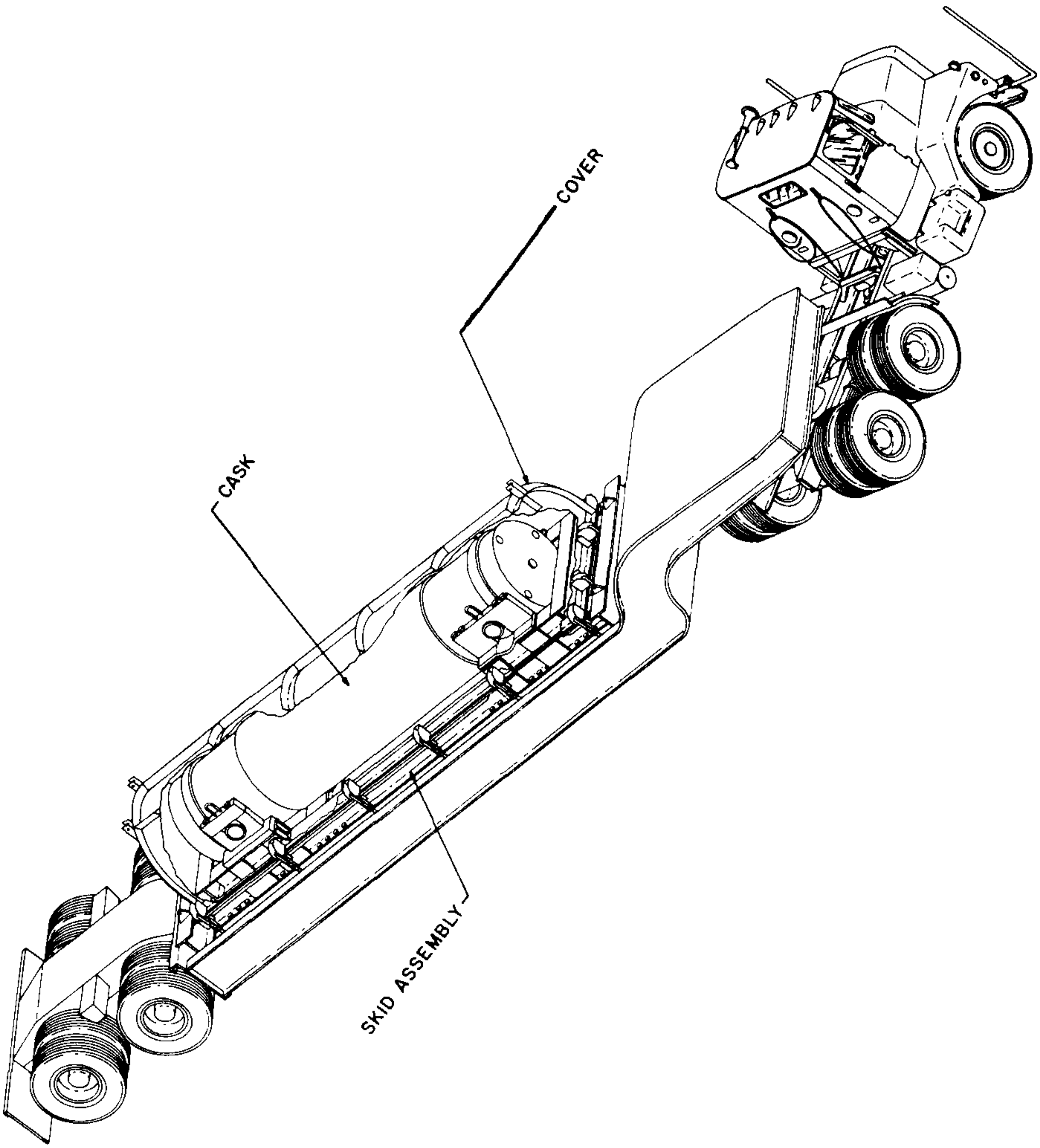

Figure A-7. Peach Bottom cask mounted on truck.

The Peach Bottom cask weighs approximately 68,400 pounds in the loaded configuration. The cask is approximately 16 feet tall and 3.5 feet in diameter. The cask is a stepped cylinder of lead with a 0.25-inch thick steel inner shell and a 1.75-inch thick steel outer shell. The lead on the cylindrical sides ranges from 5.25 to 6.25 inches thick. The closure heads on each end of the cask are essentially identical and are constructed of 8.5 inches of steel.

A.4.2.3 Large Cell Cask. The Large Cell cask, currently being designed for larger fuel types, will be a large, stainless steel shipping cask that is transported in the vertical position on a low-boy tractor trailer (Figure A-8). The major components of the Large Cell cask will include a shielded cask, closure head, shipping cask, and external impact limiters. Fuel-holding inserts will be installed inside the cask to hold the irradiated fuel modules in place. The cask will be shipped dry with the exception of a small amount of residual water. Cooling fins on the outside of the shipping cask are designed to dissipate the heat generated by the fuel.

The Large Cell cask will weigh approximately 220,000 pounds in the loaded condition. The shielded cask will be approximately 14 feet tall and 7 feet in diameter. The shielded cask body will be a closed bottom cylinder made from stainless steel forgings with 13.5-inch thick walls and a 13-inch thick bottom. The closure head will be a 14-inch thick stainless steel forging. The shielded cask will be assembled to the shipping cask during transport. The shipping cask will be a 2-inch thick aluminum closed bottom cylinder with fins extending to a total diameter of 93.6 inches. The external impact limiter assemblies, located on both ends of the cask, will be constructed of encased bi-directional aluminum honeycomb and are approximately 10 feet in diameter. The total Large Cell cask height will be approximately 17 feet.

A.4.2.4 Shipment Controls. All spent nuclear fuel transfers to a storage facility at the same site as the examination facility will be accompanied by escorts. The escorts are personnel who are specially trained to perform the duties necessary to ensure the safe transportation of the spent nuclear fuel. The escorts are in vehicles located in front of and behind the truck carrying the shipping cask.

The escorts receive specialized training in shipment safety procedures, radiological controls, security, and emergency response. The escort vehicles are equipped with distinctive warning flashers, and the escorts are capable of radio contact with each other, the driver of the transport vehicle, and on-site emergency coordinating personnel.

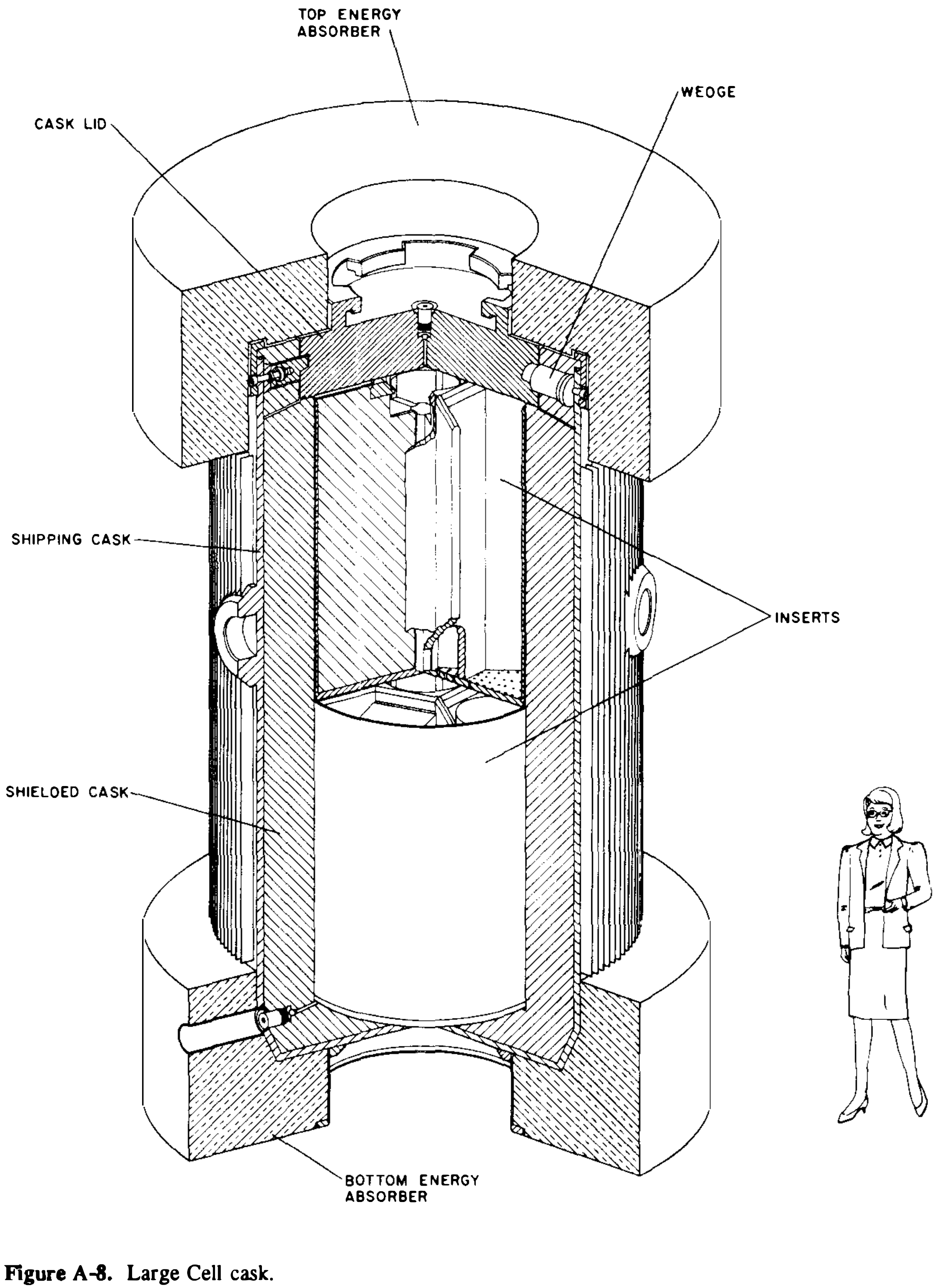

Figure A-8. Large Cell cask.

A large amount of the escorts' training involves emergency response. This training involves emergency procedures for notification of site technical and safeguards support personnel. The escorts are equipped to immediately notify emergency assistance personnel, immediately assess the containment status of the shipping cask, and communicate this information to emergency support personnel. Depending on the situation, the technical and support personnel may activate various emergency control centers that are equipped with the equipment and manpower to provide the escorts with the necessary support to quickly and safely bring an emergency situation under control.

Additional administrative controls are imposed on the transfers to further minimize risks. For example, the transfers are not allowed to travel during heavy traffic periods such as shift changes, and the convoy travels at reduced speeds. The route itself also enhances safety, since the route is essentially flat and the highest possible drop distance in the event of an accident is approximately 5 meters (16.5 feet) at the location where the highway crosses a river bed.

A.4.3 Naval Test Specimen Assembly Casks for Transfers Between TRA and the Examination Facility

For naval test specimen assemblies being transferred on-site between TRA and the examination facility, the NR-1, ATR-2, NR-3, NR-4, and Test Train casks will be used. These casks are transported by exclusive-use truck. For off-site shipments to the examination facility at the centralization sites, only the Test Train cask will be used. A brief description of each cask follows.

A.4.3.1 NR and ATR Casks. The NR and ATR casks are large, lead-lined, steel-shelled casks that are transported approximately 10° off horizontal in a cradle assembly attached to a tandem trailer (see Figure A-9). The major components of the casks include the shielded body, mast, and bottom closure/shield.

The shielded bodies of the casks are all approximately 32 inches in diameter. The outer steel shell thickness ranges from 0.5 inch to 1.0 inch. The thickness of the inner steel shell is approximately 0.4 inch for each cask. The lead ranges from approximately 10 inches to 11 inches for the various casks. The height of the shielded body ranges from approximately 6 feet to 12 feet. The mast is a tower section formed of reinforced aluminum and serves to support the structural end of the

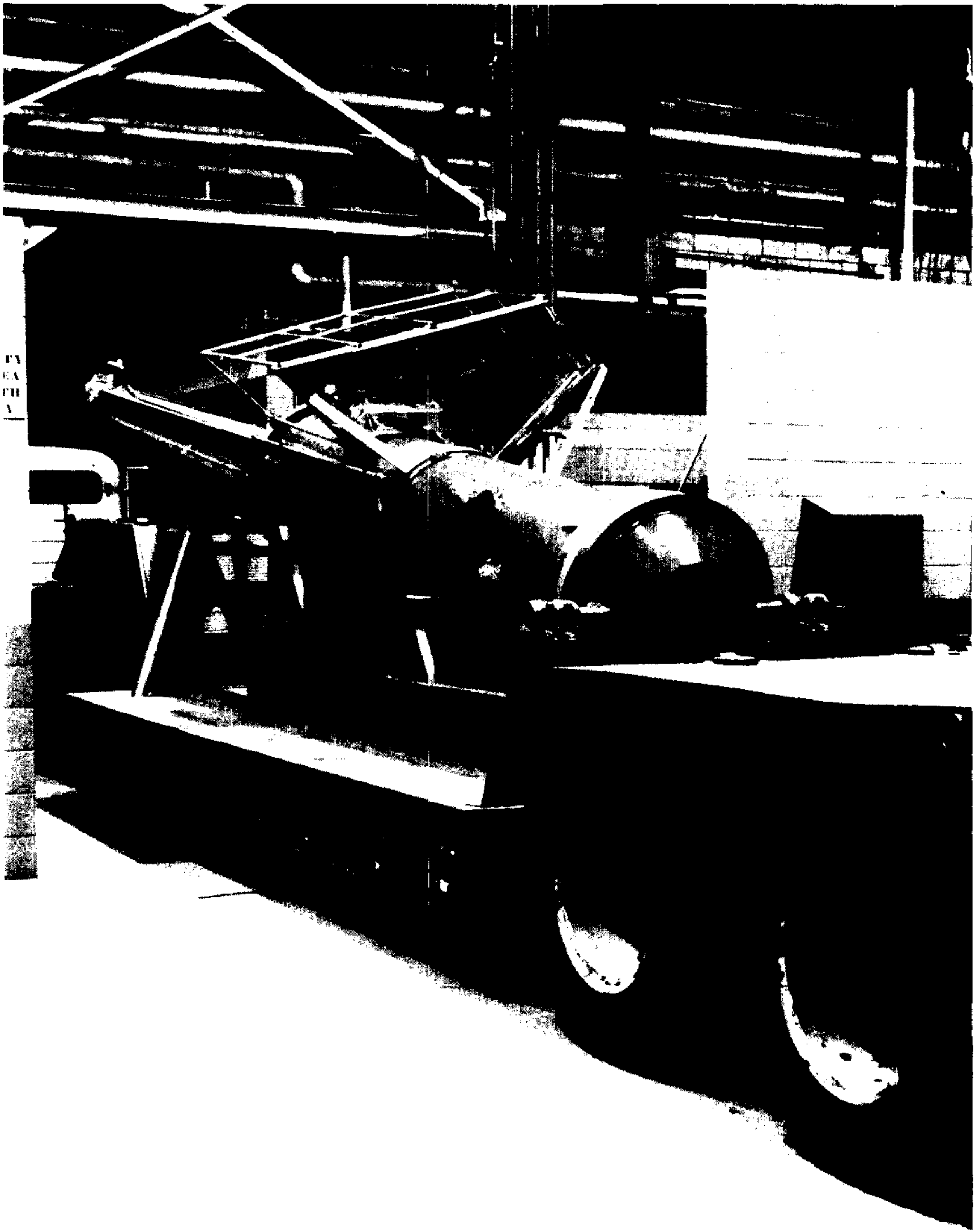

Figure A-9. NR/ATR cask mounted on truck.

specimen assemblies which require very little shielding. A winch and platform are also attached to each cask. The bottom closure/shield is constructed of 1.0 to 1.75 inches of steel and 7.0 to 8.75 inches of lead.

The NR and ATR casks range in weight from approximately 19,000 to 48,000 pounds. The overall cask height ranges from approximately 20 to 30 feet.

A.4.3.2 Test Train Casks. A new test specimen container would be required to transport irradiated test specimen assemblies between TRA and the examination facility located at the sites other than INEL for the Centralization alternative. A new cask is currently being designed to replace the current casks used to transport the test specimen assemblies between ECF and TRA, which are approaching the end of their design lifetime. The basic concept for this new cask is a thick-walled, stainless steel body with stainless steel closures on each end. Energy absorbers will be attached to the cask to prevent damage to the test specimens. The current estimated size of this cask is 34 feet long by 5 feet in diameter, weighing approximately 40 tons. This cask would be shipped by exclusive-use truck.

A.4.3.3 Shipment Controls. All spent nuclear fuel transfers to an examination facility at the same site as the irradiation facility will be accompanied by two escorts. The escorts are personnel who are specially trained to perform the duties necessary to ensure the safe transportation of the spent nuclear fuel. The escorts are in vehicles located in front of and behind the truck carrying the shipping cask.

The escorts receive specialized training in shipment safety procedures, radiological controls, security, and emergency response. A large amount of the escorts' training involves emergency response. This training involves emergency procedures for notification of site technical and safeguards support personnel. The escorts are equipped to immediately notify emergency assistance personnel, immediately assess the containment status of the shipping cask, and communicate this information to emergency support personnel. Depending on the situation, the technical and support personnel may activate various emergency control centers that are equipped with the equipment and manpower to provide the escorts with the necessary support to quickly and safely bring an emergency situation under control. The escort vehicles are equipped with distinctive warning flashers, and the escorts are capable of radio contact with each other, the driver of the transport vehicle, and emergency coordinating personnel.

Additional administrative controls are imposed on the shipments to further minimize risk. For example, the transfers are not allowed to travel during heavy traffic periods such as shift changes, and the convoy travels at reduced speeds. The route itself also enhances safety, since the route is essentially flat and the maximum possible drop in the event of an accident is from the bed of the truck to the road bed.

For the Centralization alternative, the casks would be shipped off-site. In this instance, only casks certified for over-the-road transportation in accordance with the Nuclear Regulatory Commission regulations would be used for shipments of the test trains. No escorts or additional administrative controls would be used.

A.4.4 Test Specimen Shipping Containers

For test specimens, the WAPD-40 and NRBK-41 shipping containers would be used to transport the specimens between ECF and the off-site laboratories and test facilities for all alternatives. These shipping containers are transported by an enclosed truck using a commercial carrier. A brief description of each container follows.

A.4.4.1 WAPD-40 Shipping Container. The WAPD-40 shipping container (Figure A-10) is a cylindrical, lead-shielded, steel-clad container that is shipped in a horizontal position. The inner steel shell is 0.25-inch thick, and the outer steel shell is 0.5-inch thick with 9.875 inches of lead shielding in between. The container is approximately 13 feet long and 2 feet in diameter. Steel clad, lead-shielded end plugs bolt onto each end, and 0.5-inch thick plates are bolted over the end plugs. The specimens are placed into special sealed inner containers prior to placement into the WAPD-40 shipping container. The weight of the container and skid assembly is approximately 28,000 pounds. The container and skid assembly are mounted into a special holddown cradle on the truck. This holddown cradle weighs approximately 5,000 pounds.

A.4.4.2 NRBK-41 Shipping Container. The NRBK-41 shipping container (Figure A-11) is a cylindrical, lead-shielded, steel-clad container that is shipped in the vertical position. The inner steel shell is 0.25-inch thick, and the outer steel shell is 0.5-inch thick with 10 inches of lead shielding in between. The container has a 1-inch thick steel plate welded to the bottom with a second 1-inch thick steel plate welded to the first plate with a 0.125-inch deep recess to provide a thermal break for the

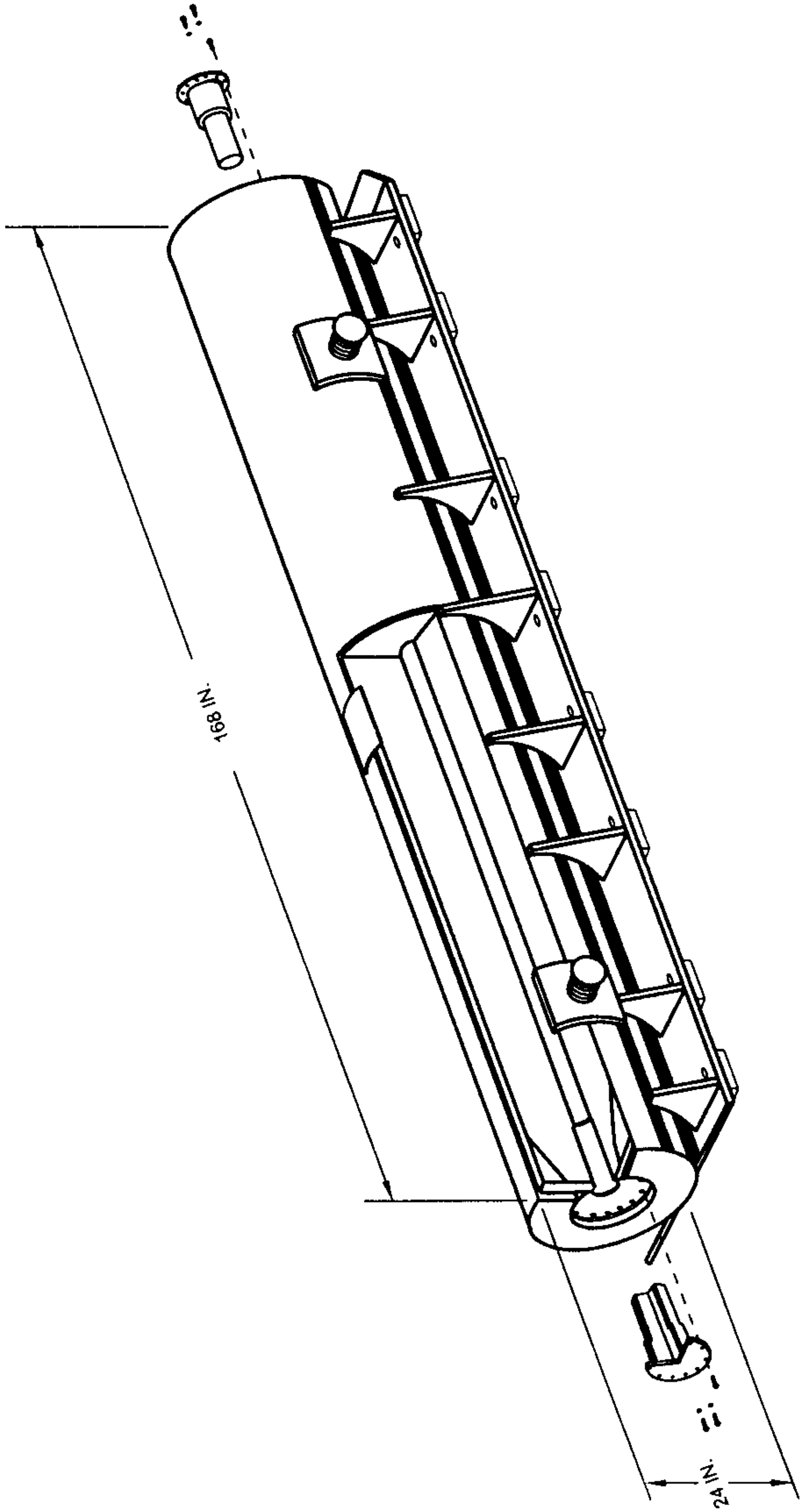

Figure A-10. WAPD-40 shipping container.

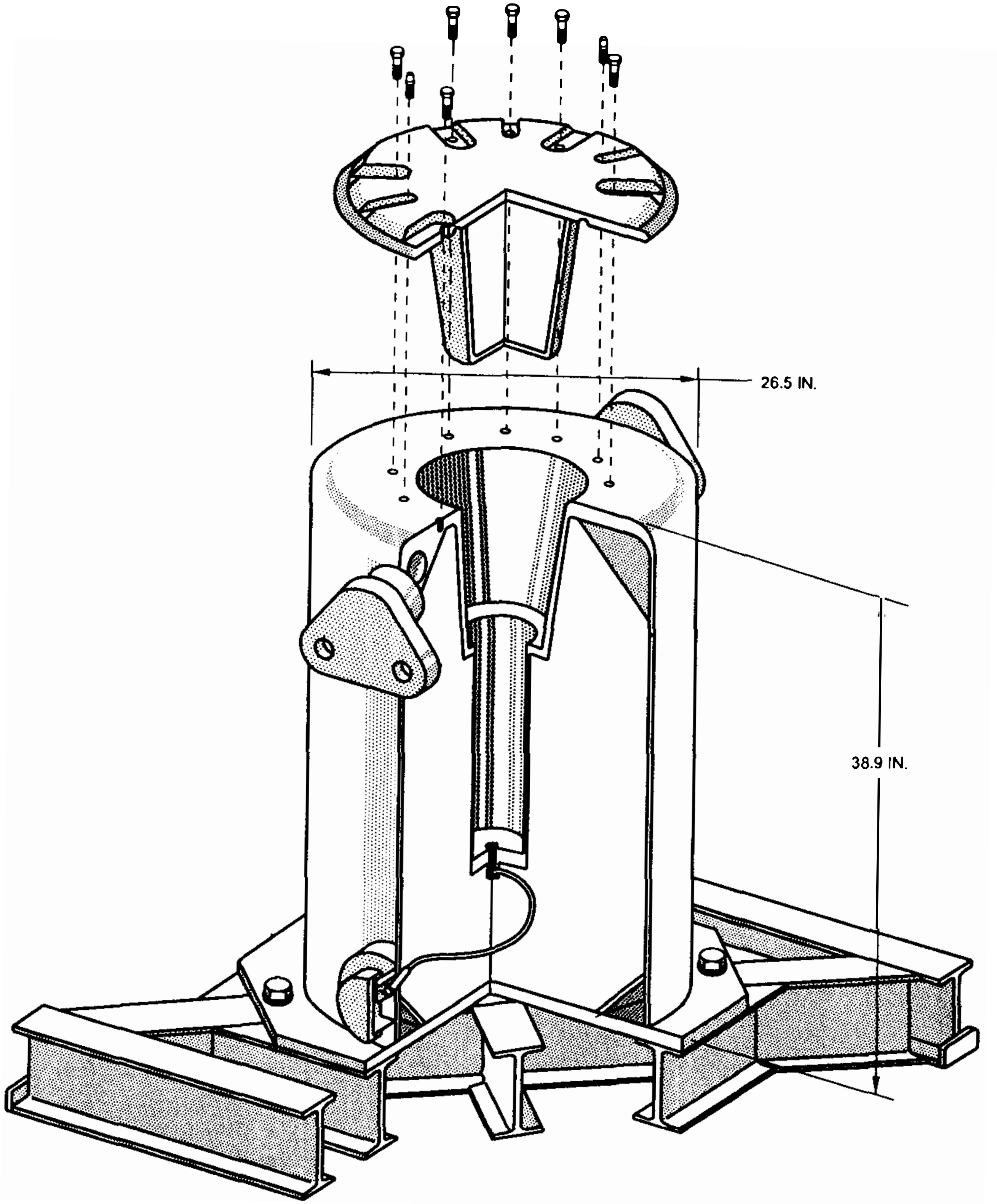

Figure A-11. NRBK-41 shipping container.

bottom of the container. The container also has a 0.25-inch thick steel outer thermal shield attached that provides a 0.125-inch air gap between the outer shell and the thermal shield. The container is approximately 4 feet tall and 2.25 feet in diameter. The container is bolted to a welded 48-inch square I-beam skid that is used to distribute the container load. The specimens are placed into a special sealed inner container prior to placement into the NRBK-41 shipping container. The weight of the loaded container is approximately 9,000 pounds.

A.4.5 Shipping Container Design Requirements

The M-130, M-140, M-160, NRBK-41, and WAPD-40 shipping containers have been designed and built to meet the regulations specified in Title 49, Code of Federal Regulations, Part 173 (49CFR173), entitled " Shippers - General Requirements for Shipments and Packagings" (CFR 1991). Shipments of naval spent nuclear fuel and test specimens are further regulated by Title 10, Code of Federal Regulations, Part 71 (10CFR71), entitled "Packaging of Radioactive Material for Transportation and Transportation of Radioactive Material Under Certain Conditions" (CFR 1993). These regulations require the shipping container to meet specific criteria under normal transport and accident conditions. The shipping container must be evaluated under free drop, puncture, heat, cold, pressure, water spray, and vibration for normal conditions and a series of severe hypothetical accident conditions with the results compared against the criteria provided in 10CFR71.

The M-130, M-140, M-160, WAPD-40, and NRBK-41 shipping containers have undergone rigorous engineering evaluations to assure compliance with 49CFR173 and 10CFR71 requirements. In addition, actual scale model or mock-up tests have been performed to verify selected engineering evaluations. This compliance has been certified by the U. S. Department of Energy and the Nuclear Regulatory Commission. The new Test Train and Large Cell casks will also be designed in accordance with the requirements of 49CFR173 and 10CFR71 and will undergo the same rigorous engineering evaluations and testing.

The safety analyses for the NFS-100, Peach Bottom, NR, and ATR casks demonstrate compliance with the requirements specified by the Department of Energy (DOE) in DOE Order 5480.3, entitled "Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes" (DOE 1985) and supplemented by DOE Idaho Operations Office Order ID 5480.3, entitled "Hazardous Materials Packaging and Transportation

Safety Requirements" (DOE 1991). These requirements are similar to the requirements of 10CFR71 with the major difference being that a worst credible accident can be defined based on site-specific information.

The NFS-100, Peach Bottom, NR, and ATR casks have undergone rigorous engineering evaluations to assure compliance with the DOE requirements. In addition, actual scale model or mock-up tests have been performed to verify selected engineering evaluations. The shipping casks comply with the requirements of DOE 5480.3 and DOE ID 5480.3 and this compliance is demonstrated by approval from the Idaho Operations Office of the Department of Energy.

A.5 TECHNICAL APPROACH - GENERAL

Several computer codes were used to assess the radiological risks associated with the transportation of naval spent nuclear fuel and test specimens. Specifically, the RADTRAN 4 risk analysis model, developed by Sandia National Laboratories (Neuhauser and Kanipe 1992), was used to calculate the general population and transportation crew (occupational) radiological risks associated with the transportation of radioactive materials. This computer code was used extensively in the incident-free and accident risk assessments. In some cases, other methods were more appropriate than the RADTRAN 4 computer code for naval spent nuclear fuel. In these cases, other calculational models were used and are specifically identified.

The RISKIND computer code, developed by Argonne National Laboratory (Yuan et al. 1993), also specifically analyzes radiological consequences and health risks to individuals from exposure associated with transportation. For incident-free evaluations, RISKIND uses a generic truck cask and does not allow adjustments for different sized casks which is not appropriate for naval spent nuclear fuel and test specimen casks; therefore, this code was not used. RISKIND (a version which accepts fuel-specific isotopes) was found to be the best code for calculation of the maximum individual and general population consequences for the accident scenario and was used for that purpose.

Several other computer codes were used to provide input for the RADTRAN 4 and RISKIND computer codes. The codes include INTERLINE, HIGHWAY, SPAN4, and ORIGEN2. A description of each computer code and how the code was used is provided below.

The INTERLINE computer code, developed by Oak Ridge National Laboratory (Johnson et al. 1993a), was used to evaluate the rail routes used for the spent nuclear fuel shipments.

The HIGHWAY computer code, also developed by Oak Ridge National Laboratory (Johnson et al. 1993b), was used to evaluate the truck routes used for the test specimen shipments.

The SPAN4 computer code (Wallace 1972) was used to perform gamma exposure rate calculations for the various shipping containers to assess the effect of increased distance from the source on exposure. SPAN4 is a point kernel code where appropriate exponential kernels are integrated over a source distribution. SPAN4 was developed by the Bettis Atomic Power Laboratory specifically for naval spent nuclear fuel.

The ORIGEN2 is a computer code, developed by Oak Ridge National Laboratory (Croff 1980), that is used to simulate radiation and decay of materials that are irradiated in a nuclear reactor. The ORIGEN2 computer code is widely accepted in the public domain and was used to independently confirm the fission product inventory for naval fuel developed using the standard Bettis Atomic Power Laboratory method. In addition, the standard Bettis Atomic Power Laboratory method has been used in Safety Analysis Reports for Packaging, reviewed and accepted by the Nuclear Regulatory Commission.

The radiological risks associated with the transportation of spent nuclear fuel and irradiated test specimens have been assessed for the general population, transportation workers (occupational), and hypothetical maximum exposed individuals under incident-free and accident conditions for the alternatives presented in Section A.3. The maximum consequences for an accident are also provided for each alternative. The radiation exposure to the government escorts for shipments was considered occupational in nature and was included with the transportation worker results.

The radiological impacts are first expressed as the calculated total exposure for the exposed population, occupational workers, and the maximum exposed individuals. The calculated total exposures are then used to estimate the hypothetical health effects, expressed in terms of estimated cancer fatalities. The health risk conversion factors used in this evaluation are taken from the International Commission on Radiological Protection (ICRP Publication 60) which specifies 0.0005 fatal cancer cases per person-rem for members of the public, 0.0004 fatal cancer cases per person-rem for workers (ICRP 1991). To calculate the estimated health detriment, the calculated exposure would be multiplied by the conversion factors of 0.00073 health detriments per person-rem for members of the public, and 0.00056 health detriments per person-rem for workers (ICRP 1991).

The numerical estimates of cancer deaths and other health detriments presented were obtained by the practice of linear extrapolation from the nominal risk estimate for lifetime total cancer mortality at 10 rad. Other methods of extrapolation to the low-dose region could yield higher or lower numerical estimates of cancer deaths. Studies of human populations exposed at low doses are inadequate to demonstrate the actual level of risk. There is scientific uncertainty about cancer risk in the low-dose region below the range of epidemiologic observation, and the possibility of no risk cannot be excluded (CIRRPC 1992). In this appendix, the doses have been provided in all cases to allow independent evaluation using any relation between exposure and health effects.

Non-radiological risks related to the transportation of naval spent nuclear fuel are also estimated. The non-radiological risks are associated with vehicle exhaust emission for incident-free transportation and fatalities resulting from transportation accidents. The non-radiological risks associated with shipments that return empty containers to the origin are also included. Risk factors for vehicle exhaust emissions and state-level accident fatality rates were obtained from "Non-Radiological Impacts of Transporting Radioactive Material" (Rao et al. 1982), "Transportation Impacts of the Commercial Radioactive Waste Management Program" (Cashwell et al. 1986), and "Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight" (Saricks and Kvitek 1994), respectively.

The shipments of radioactive waste at shipyards are not addressed. The exposure related to incident-free transportation would be small and would be the same for all alternatives which would not affect the decision-making process. The consequences of an accident would also be insignificant compared to the accidents analyzed for spent nuclear fuel.

For the ocean-going portion of the shipments of naval spent nuclear fuel from shipyards and prototypes, there would be no exposure to the general population. The basis for this conclusion is that the ship's hull provides a considerable amount of additional shielding and that there would be no members of the general population close enough to the ship to receive appreciable exposure during these shipments. The consequences of an accident during the ocean-going portion have also not been evaluated because the forces on the container during an accident aboard the ship would not be large enough to cause damage to the container or fuel inside it since the ship itself would sustain the direct impact. This is substantiated by the fact that the impact forces to the container would be less than the regulatory criteria. Therefore, no release would occur.

A.5.1 Technical Approach for the Assessment of Incident-free Transportation

For incident-free transportation of naval spent nuclear fuel, the RADTRAN 4 computer code was used to calculate the radiological exposure for the general population and a portion of the occupational exposure.

Included in the RADTRAN 4 computer code incident-free risk calculations for transport are models describing (1) exposures to persons (e.g., residents) adjacent to the transport route (off-link exposures), (2) exposures to persons (e.g., passengers on passing trains or vehicles) sharing the transport route (on-link doses), (3) exposures to persons at stops (e.g., residents or rail and truck crew not directly involved with the shipment), and (4) exposures to transportation crew members (occupational). The exposures calculated for the first three groups were added together to estimate the general population exposure estimates for rail and truck transport; the exposure calculated for the fourth group represents occupational exposure to the rail crew exposures during inspections and truck crew during transit and inspections. Table A-6 summarizes the calculational methods used for each group for the shipment of naval spent nuclear fuel and test specimens.

As shown in Table A-6, simple calculations were performed to account for situations where the RADTRAN 4 computer code was not the best calculational model with respect to the transportation of naval spent nuclear fuel. The information used in the simple calculations was based on historical information. The results obtained using these simple calculations are expected to be equal to or greater than any exposures which might actually occur.

The maximum possible radiological exposure to an individual for the routine transport of naval spent nuclear fuel and test specimens off-site was estimated for transportation workers, as well as members of the general population. For rail shipments, the three general population scenarios were: (1) a railyard worker who might be working at a distance of 10 meters (32.8 feet) from the shipping container for 2 hours, (2) a resident who might live 30 meters (98.4 feet) from the rail line

Table A-6. Calculational methods used to obtain exposures for population groups of interest.

Shipment Type	Origin	Destination[a]	Mode	General Population			Occupational	
				Off-Link and On-Link	Stops	Maximum Individual	Workers	Escorts
Spent Nuclear Fuel to ECF or Equivalent	Kesselring Site	Ballston Spa	Truck	(1)	(3)	(6)	(3)	(3)
	Shipyard/Rail Siding	Various	Rail	(1)	(1)	(6)	(2)	(5)
	Windsor Site	Griffen Siding	Truck	(1)	(3)	(6)	(3)	(3)
	Pearl Harbor	Puget Sound	Ship	N/A	N/A	N/A	(4)	(4)
Spent Nuclear Fuel to Storage	ECF or Equivalent	Various	Truck	(1)	(1)	(6)	(1)	(1)
Test Specimen Assemblies	TRA	Various	Truck	(1)	(1)	(6)	(1)	(I)
Test Specimens	ECF or Equivalent	Bettis/ KAPL, etc.	Truck	(I)	(1)	(6)	(1)	N/A

Calculational Methods:

(1) RADTRAN 4 calculations.
(2) RADTRAN 4 rail calculations for inspection exposure and simple calculations based on rail transportation data supplied by the government escorts for rail transit exposure.
(3) Simple calculation model based on truck transportation data supplied by site personnel.
(4) Simple calculation model based on ship transportation data supplied by Pearl Harbor Naval Shipyard.
(5) Exposures based on historical TLD readings.
(6) Simple calculation model based on scenarios provided in RISKIND.
(a) The methods provided in this table apply to the destination for all the alternatives evaluated.

where the shipping container was being transported, and (3) a resident who could be living 200 meters (656.2 feet) from a rail stop where the shipping container was sitting for 20 hours. The government escorts and crew members from the rail, heavy-lift transporter, and ship were evaluated for the transportation workers (occupational). Based on records of past escorted rail shipments, the government escort might be the same individual for as many as two-thirds of the shipments in a 5-year period. The crew members were postulated to be the same individuals for all shipments in the 40-year period.

For off-site truck shipments, the three scenarios for the general population were: (1) a person who might be caught in traffic and located 1 meter (3 feet) away from the surface of the shipping container for one-half hour, (2) a resident who might be living 30 meters (98.4 feet) from the highway used to transport the shipping container, and (3) a service station worker who might be working at a distance of 20 meters (65.6 feet) from the shipping container for 2 hours. The hypothetical maximum exposed individual radiological exposures were accumulated over the 40-year period. However, for the situation involving an individual who might be caught in traffic next to a truck transporting spent nuclear fuel, the radiological exposures were only calculated for one event since it was considered unlikely that the same individual would be caught in traffic next to all containers for all shipments. For truck shipments, the occupational maximum exposed individual is the driver. For each of the categories of truck shipments described in Sections A.4.2 through A.4.4, the calculations used a single individual as the driver for all shipments made in the past. For shipments in the 40-year period being evaluated, a single person was also used in the calculations as the driver for all shipments of each category.

The hypothetical maximum exposed individual scenarios for the general population described above were not applicable for on-site shipments of naval spent nuclear fuel and test specimens for two reasons. The first is that there are no members of the general population in the vicinity during the on-site shipments. The second reason is that an obstruction, if encountered, would be safely avoided under the direction of the escorts. Two alternate scenarios were developed. They were: (1) a site employee in a disabled vehicle along the transport route, located 10 meters (32.8 feet) from the container and (2) a site employee trailing the slow-moving transport vehicle for the entire trip. These scenarios were considered to be single-event occurrences.

As noted in Table A-6, simple methods were also used to calculate radiological exposures. For radiological exposures to personnel at a fixed distance from the shipping container, the following equation was used.

Exposures to personnel at a fixed distance from the container:

$$= N \times NBA \times T \times SF \times K \times TI / D^2$$

where:

N = number of people

NBA = factor to account for exposure decrease at increased distance from the source (attenuation/buildup). (Refer to Neuhauser and Kanipe 1993.)

T = time

SF = shielding factor

K = transport index to exposure rate conversion factor

TI = transport index (see Section A.7.1.1.2)

D = distance from the centerline.

For the radiological exposures associated with the ship transport of spent nuclear fuel from the Pearl Harbor Naval Shipyard to the Puget Sound Naval Shipyard, the following general equations were used:

Exposures to personnel aboard ship during transport:

$$= N \times NBA \times T \times SF \times K \times TI \times (1/(X_1 + X_2)^2 + 1/X_2^2)$$

where:

X_1 = distance between the centerlines of the two shipping containers

X_2 = distance between centerline of the nearest shipping container and the exposed individual

Exposures to personnel aboard ship during inspections:

$$= (N \times T \times TI) + (N \times NBA \times T \times K \times SF \times TI / (X_1 - R - 1)^2)$$

where:

R = effective radius to account for the exposure from the second shipping container.

Table A-7 provides an estimate of the number of people included in the analyses. To determine this number, the basic equation used was:

(Distance Traveled) x (Exposure Path Width) x (Density of People).

In each alternative, there are many shipments from several different origin/destination combinations. Since the route would be the same for each shipment from the same origin/destination combination, the people along the route would also not change, therefore, the distance used was from one trip for each origin/destination combination. The exposure path width is 1.6 kilometers (1 mile), consistent with the RADTRAN 4 computer code methodology for incident-free calculations. The population density was calculated by summing the product of the fraction of travel times the density in each population area (rural, suburban, and urban). The fraction of travel and density were obtained from HIGHWAY and INTERLINE. The total number of people was then calculated by summing the results of all origin/destination combinations for each alternative.

Table A-7. Estimated number of people included in incident-free transportation analyses.

Alternative	Number of People
No Action	890,000
Decentralization - No Examination	890,000
Decentralization - Limited Examination	9,240,000
Decentralization - Full Examination	6,820,000
1992/1993 Planning Basis	7,290,000
Regionalization or Centralization at INEL	7,290,000
Regionalization or Centralization at Hanford	8,370,000
Regionalization or Centralization at Savannah River	6,950,000
Regionalization or Centralization at Oak Ridge	5,660,000
Regionalization or Centralization at Nevada Test Site	8,320,000

A.5.2 Technical Approach for Transportation Accidents

The RADTRAN 4 computer code was used to calculate the radiological risk to the general population and transportation (occupational) crew under accident conditions. The RADTRAN 4 computer code evaluates six pathways for radiation exposures resulting from an accident. The six potential pathways are:

- Direct Radiation Exposure from the Damaged Container
- Inhalation Exposure from the Plume of Radioactive Material Released from the Damaged Container
- Direct Radiation Exposure from Immersion in the Plume of Radioactive Material Released from the Damaged Container
- Direct Radiation Exposure from Ground Deposition of the Radioactive Material Released from the Damaged Container
- Inhalation Exposure from Resuspension of the Radioactive Material Deposited on the Ground
- Ingestion Exposure from Food Products Grown on the Soil Contaminated by Ground Deposition of Radioactive Material Released from the Damaged Container.

For each pathway, a specific formula is used to determine an estimate of the radiological risk, expressed in exposure, from that particular pathway with the total radiation exposure equal to the sum of the exposure for each pathway. The total accident radiation exposure accounts for the probability of an accident occurring and the probability of an accident of a particular severity. It should be noted that all consequences are included in the risk assessment, regardless of the probability. The general equation for the population exposure from all pathways is:

$$D_R = \sum_{c,r} (N_c \times L_{r,c} \times P_r \times \sum_{i,j,k} (P_j \times RF_j \times D_{i,j,k}))$$

where: D_R = population exposure from the accident

N_c = number of naval spent nuclear fuel modules shipped of fuel type c

$L_{r,c}$ = shipment distance for fuel type c shipped through state r

P_r = frequency of traffic accidents

P_j = probability of occurrence of accident severity category j

RF_j = fraction of curies released from shipping container by severity category j

$D_{i,j,k}$ = radiation exposure resulting from accident severity category j through pathway i in population density zone k.

The accident risk evaluation was performed using neutral and stable atmospheric conditions (Pasquill Stability Classes D and F, respectively). The neutral atmospheric condition results provide a best estimate of the risk. Stable atmospheric conditions resulted in values approximately twice the neutral conditions, ignoring the lower probability of occurrence.

In addition to the estimation of the radiological risk of an accident described above, an evaluation of the consequences of an accident of the highest severity was performed. The consequences, expressed as radiological exposure, are calculated for the maximum exposed individual and the general population. Exposures to the general population were calculated for each of the three population density regions (rural, suburban, and urban). The maximum exposed individual was placed in the population area which resulted in the highest exposure.

The RISKIND computer code, modified by its authors to accept the fission product inventory unique to naval spent nuclear fuel, was used to calculate the maximum consequences. The pathways evaluated by RISKIND are identical to those used in the RADTRAN 4 computer code for the risk evaluation.

The maximum consequence evaluation presents the consequences for design basis accidents, defined as those accidents which have a probability of greater than 1×10^{-6} per year, and beyond design basis accidents, defined as those which have a probability of 1×10^{-6} to 1×10^{-7} per year. Accidents with a probability of less than 1×10^{-7} were not analyzed in the maximum consequence evaluation.

To determine the overall probabilities, the probability of an accident, the probability of the consequences, fraction of travel in each population area, and probability of the meteorological conditions had to be determined.

The probability of the accident was calculated by multiplying the accident rates for each state times the distance traveled in each state times the number of shipments. The results were summed for each combination of origin and destination for the alternative.

As described later in Section A.7, a study performed by Lawrence Livermore National Laboratory entitled "Shipping Container Response to Severe Highway and Railway Accident Conditions" (NUREG 1987) grouped accidents into categories by strain and container mid-wall temperatures and calculated the probabilities of accidents of each category. Section A.7 also describes the consequences associated with each accident category for the naval spent nuclear fuel and test specimen shipments. The probabilities were summed for the categories which have the same consequences.

The fraction of travel in each population area (rural, suburban, and urban) was obtained from INTERLINE and HIGHWAY for each origin/destination combination. Each alternative consists of many shipments from various origin/destination combinations; therefore, an overall fraction was calculated. The overall fraction, by alternative, was calculated by multiplying each origin/destination fraction (from INTERLINE and HIGHWAY) by the number of shipments from that particular origin/destination combination, summing the results and dividing by the total number of shipments.

To calculate the probability of the meteorological conditions, Pasquill Class D was considered to be equivalent to 50% meteorology; that is, 50% of the time, conditions are expected to be more severe, and 50% of the time, conditions are expected to be less severe. Pasquill Class F was considered to be equivalent to 95% meteorology; that is, 5% of the time, it is more severe, and 95% of the time, it is less severe. Since the difference in 50% (1 chance in 2) and 95% (1 chance in 20) is a factor of 10, the probability of encountering Pasquill Class F was concluded to be a factor of 10 less than Pasquill Class D. Analyses performed by the National Oceanic and Atmospheric Administration (Doty et al. 1976) confirm that this assumption is reasonable.

The overall probability of the consequence of an accident for each population area was then calculated by multiplying the accident probability times the consequence probability times the fraction of distance traveled. Starting with the highest consequences, the probabilities were then compared to the 1 x 10^{-6} per year criterion for the design basis accidents and 1 x 10^{-7} per year criterion for the beyond design basis accidents. If the probability was greater than 10 times the criterion (1 x 10^{-6} or 1 x 10^{-7}), the most severe Pasquill Class F results were presented. If not, and the probability was greater than the criterion (1 x 10^{-6} or 1 x 10^{-7}), Pasquill Class D was presented. If the probability was less than the cutoff, the probabilities having the next most severe consequences were compared to the same criterion and this step was repeated until all consequences were evaluated. As a minimum, the consequences resulting from release of 1% of the corrosion products (Pasquill Class D) were presented.

Careful attention was paid to ensure that the probabilities were not calculated for such small categories that the resulting probabilities were less than the criterion and results would inadvertently present less severe consequences. When the highest consequence accident did not meet the criterion, the probability of the next highest accident was determined by summing both the accident consequence being evaluated and the probability of the higher consequence accidents previously shown to have a probability less than the criterion. This same technique was applied to the fraction of travel (urban fraction is equivalent to highest consequence, suburban fraction is next highest, etc.) as demonstrated in the following example.

Probability of the accident of Consequence A	-	1.17 x 10^{-7}
Fraction of distance traveled in rural area	-	0.85
Fraction of distance traveled in suburban area	-	0.11
Fraction of distance traveled in urban area	-	0.04

The urban fraction was multiplied by the probability, and the resultant probability of an accident of Consequence A in an urban area was 4.68 x 10^{-9}. The consequences of this accident would not be evaluated. For the suburban area, the suburban and urban fractions were added and then multiplied by the probability (1.75 x 10^{-8}). Again, the consequences of this accident would not be evaluated since the probability is less than 1 x 10^{-7}. Likewise, for the rural area, the rural, suburban, and urban fractions were added and multiplied by the probability. Using this technique, the probabilities would indicate that the rural probability was 1.17×10^{-7}, which is greater than the 1×10^{-7} criterion and the Consequence A results would be presented. If the fractions were used at face value, however, the probability of an accident of Consequence A would have been 4.68×10^{-9} in an urban area, 1.29×10^{-8} in a suburban area, and 9.95×10^{-8} in a rural area. When individually compared to the 1×10^{-7} criterion, this accident would not have been presented for any area.

Accident results are presented for both the maximum exposed individual and the general population. These results include members of the transportation crew.

A.6 ROUTING ANALYSIS

In order to assess the radiological risks associated with transportation, it was necessary to determine route characteristics based on the origin and destination of each shipment.

For naval spent nuclear fuel shipments, the origin is the prototype or shipyard location where the naval spent nuclear fuel is removed from a prototype or shipboard reactor. The destination is ECF, Savannah River Site, Hanford Site, Oak Ridge Reservation, Nevada Test Site, or Puget Sound Naval Shipyard, depending on the alternative. For each origin and destination pair, the potential rail routes have been generated and analyzed using the INTERLINE computer code (Johnson 1993a). For shipments originating from Pearl Harbor Naval Shipyard, the containers travel by ship to Puget Sound Naval Shipyard, where they are transferred to rail for shipment to the destination following the same routes as the naval spent nuclear fuel shipments originating from Puget Sound Naval Shipyard. The shipment travel time by ocean was based on historical data on the time in transit, independent of the actual route. For heavy-lift transporter shipments from the Kesselring and Windsor prototype sites to the closest rail siding, the actual street routes and shipment duration times based on previous shipments were used.

INTERLINE is an interactive computer program designed to simulate routing using the U.S. rail system. The INTERLINE code used is the latest available from Oak Ridge National Laboratory and contains the 1990 census data. The INTERLINE data base consists of networks representing various competing rail companies in the U.S. The routes used for the transportation evaluation use the standard INTERLINE model which simulates the selection procedure that railroad companies would use to direct shipments of spent nuclear fuel. The code is updated periodically to reflect current track conditions and has been benchmarked against reported mileages and observations. INTERLINE also provides the weighted population densities for rural, suburban, and urban populations for each state and averaged over all states along the shipment route and the percentage of mileage traveled in each population density. The distance traveled, weighted population density, and percentage of distance in each population density are input variables in the RADTRAN 4 code.

For the off-site transportation of the test specimen assemblies and test specimens, all shipments are made by exclusive-use truck which includes no other freight. The destinations are ECF, Savannah River Site, Hanford Site, Oak Ridge Reservation, Nevada Test Site, Puget Sound Naval Shipyard, Bettis Atomic Power Laboratory, and Knolls Atomic Power Laboratory for the various alternatives. For each origin and destination pair, the potential truck routes have been generated and analyzed using the routing model HIGHWAY.

HIGHWAY is an interactive computer code designed to simulate routing using the U.S. highway system. The HIGHWAY code used for this report is the latest available from Oak Ridge National Laboratory. The code is updated periodically as new roads are added. HIGHWAY provides the distance between the origin and destination, the weighted population densities along the route, and the percentage of distance traveled in each population density, all input variables for the RADTRAN 4 computer code.

For the on-site transportation, HIGHWAY only has two of the sites on the INEL. This origin/destination pair was run using HIGHWAY to determine the population densities and percentage of travel in each population density. The actual distance between sites on the INEL was measured.

A.7 INPUT PARAMETERS

The major input parameters and models used to evaluate the radiological risks associated with the five alternatives described in Section A.3 are provided in this section. Standard RADTRAN 4 computer code values, as well as actual data gathered from historical naval spent nuclear fuel and test specimen shipments, were used as the basis for the input parameters. For those situations where historical data were available, the actual data were used in place of the standard RADTRAN 4 computer code values to provide the best estimate of the radiological risks associated with each alternative.

A.7.1 Shipments of Naval Spent Nuclear Fuel from Shipyards and Prototypes

A.7.1.1 Incident-free Transportation of Spent Nuclear Fuel from Shipyards and Prototypes. This section provides the input parameters used to determine the radiological impacts associated with the routine, incident-free (i.e., no accident) transportation of spent nuclear fuel for each of the five alternatives.

A.7.1.1.1 Planned Shipments. The list of planned shipments of naval spent nuclear fuel by origin is provided in Table A-8.

Table A-8. Planned shipments of naval spent nuclear fuel from shipyards and prototypes.

Alternative	Generating Site: East Coast	Generating Site: West Coast	Generating Site: NRF	Generating Site: TOTAL	Origin or Destination
No Action, Decentralization - No Exam	204	0	0	204	To Norfolk
Decentralization - Limited Exam	53	0	1	54	To Puget Sound
	181	0	0	181	To Norfolk
	234	0	1	235	
Decentralization - Full Exam	314	261	0	575	To ECF
	314	261	0	575	From ECF
	628	522	0	1150	
1992/1993 Planning Basis, Regionalization at INEL and Centralization at INEL	314	261	0	575	To ECF
All other Regionalization and Centralization Alternatives	314	261	3	578	To Regionalization or Centralization site

A.7.1.1.2 Transport Index. Historical information from prior shipments was used to estimate the expected external radiation exposure rates for future shipments. This information included actual measured radiation levels and the recorded Transport Indexes (TIs) from past shipments. The TI used in this analysis is the sum of the maximum neutron and gamma radiation measured at 1 meter (3.3 feet) from the surface of the cask. The TIs that were used ranged from 0.1 to 1.8.

A.7.1.1.3 Transportation Distances and Population Densities. Section A.6 provided a description of the general methodology used for determining transportation distances and the population densities along the transportation routes. Historical data were obtained on the distance traveled for shipments from the shipyards and prototype sites to ECF. These data were averaged by origin and compared to the value calculated by INTERLINE. The actual data were approximately 11% higher than the distance predicted by INTERLINE on average. In order to provide the best estimate exposure, which is based on the distance traveled, the INTERLINE distances were increased by 11% for the 1992/1993 Planning Basis alternative. One of the primary reasons the actual distances traveled were judged to be longer than the INTERLINE prediction was the escort responsibility to avoid potential delays due to track or security problems. The shipments to the alternative sites will also be escorted and therefore the same increased travel distance is expected. The 11% increase in distance traveled was also applied to all other alternatives. This technique allowed for comparison of the alternatives on an equal basis. The percentages of distance traveled in each population density calculated by INTERLINE were applied to the distances increased by 11%.

A.7.1.1.4 Train Speed. The RADTRAN 4 computer code provides standard values for train speeds that are dependent on the population density. For rural areas, the standard value is 64.4 kilometers per hour (40 miles per hour (mph)). For suburban areas, the standard value is 40.2 kilometers per hour (25 mph), and for urban areas, the standard value is 24.1 kilometers per hour (15 mph). However, naval spent nuclear fuel shipments are required to be transported at speeds not to exceed 56.3 kilometers per hour (35 mph). Government escort logs from historical spent nuclear fuel shipments support use of 24.1 kilometers per hour (15 mph). This 24.1 kilometers per hour (15 mph) train speed estimate was used to evaluate all five alternatives.

A.7.1.1.5 Train Stop Time. The RADTRAN 4 computer code provides standard values for train stop times that are either dependent or independent of the distances traveled. For naval spent nuclear fuel transported by rail, the government escorts are responsible for ensuring that the shipments are made in the most efficient and safe manner. The government escort logs for historical spent nuclear fuel shipments were reviewed, and actual stop times were determined to be much shorter than the standard RADTRAN 4 computer code values. The recorded stop times were divided by the actual distance traveled from historical data over the last 3 years and an average of 0.02 hour per kilometer (0.032 hour per mile) was calculated. This value was used to evaluate all five alternatives since the rail transportation of spent nuclear fuel will always be accompanied by government escorts and all alternatives originate from the same locations.

A.7.1.1.6 Number of Train Crew Members. The standard RADTRAN 4 computer code value for the number of train crew members is five. For all shipments to NRF, all rail companies with the exception of Burlington Northern have two crew members during shipments, located in the locomotive. Burlington Northern adds a third crew member in a caboose immediately behind the government escort caboose. In the RADTRAN 4 computer code, exposure to the crew members is not calculated since the distance to the crew members is large. In actuality, the distance to the Burlington Northern crew member located in the caboose is less than that used in the RADTRAN 4 computer code and therefore simple calculations were performed to determine the radiological exposure. In addition, naval spent nuclear fuel shipments also are shipped periodically by "special train." In the special train configuration, the two crew members in the locomotive are one car from the railcar with the shipping container. Historically, these shipments occur approximately 42 percent of the time. The majority of shipments by "special" train are arranged by the railroad companies to meet railroad schedules. On occasion, the Navy requests "special" train service for shipments with high-priority examination material. Simple calculations were also performed to determine the radiological exposure during these special shipments. For shipments to the sites other than NRF, there was no experience with all railroad companies which would have to be used; however, there is no reason to expect the rail companies to change their standard practices. In these cases, there would be two train crewmen, both located in the engine area. Forty-two percent of the shipments would be shipped by special train to the alternate sites. When applicable, the third Burlington Northern crew member was also accounted for.

A.7.1.1.7 Transport Index to Exposure Rate Conversion Factors. Container transport index to exposure rate conversion factors for the M-130 and M-140 shipping containers were calculated using the standard equation in the RADTRAN 4 computer code. The results were compared to detailed computer analyses performed using SPAN4, and the RADTRAN 4 results were found to overestimate the exposure by a factor of two to three. Using the SPAN4 computer code results, the effective package dimensions of the containers used in the RADTRAN 4 calculations were adjusted to provide a conservative yet more realistic value of the transport index to exposure rate conversion factor. Due to similarities in the construction and fuel shipped, the M-130 conversion factor was applicable to the M-160. The values used are provided in Table A-9.

Table A-9. Transport index to exposure rate conversion factors for the M-130, M-140, and M-160 shipping containers.

Container	Effective Package Dimension (meters)	Transport Index to Exposure Rate Conversion Factor
M-130/M-160	2.50 (8.2 feet)	5.06
M-140	3.20 (10.5 feet)	6.76

A.7.1.1.8 Train Stop Shield Factors. For train stops, the standard RADTRAN 4 computer code gamma and neutron radiation shield factors are both assigned as 0.1. This value includes the presence of substantial railyard steel structures equivalent to approximately 4 inches of steel. Four inches of steel reduces gamma radiation by more than a factor of 10; however, the steel only reduces neutron radiation by a factor of approximately 2. Therefore, a shield factor of 0.5 was conservatively used for neutron radiation. In order to incorporate this shielding into the RADTRAN 4 computer code, separate gamma and neutron radiation exposure calculations were performed. However, since RADTRAN 4 does not permit separate shielding factors to be used for different types of radiation, the stop times for the neutron radiation evaluations were increased by a factor of 5 to provide an equivalent increase in neutron exposure. These more realistic changes to the standard RADTRAN 4 computer code values were incorporated for all five alternatives.

A.7.1.1.9 Radiation Exposure Decrease Due to Distance. The RADTRAN 4 computer code provides standard values for determining the gamma and neutron radiation exposure decrease at increasing distance from the source. For gamma radiation, the RADTRAN 4 computer code uses the $1/x^2$ decrease due to distance. The RADTRAN 4 computer code also specifically calculates the decrease in neutron exposure at increased distances. The adequacy of the RADTRAN 4 radiation exposure decrease was evaluated. The gamma radiation decrease factor used by RADTRAN 4 was consistent with the results predicted for naval fuel. The RADTRAN 4 prediction for neutron radiation slightly overpredicts the decrease in exposure at far distances for the shipping containers used for naval shipments. Using the same basic equation used by RADTRAN, a value of 2.0×10^{-10} was used for the RADTRAN 4 constant a_4 in lieu of 0. The value of 2×10^{-10} produces results which are slightly higher than the standard method and agree with measurements of neutron exposure rates from naval spent nuclear fuel shipments.

A.7.1.1.10 Shipment Storage Time. As noted previously, the government escorts accompanying the rail shipments of spent nuclear fuel are responsible for ensuring that the naval spent nuclear fuel shipments are made in the most efficient and safe manner. Naval spent nuclear fuel is not stored while being shipped; therefore, there was no intermediate shipment storage time associated with any of the alternatives. There is also no intermediate storage time during the heavy-lift transport shipments from the prototype sites and the ocean shipments from Pearl Harbor Naval Shipyard.

A.7.1.1.11 Heavy-lift Transporter Transportation Crew. Information from records of naval spent nuclear fuel shipments was reviewed to determine a realistic estimate of the number of people involved, the amount of time required, and the distances between individuals and the shipping container. The number of hours worked ranged from 1 to 10 and the distance from the container ranged from 1.5 to 91 meters (5 to 300 feet). For simplicity, weighted averages of the number of hours and distances from the shipping container were calculated and are provided in Table A-10.

Table A-10. Summary of the number of people involved and distance from the container during heavy-lift transporter shipments to the rail siding at the prototype sites.

Prototype	Number of People	Number of Hours per Worker	Distance from the Shipping Container (meters)
Windsor Site	37	5.08	25.0 (82 feet)
Kesselring Site	36	5.11	32.3 (106 feet)

This information was used to evaluate all five alternatives.

A.7.1.1.12 Time to Ship by Heavy-lift Transporter. Based on discussions with personnel at the prototype facilities who have made shipments and a review of records, the average duration of the heavy-lift transporter shipment from the prototype sites to the local rail siding is 2 hours.

A.7.1.1.13 Number of Heavy-lift Transporter Inspections. The shipments are inspected prior to leaving the prototype's site boundaries, and no additional inspections are performed during the short heavy-lift transporter shipment. As a result, there are no inspections during the heavy-lift transporter shipment in the evaluation of the five alternatives.

A.7.1.1.14 Heavy-lift Transporter Stop Time. Shipments of spent nuclear fuel from the two prototype locations are first transported by heavy-lift transporter to the nearest rail siding. Information from records of naval spent nuclear fuel shipments was reviewed to determine a realistic estimate of the heavy-lift transporter stop times. For naval spent nuclear fuel heavy-lift transporter shipment from the Windsor Site, a heavy-lift transporter stop time of 24 hours was used. For heavy-lift transporter shipments from the Kenneth A. Kesselring Site, a stop time of 10 hours was used. The heavy-lift transporter shipments from the prototypes to the rail sidings occur through suburban populations only. These heavy-lift transporter stop times were used to evaluate all five alternatives.

A.7.1.1.15 Standard RADTRAN 4 Computer Code Values Used. The following standard RADTRAN 4 computer code value was reviewed and determined to reflect the best estimate of current railroad industry practice:

- Number of Inspections of the Shipping Container and Railcar.

The following standard RADTRAN 4 computer code estimates of the populations that could be affected by the shipment of spent nuclear fuel were also used for the five alternatives:

- Number of People per Vehicle Sharing the Transport Route (On Link)

- Traffic Count Passing a Specific Point - Rural, Suburban, and Urban Zones

- Average Exposure Distance When Stopped

- Persons Exposed While Stopped

- Fraction of Travel During Rush Hour, on City Streets, and on Freeways.

A.7.1.1.16 Number of Ship Inspections. Shipments of spent nuclear fuel from Pearl Harbor Naval Shipyard must first be transported by ship to the Puget Sound Naval Shipyard. Using the standard values in the RADTRAN 4 computer code, the radiological exposures to the crew and government escorts are negligible since the distances from these individuals to the shipping containers are large. As a result, the radiological exposure estimates are only expected to occur during inspections. Based on radiation monitoring results for past naval spent nuclear fuel shipments, this is not realistic for naval spent nuclear fuel, and a separate calculational model was developed to account for this potential radiation exposure. The model uses the standard point source formula (see Section A.5.1) to calculate the crew and government escort exposures during transport by ship. The model took into account the ship used, transport index, transport time, distance between shipping containers, distance from the shipping containers and living quarters, distance from the shipping containers and the engine room, the number of crew members and government escorts, and the time required for inspections based on records from historical shipments of spent nuclear fuel. After reviewing historical shipment records, it was determined that three different sized ships have recently been used. The smallest one, Ship 1, was used once and is not expected to be used in the future. Only the other two, Ships 2 and 3, would be used in the future, in equal proportion. Table A-11 below provides the information used to calculate the radiological exposures resulting from transporting naval spent nuclear fuel by ship. This model was used to evaluate all five alternatives.

Table A-11. Parameters used to calculate crew and escort exposure during ocean travel from Pearl Harbor Naval Shipyard to Puget Sound Naval Shipyard.

Parameter	Ship 1	Ship 2	Ship 3
Transport Time, T, in days	11	8	9
Separation Between M-130s, X_1, in feet	92	43	20
Nearest Distance to Living Quarters, X_2, in feet	40	80	300
Nearest Distance to Engine Room, X_3, in feet	20	80	300
Number of Crew Members, N_c	11	22	26
Number of Government Escorts (not part of crew size), N_e	2	2	2
Escort Inspection Time (per Escort), in hr/day	0.50 for historic 0.25 for future		
Shielding Factor	(1/3) for gamma, (2/3) for neutron, for every 40-foot increment from the container centerline		

A.7.1.2 Accident During Transportation of Spent Nuclear Fuel. This section provides the input parameters used to calculate the radiological impacts for accidents during transportation of spent nuclear fuel for evaluation of the five alternatives. The planned shipments, transportation distances, population densities, and the percentages of travel in each population density described in Section A.7.1.1 were also used for the accident analyses. Unless otherwise described in this section, the standard values provided by the RADTRAN 4 and RISKIND computer codes were used.

A.7.1.2.1 Accident Probability. The probability of a rail accident used for evaluation of all alternatives was obtained from "Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight" (Saricks and Kvitek 1994). The probabilities are provided both by state and a national average. The state dependent probabilities were used for the accident risk assessment. Past naval spent nuclear fuel shipments have traveled approximately 2 million kilometers (1.24 million miles) by rail without an accident, which is consistent with the national average of 5.57×10^{-8} accident per kilometer.

A.7.1.2.2 Accident Severity Categories and Probabilities. In the "Shipping Container Response to Severe Highway and Railway Accident Conditions" (NUREG 1987), referred to as the "Modal Study," Lawrence Livermore National Laboratory categorized the potential damage to shipping containers according to the magnitude of the thermal and mechanical forces that could result from an accident. The structural and thermal forces were categorized into 20 regions. Given that an accident occurs, the probability that the accident would be in each region was calculated for both rail and truck shipments. Table A-12 provides the probabilities for rail accidents by region.

Table A-12. Accident severity probabilities for rail shipments.

Structural Response (maximum strain on inner shell, %)					
	R(4,1) 1.786×10^{-9}	R(4,2) 3.290×10^{-13}	R(4,3) 2.137×10^{-13}	R(4,4) 1.644×10^{-13}	R(4,5) 3.459×10^{-14}
S_3 (30)	R(3,1) 5.545×10^{-4}	R(3,2) 1.0217×10^{-7}	R(3,3) 0.634×10^{-8}	R(3,4) 5.162×10^{-8}	R(3,5) 5.296×10^{-8}
S_2 (2)	R(2,1) 2.7204×10^{-3}	R(2,2) 5.011×10^{-7}	R(2,3) 3.255×10^{-7}	R(2,4) 2.531×10^{-7}	R(2,5) 1.075×10^{-8}
S_1 (0.2)	R(1,1) 0.993962	R(1,2) 1.2275×10^{-3}	R(1,3) 7.9511×10^{-4}	R(1,4) 6.140×10^{-4}	R(1,5) 1.249×10^{-4}
		T_1 (500)	T_2 (600)	T_3 (650)	T_4 (1050)

Thermal Response (lead mid-thickness temperature, °F)

A.7.1.2.3 Naval Spent Nuclear Fuel Integrity Following an Accident. Detailed structural and thermal analyses were performed for the shipping containers used for naval spent nuclear fuel shipments up to an equivalent strain of 30% and mid-wall temperature of 1050°F. For these cases, the naval spent nuclear fuel was not damaged. For the thermal and structural regions above 1050°F and 30% strain, the modal study defines the upper limits as unbounded. The naval spent nuclear fuel was postulated to be damaged and the fission products and corrosion products would be released in the quantities described in Table A-13 for the risk analyses.

A.7.1.2.4 Release Fractions. The release fractions were derived based on the results presented in the NRC modal study (NUREG 1987) and the results of the structural and thermal analyses described above. Although the naval spent nuclear fuel is stronger, the release fractions for the boiling water reactor (BWR), pressurized water reactor (PWR), and aluminum-clad fuel from the modal study were used. From the modal study, the release fraction in lower left region R(1,1) is zero for the risk evaluation. For the maximum consequence evaluation, 1% of the corrosion products might be released for the lower left region, R(1,1). Based on the results of the structural and thermal analyses up to 30% strain and 1050°F mid-wall temperature, the naval spent nuclear fuel is not damaged; therefore, regions R(1,2), R(1,3), R(2,1), R(2,2), R(2,3), R(1,4), R(2,4), R(3,4), R(3,1), R(3,2) and R(3,3) do not release fission products. Ten percent of the corrosion products might be released. In the remaining regions, 10% of the fission products might be available for release and released at the fractions specified below, also using a release of 10% of the corrosion products. Table A-13 provides the release fractions used.

Table A-13. Cask release fractions used for the RADTRAN 4 risk analyses.

	Release Fraction[a]					
Cask Response Region	Inert Gas	Iodine	Cesium	Ruthenium	Particulates	Corrosion Products
R(1,1)	0.0	0.0	0.0	0.0	0.0	0.0
R(1,2), R(1,3)	0.0	0.0	0.0	0.0	0.0	1.0
R(2,1), R(2,2), R(2,3)	0.0	0.0	0.0	0.0	0.0	1.0
R(1,4), R(2,4), R(3,4)	0.0	0.0	0.0	0.0	0.0	1.0
R(3,1), R(3,2), R(3,3)	0.0	0.0	0.0	0.0	0.0	1.0
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}	1.0

[a] The release fraction represents the fraction of the fuel inventory available for release in the shipping container that would be released into the atmosphere following an accident of the given severity.

A.7.1.2.5 Plume Release Height. For the accident risk assessment, a ground level release was used. For the maximum consequence assessment, a plume release height of 10 meters (32.8 feet) was used.

A.7.1.2.6 Direct Exposure from a Damaged Shipping Container. A radiation level following the accident at the 10CFR71 regulatory limit of 1 rem at 1 meter (3.3 feet) from the container surface was used.

A.7.1.2.7 Food Transfer Factors. Food transfer factors were derived for the isotopes related to naval spent nuclear fuel in accordance with the methods described in Nuclear Regulatory Commission Guide 1.109 (NUREG 1977).

A.7.1.2.8 Distance from the Accident Scene to the Maximum Exposed Individual. No shielding was accounted for as the plume passes for the calculation of the exposure to the maximum individual. This location was determined using RISKIND based on the atmospheric stability and plume release height used. The maximum exposed individual could be a member of the rail crew or the general population.

A.7.1.2.9 RISKIND Population Density. The standard national average for each population density from the RADTRAN 4 computer code was used for the RISKIND maximum consequences assessment (6 people per square kilometer for rural, 719 for suburban, and 3861 for urban).

A.7.1.2.10 Radionuclide Inventory. The amount of radionuclides which would be released from an average shipment are provided in Table A-14. The values factor in the damage fraction described in Section A.7.1.2.3 and release fractions described in Section A.7.1.2.4. The radionuclides listed result in 99 percent of the exposure in all pathways.

Table A-14. Radionuclides which would be released from an average shipment of naval spent nuclear fuel from a shipyard or prototype.

For Accidents which Release Both Fission and Corrosion Products		For Accidents which Release Only Corrosion Products	
Nuclide	Activity (Ci)	Nuclide	Activity (Ci)
Kr-85	9.85×10^{2}	Co-58	1.61×10^{-1}
Cs-134	3.72×10^{1}	Mn-54	2.22×10^{-2}
Cs-137	3.44×10^{1}	Fe-55	6.62×10^{-1}
H-3	1.39×10^{1}	Co-60	3.63×10^{-1}
Ru-106	9.02×10^{-1}	Sr-90	3.14×10^{-4}
Ce-144	4.89×10^{-1}	Ni-63	1.19×10^{-1}
Co-60	3.63×10^{-1}		
Sr-90	3.41×10^{-1}		
Pu-238	1.02×10^{-2}		
Pu-241	3.43×10^{-3}		
Cm-244	1.36×10^{-4}		

A.7.2 Transfers of Naval Spent Nuclear Fuel to Storage Following Examination

A.7.2.1 Incident-free Transportation of Naval Spent Nuclear Fuel to Storage. This section provides the input parameters used to determine the radiological impacts associated with the routine, incident-free (i.e., no accident) transportation of naval spent nuclear fuel to storage for each of the five alternatives.

A.7.2.1.1 Planned Shipments. Table A-15 provides the number of planned transfers in each cask.

Table A-15. Planned transfers of naval spent nuclear fuel to storage.

	NFS-100	Peach Bottom	Large Cell
No Action, Decentralization - No Exam, Decentralization - Limited Exam	0	0	15
Decentralization - Full Exam	0	0	14
1992/1993 Planning Basis, All Regionalization Alternatives, All Centralization Alternatives	196	64	468

A.7.2.1.2 Transport Index (TI). A TI of 0.3 was used for all NFS-100 cask transfers. This value was determined from recorded measurements over the last 3 years for the same fuel types planned to be transferred in the future. The Peach Bottom and Large Cell casks have not previously been used for the planned transfers and therefore historic data were not available. Based on a comparison of predicted TI values from conservative safety analyses to the actual measured TI's for similar casks and fuel types, a TI of 1.0 was calculated for both the Peach Bottom and Large Cell casks.

A.7.2.1.3 Transportation Distances and Population Densities. Section A.6 provided a description of the general methodology used for determining transportation distances and the population densities along the transportation routes. The distance between ECF and ICPP is 9.7 kilometers (6 miles). From the HIGHWAY computer code, the transfer of naval spent nuclear fuel to storage occurs in a rural area. As stated in Section A.3.5, the storage facility at the alternative sites was identical to ICPP. Therefore, for the evaluation of the alternatives, the distance traveled and population density of the ECF to ICPP transfer were also used for the evaluation of the other alternatives.

A.7.2.1.4 Truck Speed. The standard RADTRAN 4 computer code speed for truck shipments in a rural population is 88.5 kilometers per hour (55 miles per hour). One of the reasons an on-site worst credible accident is less severe than the 10CFR71 hypothetical accident is that the speed is severely limited by the on-site transportation procedures. An average speed of 24.1 kilometers per hour (15 miles per hour) was used.

A.7.2.1.5 Truck Stop Time. The standard RADTRAN 4 computer code provides values for truck stop times that are either dependent or independent of the distances traveled. The logs for historical transfers of naval spent nuclear fuel to storage were reviewed, and it was determined that the actual stop times (10 minutes) were much shorter than the standard RADTRAN 4 computer code values. A stop time of 10 minutes was used to evaluate all five alternatives.

A.7.2.1.6 Radiation Exposure Decrease Due to Distance. The radiation exposure decrease due to distance described in Section A.7.1.1.9 was also applied to the truck transfers of naval spent nuclear fuel to storage.

A.7.2.1.7 Distance from Source to Crew. A distance of 6.1 meters (20 feet) was measured between the shipping cask and the driver for the exclusive-use truck transfers of naval spent nuclear fuel shipments to storage. Two escorts, one located approximately 46 meters (150 feet) in front and one the same distance behind the transport vehicle, are also present. These data were used in the RADTRAN analyses for all alternatives.

A.7.2.1.8 Transport Index to Exposure Rate Conversion Factors. Transport index to exposure rate conversion factors for the casks used for transfers of naval spent nuclear fuel to storage were calculated using the standard equation in RADTRAN 4. The results were compared to detailed computer analyses performed using SPAN4, and RADTRAN 4 results were found to overestimate the exposure. Using the SPAN4 computer code results, the effective package dimensions of the casks used in the RADTRAN 4 calculations were adjusted to provide a conservative yet more realistic value of the transport index to exposure rate conversion factor. The values used are provided in Table A-16.

Table A-16. Transport index to exposure rate conversion factors for the NFS-100, Peach Bottom, and Large Cell casks.

Cask	Effective Package Dimension (meters)	Transport Index to Exposure Rate Conversion Factor
NFS-100	3.8 (12.5 feet)	8.41
Peach Bottom	2.8 (9.2 feet)	5.76
Large Cell	3.2 (10.5 feet)	6.76

A.7.2.1.9 Storage. There is no intermediate storage time during transfers of naval spent nuclear fuel to its destination.

A.7.2.1.10 Persons Exposed While Stopped. The only stop time for the transfer of naval spent nuclear fuel to storage occurs during routine surveys at the destination entrance. This area is well removed from highway and general population and therefore no people were considered to be exposed during the short 10-minute stop. The escorts are not present during the surveys and the driver remains in the cab of the truck, 6.1 meters (20 feet) from the cask during the surveys. The people performing the surveys are badged and all exposure received during the surveys is included in the normal occupational exposure which is regularly monitored.

A.7.2.1.11 Traffic Count Passing a Specific Point. The RADTRAN 4 computer code uses 470 vehicles per hour passing the transport vehicle. Travel on the transport path is restricted to INEL employees by a security checkpoint, the majority of INEL employees ride the INEL site buses to work, and the transfers are not made during high traffic times (i.e., shift changes when buses are in service); therefore, using the standard 470 vehicles per hour value would be extremely conservative. A more realistic estimate of 25 vehicles per hour was used.

A.7.2.1.12 Standard RADTRAN 4 Computer Code Values Used. The following standard RADTRAN 4 computer code value was reviewed and determined to reflect the best estimate of current industry practice and was consistent with historical data from transfers of naval spent nuclear fuel to storage:

- Minimum Number of Inspections.

The following standard RADTRAN 4 estimate of the population that could be affected by the transfer of naval spent nuclear fuel to storage was used to evaluate the five alternatives:

- Number of People per Vehicle Sharing the Transport Route (On Link).

A.7.2.2 Accident During Transportation of Spent Nuclear Fuel to Storage. This section provides the input parameters used to calculate the radiological impacts for accidents during transportation of spent nuclear fuel to storage for evaluation of the five alternatives. The planned transfers, transportation distances, population densities, and the percentages of travel in each population density described in Section A.7.2.1 were also used for the accident analyses. Unless otherwise described in this section, the standard values provided by the RADTRAN 4 and RISKIND computer codes were used.

A.7.2.2.1 Accident Probability. The probability of a truck accident used for evaluation of all alternatives was obtained from "Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight" (Saricks and Kvitek 1994). The truck accident rates are state dependent. The states in which naval spent nuclear fuel would be transferred to storage for the alternatives described in Section A.3 are Idaho, Washington, South Carolina, Tennessee, and Nevada. The corresponding accident rates for travel on rural interstates in accidents per kilometer are 2.30×10^{-7} for Idaho, 2.50×10^{-7} for Washington, 1.83×10^{-7} for South Carolina, 1.48×10^{-7} for Tennessee, and 1.57×10^{-7} for Nevada. The values correspond to 3.70×10^{-7} (Idaho), 4.02×10^{-7} (Washington), 2.94×10^{-7} (South Carolina), 2.38×10^{-7} (Tennessee), and 2.53×10^{-7} (Nevada) accidents per mile.

A.7.2.2.2 Accident Severity Categories and Probabilities. In the modal study, Lawrence Livermore National Laboratory categorized the potential damage to shipping containers according to the magnitude of the thermal and mechanical forces that could result from an accident. The structural and thermal forces were categorized into 20 regions. Given that an accident occurs, the probability that the accident would be in each region was calculated for both rail and truck shipments. Table A-17 provides the probabilities for truck accidents by region.

Table A-17. Accident severity probabilities for truck shipments.

Structural Response (maximum strain on inner shell, %)					
(above S_3 (30))	R(4,1) 1.532×10^{-7}	R(4,2) 3.926×10^{-14}	R(4,3) 1.495×10^{-14}	R(4,4) 7.681×10^{-16}	R(4,5) $< 1 \times 10^{-16}$
S_3 (30) – S_2 (2)	R(3,1) 1.7984×10^{-3}	R(3,2) 1.574×10^{-7}	R(3,3) 2.034×10^{-7}	R(3,4) 1.076×10^{-7}	R(3,5) 4.873×10^{-8}
S_2 (2) – S_1 (0.2)	R(2,1) 3.8192×10^{-3}	R(2,2) 2.330×10^{-7}	R(2,3) 3.008×10^{-7}	R(2,4) 1.592×10^{-7}	R(2,5) 7.201×10^{-8}
(below S_1 (0.2))	R(1,1) 0.994316	R(1,2) 1.687×10^{-5}	R(1,3) 2.362×10^{-5}	R(1,4) 1.525×10^{-5}	R(1,5) 9.570×10^{-6}
		T_1 (500)	T_2 (600)	T_3 (650)	T_4 (1050)

Thermal Response (lead mid-thickness temperature, °F)

A.7.2.2.3 Naval Spent Nuclear Fuel Integrity Following an Accident. Detailed structural and thermal analyses have been performed for the casks used for shipments of naval spent nuclear fuel to storage. As described in Section A.4.5, these analyses are performed using a worst credible accident which is defined based on the site specific terrain and administrative controls during the short on-site shipment. The probability of the worst credible accident is equal to that listed in region R(1,1). For accident conditions in excess of the worst credible accident, the fission product and corrosion product release fractions described in the next section were used.

A.7.2.2.4 Cask Release Fractions. The cask release fractions were derived based on the results presented in the NRC modal study (NUREG 1987). Although the naval spent nuclear fuel is stronger, the release fractions for the BWR, PWR, and aluminum-clad fuel from the modal study were used. From the modal study, the release fraction for lower left region R(1,1) is zero for the risk evaluation. For the maximum consequence evaluation, 1% of the corrosion products were released for the lower left region, R(1,1). The remaining regions used 10% of the fission products available for release, released at the fractions specified below, and release of 10% of the corrosion products. Table A-18 provides the release fractions used. The release fractions in Table A-18 for the less severe conditions differ from those in Table A-13 because supplementary structural and thermal analyses have not been performed for the casks discussed in this section.

Table A-18. Cask release fractions used for the RADTRAN 4 risk analyses.

Cask Response Region	Release Fraction[a] Inert Gas	Iodine	Cesium	Ruthenium	Particulates	Corrosion Products
R(1,1)	0.0	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}	1.0
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}	1.0
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}	1.0
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}	1.0
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}	1.0

[a] The release fraction represents the fraction of the fuel inventory available for release in the cask that would be released into the atmosphere following an accident of the given severity.

A.7.2.2.5 Plume Release Height. For the accident risk assessment, a ground level release was used. For the maximum consequence assessment, a plume release height of 10 meters (32.8 feet) was used.

A.7.2.2.6 Direct Exposure from a Damaged Shipping Container. A radiation level following the accident at the 10CFR71 regulatory limit of 1 rem at 1 meter (3.3 feet) from the cask surface was used.

A.7.2.2.7 Food Transfer Factors. Food transfer factors were derived for the isotopes related to naval spent nuclear fuel in accordance with the methods described in Nuclear Regulatory Commission Guide 1.109 (NUREG 1977).

A.7.2.2.8 Distance from the Accident Scene to the Maximum Exposed Individual. No shielding was accounted for as the plume passes for the calculation of the exposure to the maximum individual. This location was determined using RISKIND based on the selected atmospheric stability and plume release height. The maximum exposed individual could be a member of the track crew or the general population.

A.7.2.2.9 RISKIND Population Density. From the HIGHWAY computer code, the population density for the on-site shipment was determined to be one person per square kilometer (2.6 persons per square mile) in a rural area. For on-site transportation at INEL, the population density in the most populated sector, from 1990 census data, is 55 people per square kilometer, with the majority of these people in the area 64.4 to 80 kilometers (40 to 50 miles) from the site. This population density is just into the lower region of the suburban density range of 53.7 to 1284.7 people per square kilometer (139 to 3326 people per square mile) used in HIGHWAY and INTERLINE. The standard value of 6 (rural) and 719 (suburban) people per square kilometer (15.5 and 1861 people per square mile, respectively) was used for the evaluation of all alternatives.

A.7.2.2.10 Radionuclide Inventory. The transfers of naval spent nuclear fuel to storage contain the same radionuclides as listed in Table A-14. On average, there is approximately 80 percent of the activity of each radionuclide.

A.7.3 Transfers of Naval Test Specimen Assemblies Between the Examination Facility and the Test Reactor Area

A.7.3.1 Incident-free Transportation of Naval Test Specimen Assemblies. This section provides the input parameters used to determine the radiological impacts associated with the routine, incident-free (i.e., no accident) transportation of naval test specimen assemblies for each of the five alternatives.

A.7.3.1.1 Planned Shipments. Table A-19 provides the number of planned transfers in each cask.

Table A-19. Planned transfers of naval test specimen assemblies.

	NR/ATR	Test Train
No Action, Decentralization - No Exam, Decentralization - Limited Exam	0	0
Decentralization - Full Exam, 1992/1993 Planning Basis, Regionalization at INEL, and Centralization at INEL	38	922
All other Regionalization and Centralization Alternatives	0	960

A.7.3.1.2 Transport Index. A TI of 130.0 was used for all NR and ATR cask transfers. This value was derived from historic measurements over the last several years. The new Test Train casks, which are currently being designed, would have a TI of 1.0.

A.7.3.1.3 Transportation Distances and Population Densities. Section A.6 provided a description of the general methodology used for determining transportation distances and the population densities along the transportation routes. The distance between ECF and TRA is 8.0 kilometers (5 miles). From the HIGHWAY computer code, this on-site transfer of naval test specimen assemblies occurs in a rural area. For shipments from TRA to the centralization sites, the HIGHWAY computer code was used to calculate the distance traveled, the population densities, and the percent distance traveled in each population density. As described in Section A.7.4.1.3, the HIGHWAY predicted distances for off-site shipments were increased by 3%.

A.7.3.1.4 Truck Speed. The standard RADTRAN 4 computer code speed for truck shipments in a rural population is 88.5 kilometers per hour (55 miles per hour). One of the reasons an on-site worst credible accident is less severe than the 10CFR71 hypothetical accident is that the speed is severely limited. An average speed of 16.1 kilometers per hour (10 miles per hour) was used for the on-site shipments. For off-site shipments to the centralization sites, the standard RADTRAN 4 computer code values were used.

A.7.3.1.5 Truck Stop Time. The standard RADTRAN 4 computer code provides values for truck stop times that are either dependent or independent of the distances traveled. The logs for historical on-site transfers of naval test specimen assemblies were reviewed, and it was determined that the actual stop time (one and one-half hours) was less than the standard RADTRAN 4 computer code values. For the alternative in which on-site transfers would continue, the one and one-half hour stop time was used. For the off-site shipments of test specimen assemblies to the centralization sites, a stop time of 0.006 hour per kilometer (0.01 hour per mile) was used, consistent with the value used for other past truck shipments outside the boundaries of DOE facilities (see Section A.7.4.1.4).

A.7.3.1.6 Radiation Exposure Decrease Due to Distance. The radiation exposure decrease due to distance described in Section A.7.1.1.9 was also applied to the truck transfers of test specimen assemblies.

A.7.3.1.7 Distance from Source to Crew. A distance of 3.6 meters (12 feet) was measured between the NR/ATR shipping cask and the driver for the exclusive-use truck transfers of test specimen assemblies on-site. Two escorts, one located approximately 46 meters (150 feet) in front and one the same distance behind the transport vehicle, are also present for on-site shipments.

For off-site shipments to the centralization sites, the standard RADTRAN 4 computer code value for the number of crew members was used (2). The value used for the distance from the crew to the centerline of the cask for off-site shipments was 5.85 meters (20 feet), based on the conceptual design of the new Test Train cask.

A.7.3.1.8 Transport Index to Exposure Rate Conversion Factors. Transport index to exposure rate conversion factors for the casks used for test specimen assembly transfers were calculated using the standard equation used by RADTRAN 4. The results were compared to detailed computer analyses performed using SPAN4, and RADTRAN 4 results were found to overestimate the exposure. Using the SPAN4 computer code results, the effective package dimensions of the casks used in the RADTRAN 4 calculations were adjusted to provide a conservative yet more realistic value of the transport index to exposure rate conversion factor. The values used are provided in Table A-20.

Table A-20. Transport index to exposure rate conversion factors for the NR/ATR and Test Train casks.

Cask	Effective Package Dimension (meters)	Transport Index to Exposure Rate Conversion Factor
NR/ATR	0.61 (2 feet)	1.70
Test Train	1.70 (5.6 feet)	3.42

A.7.3.1.9 Storage. There is no intermediate storage time during transfers of naval test specimen assemblies.

A.7.3.1.10 Persons Exposed While Stopped. The only stop time for the transfer of naval test specimen assemblies on-site occurs during routine surveys at the destination entrance. This area is well removed from highway and population and therefore no people were considered to be exposed during the one and one-half hour stop. The escorts are not present during the surveys and the driver is positioned approximately 46 meters (150 feet) from the source during the surveys. The people performing the surveys are badged and all exposure received during the survey is included in the normal occupational exposure which is regularly monitored. For off-site shipments, the standard RADTRAN 4 computer code values were used.

A.7.3.1.11 Traffic Count Passing a Specific Point. The RADTRAN 4 computer code uses 470 vehicles per hour passing the transport vehicle. Travel on the on-site transport path is restricted to INEL employees, the majority of INEL employees ride the INEL site buses to work, and the transfers are not made during high traffic times (i.e., shift changes); therefore, using the standard 470 vehicles per hour value would excessively overestimate the number of persons involved. A more realistic estimate of 25 vehicles per hour was used for on-site shipments. For off-site shipments, the standard RADTRAN 4 computer code values were used.

A.7.3.1.12 Standard RADTRAN 4 Computer Code Values Used. The following standard RADTRAN 4 computer code value was reviewed and determined to reflect the best estimate of current industry practice and was consistent with recorded data from transfers of naval test specimen assemblies:

- Minimum Number of Inspections.

The following standard RADTRAN 4 estimate of the population that could be affected by the transfer of test specimen assemblies was used for evaluation of the five alternatives:

- Number of People per Vehicle Sharing the Transport Route (On Link).

A.7.3.2 Accident During Transportation of Naval Test Specimen Assemblies. This section provides the input parameters used to calculate the radiological impacts for accidents during transportation of naval test specimen assemblies for evaluation of the five alternatives. The planned transfers, transportation distances, population densities, and the percentages of travel in each population density described in Section A.7.3.1 were also used for the accident analyses. Unless otherwise described in this section, the standard values provided by the RADTRAN 4 and RISKIND computer codes were used. All variables described in Section A.7.2.2 are applicable to these transfers with the exception of the RISKIND population density.

A.7.3.2.1 RISKIND Population Densities. For the Decentralization, 1992/1993 Planning Basis, Regionalization at INEL, and Centralization at INEL alternatives, the test specimen assembly transfers would occur on the INEL site. For these transfers, the same conditions described in Section A.7.2.2.9 were used. For the other Regionalization and Centralization alternative risk assessments, the population densities from RADTRAN 4 were used.

A.7.3.2.2 Release Fractions. For the Decentralization, 1992/1993 Planning Basis, and Regionalization at INEL, and Centralization at INEL alternatives, the test specimen assembly transfers would occur on the INEL site. For these transfers, the same conditions described in Sections A.7.2.2.3 and A.7.2.2.4 were used. For the other Regionalization and Centralization alternatives, the conditions described in Sections A.7.1.2.3 and A.7.1.2.4 were used.

A.7.3.2.3 Radionuclide Inventory. The radionuclides which would be released from an average transfer are listed in Table A-21, along with the activity. The values factor in the damage fractions and release fractions described in Section A.7.3.2.2. The radionuclides listed result in 99 percent of the exposure in each pathway.

Table A-21. Radionuclides which would be released from an average transfer of test specimen assemblies.

For Accidents which Release Both Fission and Corrosion Products

Nuclide	Activity (Ci)
I-131	1.30×10^{3}
H-3	3.51×10^{2}
I-132	3.10×10^{2}
Eu-156	3.75×10^{1}
Eu-152	1.41×10^{1}
Zr-95	1.09×10^{1}
Zn-65	9.80×10^{0}
Co-60	7.68×10^{0}
Eu-154	6.15×10^{0}
Sc-46	3.25×10^{0}
Cs-137	1.78×10^{0}
Ru-106	3.36×10^{-1}
Nb-95	2.64×10^{-1}
Pr-144	2.19×10^{-1}
Ce-144	2.19×10^{-1}

For Accidents which Release Only Corrosion Products

Nuclide	Activity (Ci)
Eu-156	3.75×10^{1}
Lu-177	1.59×10^{1}
Eu-152	1.41×10^{1}
Zr-95	1.07×10^{1}
Zn-65	9.80×10^{0}
Co-60	7.68×10^{0}
Ce-141	6.60×10^{0}
Eu-154	6.15×10^{0}
Cs-136	4.69×10^{0}
Sc-46	3.25×10^{0}
I-131	2.37×10^{0}
Hf-181	2.35×10^{0}

A.7.4 Shipments of Naval Irradiated Test Specimens to Examination and Testing Facilities

A.7.4.1 Incident-free Transportation of Test Specimens. This section provides the input parameters used to determine the radiological impacts associated with the routine, incident-free (i.e., no accident) transportation of test specimens for evaluation of the five alternatives.

A.7.4.1.1 Planned Shipments. Table A-22 provides the estimated number of shipments used in the analysis.

Table A-22. Planned shipments of naval test specimens.

	NRBK-41/WAPD-40				
Alternative	ICPP	PSNS	Centralization Site	BETTIS	KAPL
No Action Decentralization - No Exam	29	0	0	0	320
Decentralization - Limited Exam	26	3	0	0	320
Decentralization - Full Exam	0	0	0	0	320
1992/1993 Planning Basis, Regionalization at INEL, and Centralization at INEL Alternatives	0	0	0	120	641
All other Regionalization and Centralization Alternatives	0	0	29	120	641

A.7.4.1.2 Transport Index. A TI of 0.1 was used for all NRBK-41 and WAPD-40 shipping container shipments. These values were derived from recorded measurements over the last several years.

A.7.4.1.3 Transportation Distances and Population Densities. Section A.6 provided a description of the general methodology used for determining transportation distances and the population densities along the transportation routes. Historical data were obtained for shipments of test specimens. The distance traveled was averaged based on the point of origin and compared to the value calculated by HIGHWAY. The actual distance traveled was approximately 3% higher on the average. In order to provide the best estimate exposure, which is based on the distance traveled, the HIGHWAY distances were increased by 3% for all alternatives. This technique allowed for comparison of the alternatives on an equal basis. The percentages of distance traveled in each population density calculated by HIGHWAY applied to the distances which were increased by the 3%.

A.7.4.1.4 Truck Stop Time. The RADTRAN 4 computer code provides standard values for truck stop times that are either dependent or independent of the distances traveled. The shipping logs for historical test specimen shipments were reviewed, and it was determined that the actual stop times were much shorter than the standard RADTRAN 4 computer code values. The recorded stop times were divided by the actual distance traveled from historical data over the last three years and an average of 0.006 hour per kilometer (0.01 hour per mile) was calculated. This value was used to evaluate all five alternatives.

A.7.4.1.5 Radiation Exposure Decrease Due to Distance. The radiation exposure decrease due to distance described in Section A.7.I.1.9 was also applied to the truck shipments of test specimens.

A.7.4.1.6 Transport Index to Exposure Rate Conversion Factors. Container transport index to exposure rate conversion factors for the casks used for test specimen shipments were calculated using the standard equation used by RADTRAN 4. The results were compared to detailed computer analyses performed using SPAN4, and RADTRAN 4 results were found to overestimate the exposure. Using the SPAN4 computer code results, the effective package dimensions of the containers used in the RADTRAN 4 calculations were adjusted to provide a conservative yet more realistic value of the transport index to exposure rate conversion factor. The values used are provided in Table A-23.

Table A-23. Transport index to exposure rate conversion factors for the NRBK-41 and WAPD-40 shipping containers.

Container	Effective Package Dimension (meters)	Transport Index to Exposure Rate Conversion Factor
NRBK-41	0.74 (2.4 feet)	1.88
WAPD-40	3.2 (10.5 feet)	6.76

A.7.4.1.7 Storage. The test specimen shipping containers are not stored during shipment.

A.7.4.1.8 Standard RADTRAN 4 Computer Code Values Used. The following standard RADTRAN 4 computer code values were reviewed and were determined to reflect the best estimate of current industry practice and were consistent with historical data from shipments of naval test specimens:

- Truck Speed
- Distance from Source to Crew
- Number of Crewmen
- Minimum Number of Inspections.

The following standard RADTRAN 4 estimates of the populations that could be affected by the shipment of test specimens were also used to evaluate the five alternatives:

- Persons Exposed While Stopped
- Average Exposure Distance While Stopped
- Number of People per Vehicle Sharing the Transport Route (On Link)
- Traffic Count Passing a Specific Point - Rural, Suburban, and Urban Zones
- Fraction of Travel During Rush Hour, on City Streets, and on Freeways.

A.7.4.2 Accident During Transportation of Test Specimens. This section provides the input parameters used to calculate the radiological impacts for accidents during transportation of test specimens to evaluate the five alternatives. The planned shipments, transportation distances, population densities, and the percentages of travel in each population density described in Section A.7.4.1 were also used for the accident analyses. Unless otherwise described in this section, the standard values provided by the RADTRAN 4 and RISKIND computer codes were used. All the conditions and variables described in Section A.7.1.2 are applicable to these shipments with the exception of the Accident Probability.

A.7.4.2.1 Accident Probability. The probability of a truck accident used for evaluation of all alternatives was obtained from "Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight" (Saricks and Kvitek 1994). The truck accident rates are state dependent. The states in which naval spent nuclear fuel would be shipped to storage for the alternatives described in

Section A.3 were obtained from HIGHWAY. The accident rate values are consistent with past test specimen shipments which have traveled approximately 2.4 million kilometers (1.5 million miles) without an accident.

A.7.4.2.2 Test Specimen Integrity Following an Accident. Detailed structural and thermal analyses were performed for the shipping containers used for naval test specimen shipments up to an equivalent strain of 30% and mid-wall temperature of 1050°F. For these cases, the sealed inner container was not damaged; therefore, only the activity on the outside of the inner container, which would be corrosion products, was released. For the thermal and structural regions above 1050°F and 30% strain, the modal study defines the upper limits as unbounded. For these cases, the sealed inner container holding the test specimens was postulated to be damaged and the fission products and corrosion products would be released in the quantities described in Section A.7.1.2.4.

A.7.4.2.3 Radionuclide Inventory. The test specimen shipments contain the same radionuclides as listed in Table A-21. On average, there is approximately 1.5 percent of the activity of each nuclide.

A.8 SUMMARY OF RESULTS

A.8.1 Historical - Incident Free

This section summarizes the results of the calculations for the radiological and non-radiological impacts of the incident-free transportation of naval spent nuclear fuel and test specimens. Table A-24 shows the radiological impact on the general population, transportation workers (occupational), and the maximum exposed individual, and the non-radiological impact on all persons. The radiological impact on the general population for all historical shipments is 1.95 person-rem, which statistically corresponds to 0.00098 cancer fatalities in the entire population over the 40-year period considered. The radiological impact on transportation workers for all historical shipments is 16.6 person-rem, which statistically corresponds to 0.0066 cancer fatalities. As can be seen from Table A-24, the radiological impact to the general population is greatest for the highway transportation of test specimens. Incident-free radiological impacts tend to be greater for highway transportation than for rail transportation since both the general population and transportation workers are closer to the shipping container in transit. In all cases, the maximum exposed individual is a

Table A-24. Incident-free results for historical Navy shipments.

	General Population		Occupational		MEI-General Population		MEI-Occupational		Estimated Non-Radiological Fatalities
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Dose (rem)	Estimated Cancer Fatalities	Dose (rem)	Estimated Cancer Fatalities	
Naval Spent Nuclear Fuel to ECF[2]	0.70	3.5×10^{-4}	3.2	1.3×10^{-3}	0.033	1.7×10^{-5}	0.10	4.0×10^{-5}	1.6×10^{-2}
Naval Spent Nuclear Fuel to ICPP[1]	0.10	5.0×10^{-5}	2.8	1.1×10^{-3}	2.1×10^{-5}	1.1×10^{-8}	2.8	1.1×10^{-3}	0
Test Specimen Assemblies Between ECF and TRA[1]	0.22	1.1×10^{-4}	7.6	3.0×10^{-3}	0.062	3.1×10^{-5}	7.5	3.0×10^{-3}	0
Test Specimens[2]	0.93	4.7×10^{-4}	3.0	1.2×10^{-3}	0.026	1.3×10^{-5}	1.5	6.0×10^{-4}	1.2×10^{-2}
TOTAL[3]	1.95	9.8×10^{-4}	16.6	6.6×10^{-3}	0.062	3.1×10^{-5}	7.5	3.0×10^{-3}	2.8×10^{-2}

[1] On-site
[2] Off-site
[3] Maximum Exposed Individual exposures are not cumulative, they are the maximum value.

transportation worker, since the workers are closer to the shipment for a longer time than any member of the general population. The maximum exposed individual for all shipments is a driver for the trucks transferring test specimen assemblies between ECF and TRA. Under the limiting modeling approach that the same person drove every shipment for the entire period, this person received a total exposure of 7.5 rem over the approximate 40-year period, or about 0.19 rem per year, which is within DOE limits for occupationally exposed individuals. By comparison, the maximum exposed individual for the general population received only 0.062 rem over the entire historical period, which is much less than the exposure to the maximum exposed individual transportation worker and corresponds to 0.0016 mrem exposure per year. It should be noted that the majority of the exposure to the transportation worker and maximum exposed worker is already accounted for since most transportation workers are badged and therefore this exposure is included with all other exposure they would receive on the job. The rail employees and off-site truck drivers are the only transportation workers who are not badged. Their exposure was calculated to be only approximately 30% of the total.

The estimated non-radiological fatalities due to vehicle emissions is 0.028 for the entire 40-year period.

A.8.2 Incident Free

Table A-25 provides a summary of the annual exposures and risks from incident-free transportation of naval spent nuclear fuel and test specimens for all alternatives. The values are calculated by dividing the values in Table A-26 by the 40 years evaluated to obtain the average annual values.

The annual radiological impact on the general population ranges from 0.0085 to 0.30 person-rem. The general population annual radiological risk ranges from 0.0000043 to 0.00015 for cancer fatalities.

The radiological impact on the transportation crew (occupational) ranges from 0.038 to 0.38 person-rem. The transportation crew annual radiological risk ranges from 0.000015 to 0.00015 for cancer fatalities.

Table A-25. Summary of annual incident-free impacts during transportation of naval spent nuclear fuel and test specimens.

	General Population		Occupational		MEI-General Population		MEI-Occupational		Estimated Non-Radiological Fatalities (per year)
	Collective Dose (person-rem/yr)	Estimated Cancer Fatalities (per year)	Collective Dose (person-rem/yr)	Estimated Cancer Fatalities (per year)	Dose (rem/yr)	Estimated Cancer Fatalities (per year)	Dose (rem/yr)	Estimated Cancer Fatalities (per year)	
No Action	0.0085	4.3×10^{-6}	0.038	1.5×10^{-5}	0.00098	4.9×10^{-7}	0.0087	3.5×10^{-6}	1.5×10^{-4}
Decentralization - No Exam	0.0085	4.3×10^{-6}	0.038	1.5×10^{-5}	0.00098	4.9×10^{-7}	0.0087	3.5×10^{-6}	1.5×10^{-4}
Decentralization - Limited Exam	0.021	1.1×10^{-5}	0.068	2.7×10^{-5}	0.0011	5.5×10^{-7}	0.0087	3.5×10^{-6}	2.2×10^{-4}
Decentralization - Full Exam	0.083	4.2×10^{-5}	0.30	1.2×10^{-4}	0.0043	2.2×10^{-6}	0.032	1.3×10^{-5}	7.5×10^{-4}
1992-1993 Planning Basis	0.053	2.7×10^{-5}	0.18	7.2×10^{-5}	0.0022	1.1×10^{-6}	0.020	8.0×10^{-6}	6.3×10^{-4}
Regionalization or Centralization at INEL	0.053	2.7×10^{-5}	0.18	7.2×10^{-5}	0.0022	1.1×10^{-6}	0.020	8.0×10^{-6}	6.3×10^{-4}
Regionalization or Centralization at Hanford	0.12	6.0×10^{-5}	0.25	1.0×10^{-4}	0.0040	2.0×10^{-6}	0.027	1.1×10^{-5}	8.8×10^{-4}
Regionalization or Centralization at Savannah River	0.30	1.5×10^{-4}	0.38	1.5×10^{-4}	0.0040	2.0×10^{-6}	0.12	4.8×10^{-5}	8.3×10^{-4}
Regionalization or Centralization at Oak Ridge	0.28	1.4×10^{-4}	0.35	1.4×10^{-4}	0.0040	2.0×10^{-6}	0.10	4.0×10^{-5}	7.0×10^{-4}
Regionalization or Centralization at Nevada Test Site	0.15	7.5×10^{-5}	0.28	1.1×10^{-4}	0.0040	2.0×10^{-6}	0.042	1.7×10^{-5}	9.3×10^{-4}

Table A-26. Summary of 40-year cumulative incident-free impacts during transportation of naval spent nuclear fuel and test specimens.

	General Population		Occupational		MEI-General Population		MEI-Occupational		Estimated Non-Radiological Fatalities
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Dose (rem)	Estimated Cancer Fatalities	Dose (rem)	Estimated Cancer Fatalities	
No Action	0.34	1.7×10^{-4}	1.5	6.0×10^{-4}	0.039	2.0×10^{-5}	0.35	1.4×10^{-4}	5.9×10^{-3}
Decentralization - No Exam	0.34	1.7×10^{-4}	1.5	6.0×10^{-4}	0.039	2.0×10^{-5}	0.35	1.4×10^{-4}	5.9×10^{-3}
Decentralization - Limited Exam	0.83	4.2×10^{-4}	2.7	1.1×10^{-3}	0.045	2.3×10^{-5}	0.35	1.4×10^{-4}	8.9×10^{-3}
Decentralization - Full Exam	3.3	1.7×10^{-3}	12	4.8×10^{-3}	0.17	8.5×10^{-5}	0.43	1.7×10^{-4}	3.0×10^{-2}
1992-1993 Planning Basis	2.1	1.1×10^{-3}	7.3	2.9×10^{-3}	0.086	4.3×10^{-5}	0.80	3.2×10^{-4}	2.5×10^{-2}
Regionalization or Centralization at INEL	2.1	1.1×10^{-3}	7.3	2.9×10^{-3}	0.086	4.3×10^{-5}	0.80	3.2×10^{-4}	2.5×10^{-2}
Regionalization or Centralization at Hanford	4.7	2.4×10^{-3}	9.8	3.9×10^{-3}	0.16	8.0×10^{-5}	1.1	4.4×10^{-4}	3.5×10^{-2}
Regionalization or Centralization at Savannah River	12	6.0×10^{-3}	15	6.0×10^{-3}	0.16	8.0×10^{-5}	4.7	1.9×10^{-3}	3.3×10^{-2}
Regionalization or Centralization at Oak Ridge	11	5.5×10^{-3}	14	5.6×10^{-3}	0.16	8.0×10^{-5}	4.1	1.6×10^{-3}	2.8×10^{-2}
Regionalization or Centralization at Nevada Test Site	6.0	3.0×10^{-3}	11	4.4×10^{-3}	0.16	8.0×10^{-5}	1.7	6.8×10^{-4}	3.7×10^{-2}

For all alternatives, the maximum exposed individual is a transportation worker who drives the truck shipments. The annual radiological impact on the maximum exposed individual ranges from 0.0087 to 0.12 rem. These values were calculated based on the modeling approach that for each of the categories of shipments described in Sections A.4.2 through A.4.4, the same person would drive all shipments. The maximum exposed individual annual radiological risk ranges from 0.0000035 to 0.000048 for cancer fatalities. The annual exposure to the maximum exposed individual of the general population ranges from 0.00098 to 0.0043 rem for the various alternatives. The estimated exposure and health effects to the maximum exposed individual for the general population correspond to approximately a factor of 10 less than those estimated for the transportation worker.

The annual non-radiological risk ranges from 0.00015 to 0.00093 fatalities.

The summary of exposures and risks from incident-free transportation of naval spent nuclear fuel and test specimens for all alternatives are included in Table A-26 for the 40-year period.

The radiological impact on the general population ranges from 0.34 to 12 person-rem. The general population radiological risk for the entire 40-year period ranges from 0.00017 to 0.006 for cancer fatalities.

The radiological impact on the transportation crew (occupational) ranges from 1.5 to 15 person-rem. The transportation crew radiological risk for the entire 40-year period ranges from 0.0006 to 0.006 for cancer fatalities.

For all alternatives, the maximum exposed individual is a transportation worker who drives the truck shipments. The radiological impact on the maximum exposed individual ranges from 0.35 to 4.7 rem. These values were calculated based on using the same driver for all shipments for each of the categories of shipments described in Sections A.4.2 through A.4.4. The maximum exposed individual radiological risk for the entire 40-year period, 1995 through 2035, ranges from 0.00014 to 0.0019 for cancer fatalities. The exposure to the maximum exposed individual of the general population ranges from 0.039 to 0.17 rem for the various alternatives. The estimated exposure and health effects to the maximum exposed individual for the general population correspond to approximately a factor of 10 less than those estimated for the transportation worker.

The non-radiological risk ranges from 0.0059 to 0.037 fatalities for the entire 40-year period.

There are appreciable differences in exposure to the general population, transportation crew, and the maximum exposed individual among the various alternatives. Part of these differences is due to the varying number of shipments. For example, for the Decentralization - Full Examination alternative, all shipments of naval spent nuclear fuel are shipped to the INEL and then returned to the shipyards and prototypes, thereby doubling the number of shipments. However, the single most important contributor to the differences among the alternatives is the shipment of test specimen assemblies. For the No Action, Decentralization - No Examination, and Decentralization - Limited Examination alternatives, there are no shipments; for the Decentralization - Full Examination, 1992/1993 Planning Basis, Regionalization at INEL, and Centralization at INEL alternatives, the exposure is minimal since the shipments remain on the INEL site. However, for the other Regionalization and Centralization alternatives, the test specimen assemblies would be shipped off-site between the INEL and the alternative sites. While the exposure rates on the casks are low, the number of shipments and the distances involved increase the radiological impact on the transportation crew and the general population.

Tables A-27 and A-28 provide the 40-year cumulative incident-free results separately for on-site and off-site shipments. For all alternatives, the shipments of naval spent nuclear fuel from shipyards and prototypes and shipments of naval irradiated test specimens are off-site. Likewise, the transfers of naval spent nuclear fuel to storage following examination are on-site for all alternatives. The transfers of naval test specimen assemblies are off-site for the Regionalization and Centralization alternatives at Hanford, Savannah River, Oak Ridge, and the Nevada Test Site, otherwise they would be on-site.

As described in Section 3.8 of the main body of this Appendix, all alternatives which do not make use of the existing Expended Core Facility at INEL would require a transition period while new facilities for examination and storage of naval spent nuclear fuel were developed. During the transition period, approximately 80 shipments from Navy sites to ECF would be needed. These shipments are not included explicitly in the detailed analyses; however, the appropriate number of shipments needed by each alternative during this period is explicitly included, so the range of environmental effects of these shipments is bounded. For example, the estimated fatalities for the No Action, Decentralization - No Examination, and Decentralization - Limited Examination alternatives would actually increase slightly if the transition shipments were included. The estimated fatalities for the alternatives in which the INEL continues to receive shipments would remain the same. For the Regionalization and Centralization alternatives at sites other than INEL, the estimated fatalities would

Table A-27. Summary of 40-year cumulative incident-free impacts of on-site transportation.

	General Population		Occupational		MEI-General Population		MEI-Occupational		Estimated Non-Radiological Fatalities
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Dose (rem)	Estimated Cancer Fatalities	Dose (rem)	Estimated Cancer Fatalities	
No Action	0.00010	5.0×10^{-8}	0.0018	7.2×10^{-7}	0.000017	8.5×10^{-9}	0.0017	6.8×10^{-7}	0
Decentralization - No Exam	0.00010	5.0×10^{-8}	0.0018	7.2×10^{-7}	0.000017	8.5×10^{-9}	0.0017	6.8×10^{-7}	0
Decentralization - Limited Exam	0.00010	5.0×10^{-8}	0.0018	7.2×10^{-7}	0.000017	8.5×10^{-9}	0.0017	6.8×10^{-7}	0
Decentralization - Full Exam	0.013	6.5×10^{-6}	0.44	1.8×10^{-4}	0.062	3.1×10^{-5}	0.43	1.7×10^{-4}	0
1992-1993 Planning Basis	0.015	7.5×10^{-6}	0.50	2.0×10^{-4}	0.062	3.1×10^{-5}	0.43	1.7×10^{-4}	0
Regionalization or Centralization at INEL	0.015	7.5×10^{-6}	0.50	2.0×10^{-4}	0.062	3.1×10^{-5}	0.43	1.7×10^{-4}	0
Regionalization or Centralization at Hanford	0.0024	1.2×10^{-6}	0.067	2.7×10^{-5}	0.000017	8.5×10^{-9}	0.065	2.6×10^{-5}	0
Regionalization or Centralization at Savannah River	0.0024	1.2×10^{-6}	0.067	2.7×10^{-5}	0.000017	8.5×10^{-9}	0.065	2.6×10^{-5}	0
Regionalization or Centralization at Oak Ridge	0.0024	1.2×10^{-6}	0.067	2.7×10^{-5}	0.000017	8.5×10^{-9}	0.065	2.6×10^{-5}	0
Regionalization or Centralization at Nevada Test Site	0.0024	1.2×10^{-6}	0.067	2.7×10^{-5}	0.000017	8.5×10^{-9}	0.065	2.6×10^{-5}	0

Table A-28. Summary of 40-year cumulative incident-free impacts of off-site transportation.

	General Population		Occupational		MEI-General Population		MEI-Occupational		Estimated Non-Radiological Fatalities
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Dose (rem)	Estimated Cancer Fatalities	Dose (rem)	Estimated Cancer Fatalities	
No Action	0.34	1.7×10^{-4}	1.5	6.0×10^{-4}	0.039	2.0×10^{-5}	0.35	1.4×10^{-4}	5.9×10^{-3}
Decentralization - No Exam	0.34	1.7×10^{-4}	1.5	6.0×10^{-4}	0.039	2.0×10^{-5}	0.35	1.4×10^{-4}	5.9×10^{-3}
Decentralization - Limited Exam	0.83	4.2×10^{-4}	2.7	1.1×10^{-3}	0.045	2.3×10^{-5}	0.35	1.4×10^{-4}	8.9×10^{-3}
Decentralization - Full Exam	3.3	1.7×10^{-3}	11	4.4×10^{-3}	0.17	8.5×10^{-5}	0.35	1.4×10^{-4}	3.0×10^{-2}
1992-1993 Planning Basis	2.1	1.1×10^{-3}	6.8	2.7×10^{-3}	0.086	4.3×10^{-5}	0.80	3.2×10^{-4}	2.5×10^{-2}
Regionalization or Centralization at INEL	2.1	1.1×10^{-3}	6.8	2.7×10^{-3}	0.086	4.3×10^{-5}	0.80	3.2×10^{-4}	2.5×10^{-2}
Regionalization or Centralization at Hanford	4.7	2.4×10^{-3}	9.7	3.9×10^{-3}	0.16	8.0×10^{-5}	1.1	4.4×10^{-4}	3.5×10^{-2}
Regionalization or Centralization at Savannah River	12	6.0×10^{-3}	15	6.0×10^{-3}	0.16	8.0×10^{-5}	4.7	1.9×10^{-3}	3.3×10^{-2}
Regionalization or Centralization at Oak Ridge	11	5.5×10^{-3}	14	5.6×10^{-3}	0.16	8.0×10^{-5}	4.1	1.6×10^{-3}	2.8×10^{-2}
Regionalization or Centralization at Nevada Test Site	6.0	3.0×10^{-3}	11	4.4×10^{-3}	0.16	8.0×10^{-5}	1.7	6.8×10^{-4}	3.7×10^{-2}

also remain approximately the same since the number of shipments is approximately evenly distributed between the east and west coast origins and therefore the total distance traveled is the same.

A.8.3 Accident Risk

This section summarizes the results of the calculations for radiological and non-radiological risks from accidents which could occur during shipments of naval spent nuclear fuel and test specimens. Tables A-29 and A-30 provide the results of the accident risk assessment for each alternative. The risks are provided for the general population in terms of exposure and estimated cancer fatalities. The risks are presented for 50% meteorological conditions, Pasquill Stability Class D. Table A-29 provides the risks on an annual basis and Table A-30 provides the total risks over the entire 40-year period.

The annual radiological impact, from Table A-29, on the general population ranges from 0.00021 to 0.021 person-rem. These exposures equate to 0.00000011 to 0.000011 estimated cancer fatalities. For non-radiological impacts, the estimated annual fatalities from traffic accidents range from 0.0012 to 0.022.

The cumulative radiological impact, from Table A-30, on the general population ranges from 0.0082 to 0.84 person-rem. These exposures equate to 0.0000041 to 0.00042 estimated cancer fatalities. For non-radiological impacts, the estimated fatalities from traffic accidents range from 0.047 to 0.84.

There are appreciable differences in exposure to the general population, transportation crew, and the maximum exposed individual among the various alternatives. Part of these differences is due to the varying number of shipments. For example, for the Decentralization - Full Examination alternative, all shipments of naval spent nuclear fuel are shipped to the INEL and then returned to the shipyards and prototypes, thereby doubling the number of shipments. As in the incident-free assessment, the shipment of test specimen assemblies is a large factor. For the No Action, Decentralization - No Examination, and Decentralization - Limited Examination alternatives, there are no shipments; for the Decentralization - Full Examination, 1992/1993 Planning Basis, Regionalization at INEL, and Centralization at INEL alternatives, the exposure is minimal since the shipments remain

Table A-29. Summary of annual accident risk for transportation of naval spent nuclear fuel and test specimens.

	General Population Collective Dose (person-rem/yr)	Estimated Cancer Fatalities (per year)	Estimated Traffic Fatalities (per year)
	Class D	Class D	
No Action	0.00021	1.1×10^{-7}	1.2×10^{-3}
Decentralization - No Exam	0.00021	1.1×10^{-7}	1.2×10^{-3}
Decentralization - Limited Exam	0.00043	2.2×10^{-7}	1.6×10^{-3}
Decentralization - Full Exam	0.0028	1.4×10^{-6}	2.2×10^{-2}
1992/1993 Planning Basis	0.0020	1.0×10^{-6}	1.3×10^{-2}
Regionalization or Centralization at INEL	0.0020	1.0×10^{-6}	1.3×10^{-2}
Regionalization or Centralization at Hanford	0.0033	1.7×10^{-6}	1.3×10^{-2}
Regionalization or Centralization at Savannah River	0.0210	1.1×10^{-5}	1.5×10^{-2}
Regionalization or Centralization at Oak Ridge	0.015	7.5×10^{-6}	1.4×10^{-2}
Regionalization or Centralization at Nevada Test Site	0.0070	3.5×10^{-6}	1.5×10^{-2}

Table A-30. Summary of cumulative accident risk over the 40-year period for transportation of naval spent nuclear fuel and test specimens.

	General Population Collective Dose (person-rem)	Estimated Cancer Fatalities	Estimated Traffic Fatalities
	Class D	Class D	
No Action	0.0082	4.1×10^{-6}	4.7×10^{-2}
Decentralization - No Exam	0.0082	4.1×10^{-6}	4.7×10^{-2}
Decentralization - Limited Exam	0.017	8.5×10^{-6}	6.5×10^{-2}
Decentralization - Full Exam	0.11	5.5×10^{-5}	8.6×10^{-1}
1992/1993 Planning Basis	0.079	4.0×10^{-5}	5.1×10^{-1}
Regionalization or Centralization at INEL	0.079	4.0×10^{-5}	5.1×10^{-1}
Regionalization or Centralization at Hanford	0.13	6.5×10^{-5}	5.3×10^{-1}
Regionalization or Centralization at Savannah River	0.84	4.2×10^{-4}	6.0×10^{-1}
Regionalization or Centralization at Oak Ridge	0.61	3.1×10^{-4}	5.7×10^{-1}
Regionalization or Centralization at Nevada Test Site	0.28	1.4×10^{-4}	6.1×10^{-1}

on the INEL site. However, for the other Regionalization and Centralization alternatives, the test specimen assemblies would be shipped off-site between the INEL and the alternate sites. While the exposure rates on the containers are low, the number of shipments and the distances involved increase the radiological impact on the transportation crew and the general population. In addition, the routes themselves are an important factor. While differences in distance and population densities are important, the higher risk for the Regionalization at Savannah River and Centralization at Savannah River alternatives, in particular, is due to the higher accident rates along the route taken and higher food transfer factors for shipments through farming states with much higher ingestion rates.

Table A-31 provides the 40-year cumulative risk, separated by on-site and off-site shipments.

As described in Section 3.8 of the main body of this Appendix, a transition period could be necessary which would require approximately 80 shipments from Navy sites to ECF. These shipments are not included explicitly in the detailed analyses; however, the appropriate number of shipments engendered by each alternative during this period is explicitly included, so the range of environmental effects of these shipments is bounded. The addition of the transition shipments would increase the distance traveled for the No Action, Decentralization - No Examination, and Decentralization - Limited Examination alternatives. Since the accident risk is proportional to the distance traveled, the risk would increase slightly for these alternatives, which were the lowest of all alternatives. All other alternatives would remain the same. Therefore, incorporating the transition period would actually reduce the difference between alternatives from the standpoint of transportation effects.

A.8.4 Accident Maximum Consequences

This section summarizes the results of the calculations of maximum consequences of accidents which could occur during shipments of naval spent nuclear fuel and test specimens. Tables A-32 and A-33 provide the results of the maximum consequence assessment for each alternative. The maximum consequences are provided for the general population by population area (rural, suburban, and urban) and the maximum exposed individual in terms of exposure. The members of the transportation crew may be the maximum exposed individual.

Table A-31. Summary of cumulative risk over the 40-year period for transportation of naval spent nuclear fuel and test specimens (on-site/off-site).

	ON-SITE			OFF-SITE		
	General Population			General Population		
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Estimated Traffic Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Estimated Traffic Fatalities
No Action	1.3×10^{-6}	6.5×10^{-10}	6.8×10^{-6}	0.0082	4.1×10^{-6}	4.7×10^{-2}
Decentralization - No Exam	1.3×10^{-6}	6.5×10^{-10}	6.8×10^{-6}	0.0082	4.1×10^{-6}	4.7×10^{-2}
Decentralization - Limited Exam	1.3×10^{-6}	6.5×10^{-10}	6.8×10^{-6}	0.017	8.5×10^{-6}	6.3×10^{-2}
Decentralization - Full Exam	4.1×10^{-5}	2.1×10^{-8}	3.2×10^{-4}	0.11	5.5×10^{-5}	8.4×10^{-1}
1992-1993 Planning Basis	1.3×10^{-4}	6.5×10^{-8}	6.1×10^{-4}	0.079	4.0×10^{-5}	5.0×10^{-1}
Regionalization or Centralization at INEL	1.3×10^{-4}	6.5×10^{-8}	6.1×10^{-4}	0.079	4.0×10^{-5}	5.0×10^{-1}
Regionalization or Centralization at Hanford	8.7×10^{-5}	4.4×10^{-8}	2.1×10^{-4}	0.13	6.5×10^{-5}	5.3×10^{-1}
Regionalization or Centralization at Savannah River	8.7×10^{-5}	4.4×10^{-8}	3.6×10^{-4}	0.84	4.2×10^{-4}	5.9×10^{-1}
Regionalization or Centralization at Oak Ridge	8.7×10^{-5}	4.4×10^{-8}	2.3×10^{-4}	0.61	3.1×10^{-4}	5.7×10^{-1}
Regionalization or Centralization at Nevada Test Site	8.7×10^{-5}	4.4×10^{-8}	1.6×10^{-4}	0.28	1.4×10^{-4}	6.0×10^{-1}

Table A-32. Summary of maximum consequences (person-rem) of an accident (Design Basis).

	MAXIMUM CONSEQUENCES			
	DESIGN BASIS (accident probability between 1 and 1 x 10^{-6})			
	Maximum Exposed Individual (rem)	Rural (person-rem)	Suburban (person-rem)	Urban (person-rem)
No Action	0.0034	0.51	4.3	13
Decentralization - No Exam	0.0034	0.51	4.3	13
Decentralization - Limited Exam	0.014	4.0	4.3	13
Decentralization - Full Exam	0.045	7.4	25	13
1992/1993 Planning Basis	0.045	7.4	25	13
Regionalization or Centralization at INEL	0.045	7.4	25	13
Regionalization or Centralization at Hanford	0.25	38	100	56
Regionalization or Centralization at Savannah River	0.25	38	320	560
Regionalization or Centralization at Oak Ridge	0.25	38	320	560
Regionalization or Centralization at Nevada Test Site	0.25	38	320	560

Table A-33. Summary of maximum consequences (person-rem) of an accident (Beyond Design Basis).

	MAXIMUM CONSEQUENCES							
	BEYOND DESIGN BASIS (accident probability between 1×10^{-6} and 1×10^{-7})							
	Maximum Exposed Individual		Rural		Suburban		Urban	
	Estimated Dose (rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Estimated Collective Dose (person-rem)	Estimated Fatal Cancers	Estimated Collective Dose (person-rem)	Estimated Cancer Fatalities
No Action	0.014	7.0×10^{-6}	4.0	2.0×10^{-3}	25	1.3×10^{-2}	23	1.2×10^{-2}
Decentralization - No Exam	0.014	7.0×10^{-6}	4.0	2.0×10^{-5}	25	1.3×10^{-2}	23	1.2×10^{-2}
Decentralization - Limited Exam	0.045	2.3×10^{-5}	7.4	3.7×10^{-3}	25	1.3×10^{-2}	130	6.5×10^{-2}
Decentralization - Full Exam	1.8	9.0×10^{-4}	2700	1.4	3300	1.7	130	6.5×10^{-2}
1992/1993 Planning Basis	2.2	1.1×10^{-5}	3300	1.7	4100	2.1	130	6.5×10^{-2}
Regionalization or Centralization at INEL	2.2	1.1×10^{-3}	3300	1.7	4100	2.1	130	6.5×10^{-2}
Regionalization or Centralization at Hanford	2.2	1.1×10^{-3}	3300	1.7	4100	2.1	560	2.8×10^{-1}
Regionalization or Centralization at Savannah River	2.2	1.1×10^{-3}	3300	1.7	4100	2.1	1700	8.5×10^{-1}
Regionalization or Centralization at Oak Ridge	2.2	1.1×10^{-5}	3300	1.7	4100	2.1	1700	8.5×10^{-1}
Regionalization or Centralization at Nevada Test Site	2.2	1.1×10^{-3}	3300	1.7	4100	2.1	1700	8.5×10^{-1}

For design basis accidents, the calculated exposure to the general population ranges from 0.51 person-rem in a rural area to 560 person-rem in an urban area. The risk associated with these exposures ranges from 0.00026 to 0.28 cancer fatalities. The exposure to the maximum exposed individual ranges from 0.0034 rem to 0.25 rem. The risk to the maximum individual ranges from 0.0000017 to 0.00013 cancer fatalities.

For beyond design basis accidents, the exposure to the general population ranges from 4.0 person-rem in a rural area to 4100 person-rem in a suburban area (in this case, the probability of the accident of the same consequence in the urban area was less than 1×10^{-7}). The risk associated with these exposures ranges from 0.002 to 2.1 cancer fatalities. The exposure to the maximum exposed individual ranges from 0.014 rem to 2.2 rem. The risk to the maximum individual ranges from 0.000007 to 0.0011 cancer fatalities.

The shipments of naval spent nuclear fuel from shipyards and prototypes, transfers of naval spent nuclear fuel to storage, transfers of test specimen assemblies to the examination facility, and shipments of test specimens to test facilities were evaluated for the maximum consequences of an accident. Although the naval spent nuclear fuel shipments contain a higher amount of activity per shipment, there are cases where the test specimen shipment consequences are larger. The consequences are larger primarily due to the higher number of shipments which increases the probabilities such that a more severe consequence is evaluated.

Tables A-34 and A-35 provide the maximum consequences, separated by on-site and off-site shipments, respectively.

As described in Section 3.8 of the main body of this Appendix, a transition period could be necessary which would require approximately 80 shipments from Navy sites to ECF. These shipments are not included explicitly in the detailed analyses; however, the appropriate number of shipments engendered by each alternative during this period is explicitly included, so the range of environmental effects of these shipments is bounded. Since all alternatives ship the same basic fuel types, the maximum consequences are determined by the probability of the accident which is a function of the distance traveled. As described in Section A.8.3, only the No Action, Decentralization - No Examination, and Decentralization - Limited Examination alternatives, which have the lowest estimated maximum consequences, would increase the distance traveled if the

Table A-34. Summary of maximum consequences of an on-site accident (Beyond Design Basis).

	MEI		Rural		Suburban		Urban	
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities
No Action	0.0013	6.5×10^{-7}	0.37	1.9×10^{-4}	2.4	1.2×10^{-3}	N/A	N/A
Decentralization - No Exam	0.0013	6.5×10^{-7}	0.37	1.9×10^{-4}	2.4	1.2×10^{-3}	N/A	N/A
Decentralization - Limited Exam	0.0013	6.5×10^{-7}	0.37	1.9×10^{-4}	2.4	1.2×10^{-3}	N/A	N/A
Decentralization - Full Exam	0.51	2.6×10^{-4}	200	1.0×10^{-1}	100	5.0×10^{-2}	N/A	N/A
1992-1993 Planning Basis	2.2	1.1×10^{-3}	3300	1.7	4100	2.1	N/A	N/A
Regionalization or Centralization at INEL	2.2	1.1×10^{-3}	3300	1.7	4100	2.1	N/A	N/A
Regionalization or Centralization at Hanford	2.2	1.1×10^{-3}	3300	1.7	4100	2.1	N/A	N/A
Regionalization or Centralization at Savannah River	2.2	1.1×10^{-3}	3300	1.7	4100	2.1	N/A	N/A
Regionalization or Centralization at Oak Ridge	2.2	1.1×10^{-3}	3300	1.7	4100	2.1	N/A	N/A
Regionalization or Centralization at Nevada Test Site	2.2	1.1×10^{-3}	3300	1.7	4100	2.1	N/A	N/A

Table A-35. Summary of maximum consequences of an off-site accident (Beyond Design Basis).

	MEI		Rural		Suburban		Urban	
	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities	Collective Dose (person-rem)	Estimated Cancer Fatalities
No Action	0.014	7.0×10^{-6}	4.0	2.0×10^{-3}	25	1.3×10^{-2}	23	1.2×10^{-2}
Decentralization - No Exam	0.014	7.0×10^{-6}	4.0	2.0×10^{-3}	25	1.3×10^{-2}	23	1.2×10^{-2}
Decentralization - Limited Exam	0.045	2.3×10^{-5}	7.4	3.7×10^{-3}	25	1.3×10^{-2}	130	6.5×10^{-2}
Decentralization - Full Exam	1.8	9.0×10^{-4}	2700	1.4	3300	1.7	130	6.5×10^{-2}
1992-1993 Planning Basis	1.8	9.0×10^{-4}	2700	1.4	79	4.0×10^{-2}	130	6.5×10^{-2}
Regionalization or Centralization at INEL	1.8	9.0×10^{-4}	2700	1.4	79	4.0×10^{-2}	130	6.5×10^{-2}
Regionalization or Centralization at Hanford	1.8	9.0×10^{-4}	2700	1.4	320	1.6×10^{-1}	560	2.8×10^{-1}
Regionalization or Centralization at Savannah River	1.8	9.0×10^{-4}	2700	1.4	320	1.6×10^{-1}	1700	8.5×10^{-1}
Regionalization or Centralization at Oak Ridge	1.8	9.0×10^{-4}	2700	1.4	320	1.6×10^{-1}	1700	8.5×10^{-1}
Regionalization or Centralization at Nevada Test Site	1.8	9.0×10^{-4}	2700	1.4	320	1.6×10^{-1}	1700	8.5×10^{-1}

transition shipments were included. Therefore, incorporating the transition period would actually reduce the difference between alternatives from the standpoint of transportation effects.

A.9 EFFECT ON ENVIRONMENTAL JUSTICE

The only method used to ship naval spent nuclear fuel to INEL in the past and the only method proposed for future shipments is by rail. The only exceptions to this are that naval spent nuclear fuel from Pearl Harbor Naval Shipyard is transported by ship from Hawaii to Puget Sound Naval Shipyard where the shipping containers are transferred to railcars for the journey to INEL, and a heavy-lift transporter is used to move the shipping containers from the Kesselring Site a few miles to the nearest railhead. The mode of shipment used for naval spent nuclear fuel tends to limit the exposure to members of the general public during transportation. The shipments pass through urban, suburban, and rural areas, using routes selected by the railroads in accordance with applicable regulations and the requirements of the load. The fractions of the distance traveled in urban, suburban, and rural areas range from about 2.5% urban, 12.5% suburban, and 85% rural to approximately 4% urban, 35% suburban, and 61% rural, depending on the alternative considered.

As shown in the analyses in this Attachment, the impacts on human health or the environment resulting from routine transport of naval spent nuclear fuel and hypothetical transportation accidents would be small for all of the alternatives considered. For example, it is unlikely that a single additional cancer would occur as a result of the transportation of naval spent nuclear fuel under any alternative. Shipping accidents could occur at any location along the routes used, so it is not possible to identify the minority or low-income composition of the populations along the routes. However, the fact that the potential impacts due to an accident for any of the alternatives considered would present no significant risk and do not constitute a credible adverse impact on the population along the shipping routes makes it possible to state that no adverse effects from accidents associated with the management of naval spent nuclear fuel would be expected for any specific segment of the population, minorities and low-income groups included.

To place the impacts on environmental justice in perspective, the risk from routine shipping activities or hypothetical accidents associated with transportation of naval spent nuclear fuel under any of the alternatives considered would amount to less than one additional fatality per year in the entire population. For comparison, in 1990 there were approximately 40,000 traffic fatalities in the United

States population and there were about 7,400 deaths caused by traffic accidents among people of color in the U. S. Even if all of the additional cancer deaths associated with an accident for any of the alternatives considered for naval spent nuclear fuel management were assumed to occur only among people of color, that group would experience far less than one additional fatality per year. The same conclusion can be drawn for low-income groups.

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ATTACHMENT B - DESCRIPTION OF NAVAL SPENT NUCLEAR FUEL RECEIPT AND HANDLING AT THE EXPENDED CORE FACILITY AT THE IDAHO NATIONAL ENGINEERING LABORATORY

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DESCRIPTION OF NAVAL SPENT NUCLEAR FUEL RECEIPT AND HANDLING AT THE EXPENDED CORE FACILITY AT THE IDAHO NATIONAL ENGINEERING LABORATORY

B.1 GENERAL DESCRIPTION AND OPERATION OF FACILITIES

The Expended Core Facility (ECF) is located within the confines of the Naval Reactors Facility (NRF) at the Idaho National Engineering Laboratory (INEL). It is a large laboratory facility used to receive, examine, prepare for storage, and ship naval spent nuclear fuel and irradiated test specimen assemblies. The information derived from the examinations performed at ECF provides engineering data on nuclear reactor environments, material behavior, and design performance. These data are used to develop new technology and to improve the cost-effectiveness of existing designs. Naval spent nuclear fuel is prepared at ECF for storage and shipment to the Idaho Chemical Processing Plant (ICPP). Some naval equipment contaminated by radioactive material during use in the fleet is refurbished for reuse.

The building which houses ECF is a concrete block structure approximately 1000 feet by 194 feet. This space provides offices and enclosed work areas, including an array of interconnected reinforced concrete water pools which permit visual observation of naval spent nuclear fuel during handling and inspection while shielding workers from radiation. Adjacent to the water pools are shielded cells used for operations which must be performed dry. Access to ECF for receipt and shipping of large containers is provided by large roll-up doors that allow railcar and truck entry. A schematic view of ECF is shown in Figure B-1 and a photograph of the water pool area is provided in Figure B-2.

ECF has been specifically designed to provide the unique physical and administrative controls required by the Naval Nuclear Propulsion Program to ensure safe handling of irradiated and contaminated nuclear fuels and components with a high degree of worker safety and protection for the

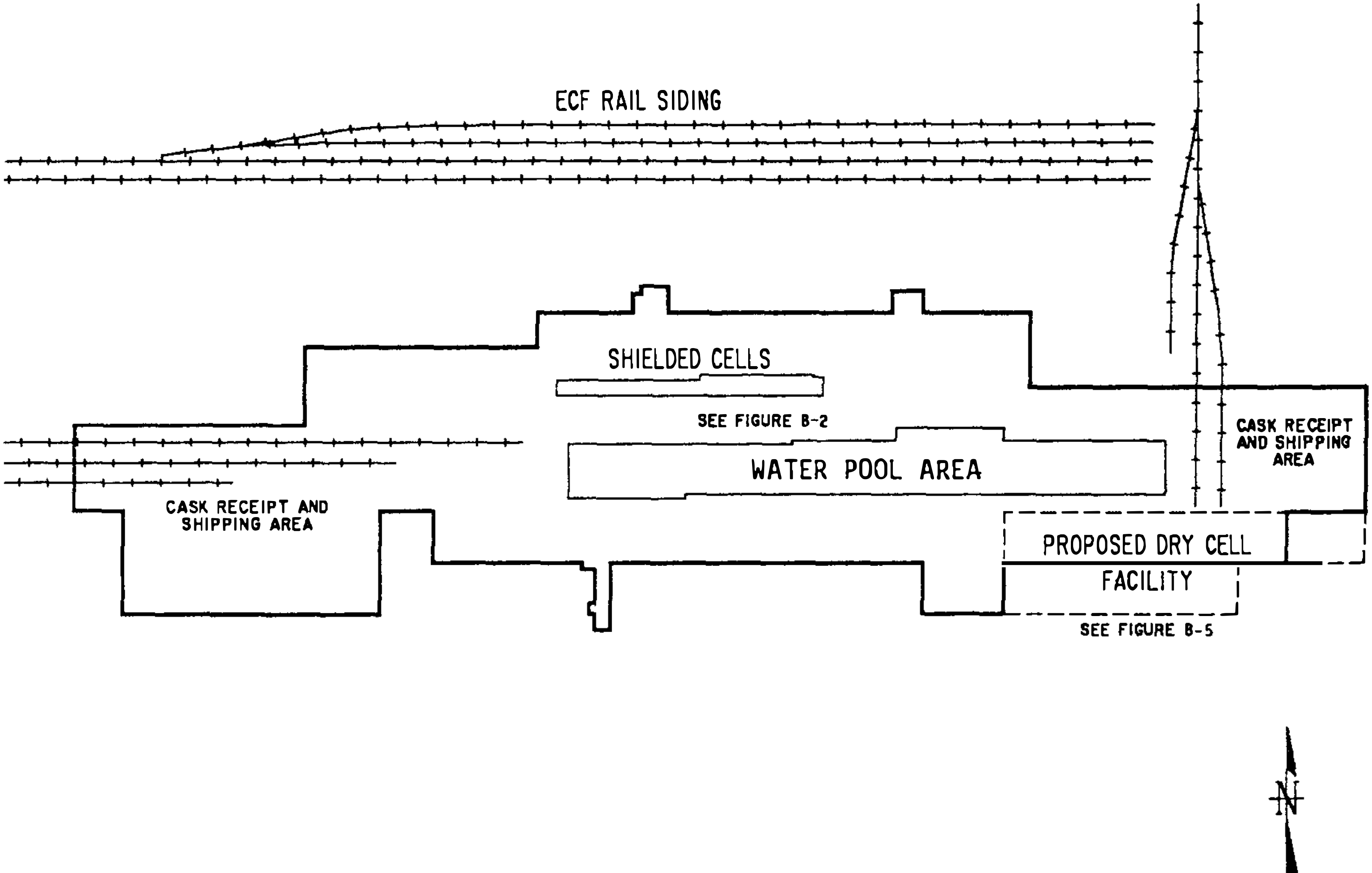

Figure B-1. Schematic view of Expended Core Facility.

Figure B-2. Expended Core Facility water pool area.

environment. The original ECF building was constructed in 1957, and consisted of a water pool and a shielded cell with a connecting transfer canal. The facility has been modified as necessary to accomplish the expanding mission of the facility since then, including the addition of three more water pools, several shielded cells, and other capabilities dictated by the nature of the work required.

B.1.1 Water Pools

The purpose of the four interconnected water pools is to permit viewing and examination of radioactive reactor components and specimens while providing radiation shielding for workers.

Walls and stainless steel gates divide the water pools into smaller work areas called zones. This partitioning makes it possible to drain a small portion of the total water pool volume when facility equipment maintenance or repair is required. It also would permit isolation of an individual zone if a leak were to develop which, combined with transfer of the water from that pool to holding facilities, would minimize the loss of water.

B.1.1.1 Water Pit No. 1. This pool is used for the removal of spent fuel from shipping containers, and for preparation of fuel and low-level waste for shipment to ICPP. It also contains fuel and non-fuel storage areas.

B.1.1.2 Water Pit No. 2. This water pool is used for handling irradiation test assemblies. Various components are tested for their reaction to radiation. Test assemblies returned from the Advanced Test Reactor (ATR) at INEL are unloaded from the shipping cask and disassembled. Verification of test integrity and connection of electrical and mechanical monitoring devices are performed.

B.1.1.3 Water Pit No. 3. Radioactive components are separated by milling machines into smaller units for examination in this water pool. Dimensional measuring equipment is used to examine selected components. Fuel storage racks are also located in Water Pit No. 3.

Observation rooms are located along the northern wall of this water pool. These rooms are below the level of the water surface and have viewing windows into the water pool. Components may be visually examined and remotely handled underwater for shielding purposes from these rooms.

B.1.1.4 Water Pit No. 4. Operations performed in this water pool include spent fuel removal from transfer containers, temporary fuel storage in racks, fuel examination, and preparations for spent fuel shipments. Observation rooms are located along the northern wall of the water pool. This water pool also contains the transfer canals that would link the water pools with the proposed Dry Cell Project, which would prepare spent fuel for shipment in a dry, enclosed environment.

B.1.1.5 Construction. All of the water pools are constructed of reinforced concrete in such a manner that they are watertight. The water pool floors are designed to support installed equipment and shielded shipping containers weighing up to 100 tons with a minimum base area of 8 square feet. Water pool zone depths range from 20 feet to 45 feet. Water pool walls and floors are coated with a thermo-setting plastic coating which is highly resistant to radiation damage, is easy to decontaminate, and serves as an extra barrier to water leakage.

B.1.1.6 Water Treatment and Minimizing Radioactive Contamination. Radioactive contaminants which have accumulated in the ECF water pools through the introduction of corrosion products from irradiation test assemblies and the unloading of spent fuel are removed by various filtration techniques. The design basis for the ECF water treatment system is to allow no discharge of radioactive material to the environment, maintain water clarity, and minimize the amount of radioactive contaminants in the water.

The design goals are accomplished through the use of water purification modules, water pool surface skimming to remove film and floating material, and water recycling systems. The water purification modules prefilter the water to remove particles larger than 60 microns in diameter, remove any dissolved solids in ion-exchange resin beds, and remove any organic or suspended material by absorption in an activated carbon bed. Spent resin, carbon, and filter elements are disposed of as solid radioactive waste.

B.1.1.7 Water Management. The total volume of the ECF water pools (excluding the two new transfer canals that are empty) is 3,000,000 gallons. A 1-inch difference in the water pool level is equivalent to approximately 9,300 gallons.

The water pools are maintained at a nearly constant level. Alarms are installed to indicate both high and low level conditions. The total water volume is accounted for monthly. Any addition of water to the system is reported to a separate NRF site organization for an independent verification of water volume.

Water leaves the water pools via evaporation, temporary filling of shipping containers, decontamination of equipment, and transfers to retention basins. The water pool evaporation rate has been calculated theoretically and confirmed by experiment. Water returns to the water pools by transfers from the retention basins and by draining shipping containers. Water removed from the system due to evaporation and equipment decontamination is replaced by adding demineralized water.

ECF has the capability of storing 235,000 gallons of water pool water in three underground, steel-reinforced, concrete storage basins. Two of the vaults each have a 40,000-gallon capacity, and the third has a 155,000-gallon capacity. These basins provide the capability to replenish the water pools and receive water pool water if draining a water pool zone is necessary.

B.1.2 Shielded Cells

There are 14 concrete shielded cells in the facility. These shielded cells are used for examination of smaller components, such as specimens which have been removed from irradiation tests that have been exposed to a neutron flux in the ATR, and fuel and non-fuel components from the water pools.

The shielded cells are constructed of concrete, with walls 3 feet thick to provide shielding from radiation. Ventilation in the cell bank maintains negative pressure inside the cells in relation to the rest of the facility. This ensures that radiological contamination is contained within the cells.

All work in the shielded cells is performed remotely by equipment controlled from the cell gallery, and is viewed through shielded lead glass windows. The windows are 3 feet thick, and provide the same shielding value as the concrete walls. The interior of the cells can also be viewed through wall periscopes that permit undistorted viewing of equipment and components.

B.2 RECEIPT AND HANDLING OF NAVAL SPENT NUCLEAR FUEL

B.2.1 Receipt of Spent Fuel

Nuclear-powered ship assignments for refueling, defueling, and overhaul are currently performed by the six nuclear-capable public shipyards (Mare Island, Puget Sound, Pearl Harbor, Portsmouth, Norfolk, and Charleston) and one nuclear-capable private shipyard (Newport News). In 1993, the federal base closing commission included Mare Island and Charleston Naval Shipyards among the bases to be closed in the near future. The spent fuel is removed from nuclear-powered ships and loaded into shipping containers designed specifically for naval spent nuclear fuel. The spent fuel containers are loaded and sealed at the shipyard and shipped to ECF via railcars, as described in Attachment A. A maximum of 48 containers can be staged on the rail siding at NRF outside ECF while awaiting transfer of the spent fuel to the water pools. ECF also receives spent fuel from naval prototype plants in a similar manner.

B.2.2 Handling of Spent Fuel

The shipping containers are brought into the ECF building at one of the two defueling stations and are prepared for defueling by removing the dust cover, leveling, and filling with water. Appropriate containments to prevent release of radioactive material are installed and the container access plug is removed to allow access to the fuel modules.

The containers are unloaded at either the west end defueling station or the east end defueling station. Regardless of the defueling station used, the fuel modules are removed from their shipping container one at a time using a fuel handling machine which draws the module out of the container into a shielded volume, and the entire machine is transferred to the water pools. The fuel module is then discharged into a receiving receptacle in the water pools. Photographs of the two fuel handling machines used are provided in Figures B-3 and B-4.

Every item containing nuclear fuel received at ECF has a unique serial number. When the fuel is removed from its shipping container, two ECF fuel handlers independently read the serial number and compare it to the shipping paperwork. After the serial number is confirmed, the fuel is

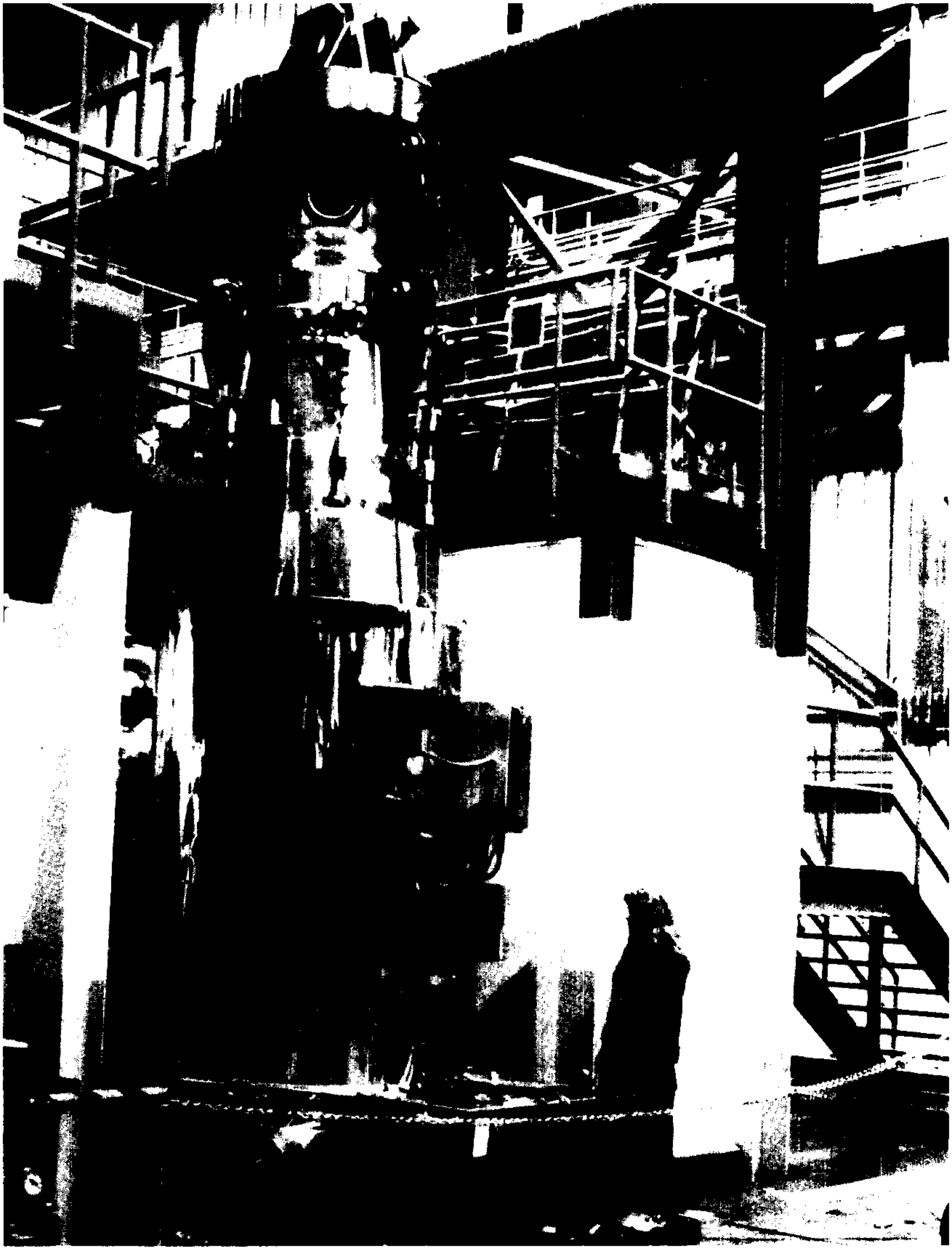

Figure B-3. M-140 container fuel handling machine.

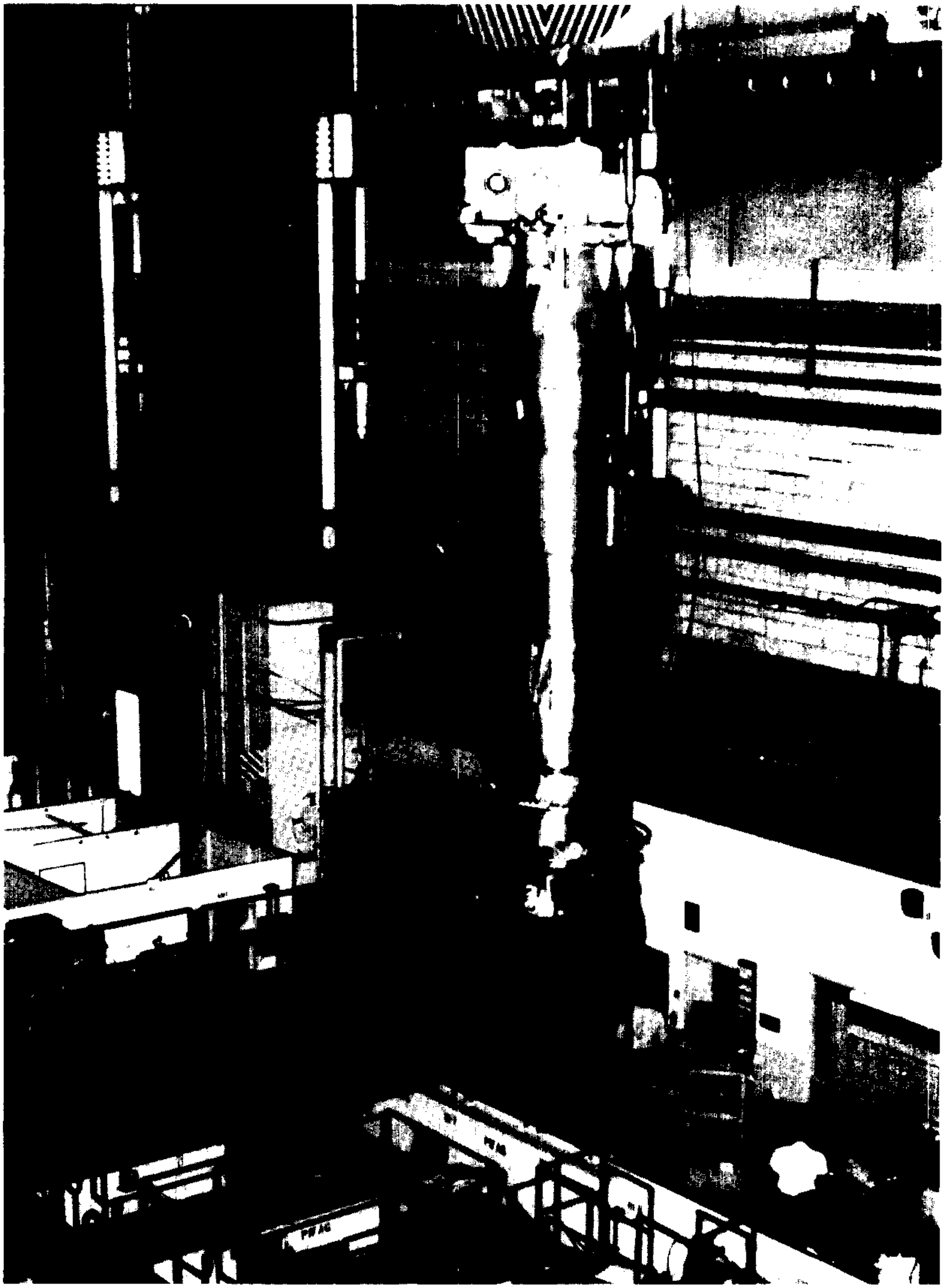

Figure B-4. M-130 container fuel handling machine.

moved to a uniquely numbered storage port location. Two fuel handlers then independently verify that the fuel is stored in the correct storage location. ECF has a computer-based fuel accountability system which maintains a record of the location and type of every piece of nuclear fuel and how many grams of uranium are contained within the fuel. This system tracks every fuel movement during the time that the fuel is at ECF.

All naval fuel modules have metal structures which contain no fuel above and below the fuel region to facilitate coolant flow and maintain proper support and spacing within the reactor. These upper and lower non-fuel bearing structures must be removed to provide access to the fuel-bearing sections to permit inspection of the module. Removal also reduces the storage space ultimately required for the fuel by approximately 50 percent. The upper and lower non-fuel bearing structures removed during the preparation of fuel modules are evaluated using the waste classification criteria established by federal regulations in 10CFR61 and DOE Order 5820.2. These non-fuel bearing structures do not contain any fuel, or fission products from fuel, and therefore cannot be considered "spent nuclear fuel." They also do not contain transuranic elements or fission products and thus cannot be considered high-level waste or transuranic waste. Therefore, the amounts of radioactivity in the end boxes cause them to be classified as low-level waste. As indicated in Section 5.2.15, the amount of low-level waste generated each year at the Expended Core Facility is 425 cubic meters. The radioactive isotopes which represent 99 percent of the activity in this material are identified as follows:

ISOTOPE	HALF-LIFE (Years)	PRIMARY MODE OF DECAY
Fe-55	2.73	Electron Capture (x-ray)
Co-60	5.271	Beta and Gamma
Ni-59	76,000	Electron Capture
Ni-63	100	Beta

U.S. Nuclear Regulatory Commission 10CFR61 identifies three classes of low-level wastes which are generally suitable for near-surface disposal, namely, Classes A, B, and C. Those meeting the requirements for near-surface disposal are shipped to the INEL Radioactive Waste Management Complex using a shielded cask. Wastes with concentrations greater than those specified for Class C for certain short- and long-lived isotopes were found to be not generally suitable for near-surface disposal. These wastes are classified as Greater Than Class C Low-Level Radioactive Waste. In May 1989, the Nuclear Regulatory Commission promulgated a rule that requires disposal of commercially generated low-level waste with concentrations of radioactivity greater than Class C in a deep geologic repository, unless disposal elsewhere is approved by the Nuclear Regulatory Commission.

Currently, a small amount (about 25 cubic meters) of greater than Class C low-level waste in material removed from the ends of naval spent nuclear fuel modules over the years is being stored at the Naval Reactors Facility pending availability of a disposal facility licensed by the Nuclear Regulatory Commission. This material has been collected and held at the Expended Core Facility for many years. This practice is expected to continue over the period of time covered by this Environmental Impact Statement.

After these upper and lower metal structures have been removed from a fuel module, a lifting fixture is installed to facilitate handling. Prepared fuel may then be inspected immediately or it may be held for a time prior to inspection in storage racks in the water pool. In the event that the fuel is temporarily stored while awaiting inspection, spacers are placed at the bottom of the selected port in the storage rack to maintain the position of the fuel module close to the top of the rack to make movement of the module easier.

Visual examinations of all modules are performed to verify that the fuel has performed as expected. As discussed in Section 2.4.1, about 10 to 20 percent of the spent reactor cores are selected for more detailed examination or destructive analysis in accordance with the needs of the Naval Reactors fuel development program. The more extensive examinations performed in the water pools include measurements of key dimensions of the modules and collection of specimens to be examined in the shielded cells. The specialized equipment used to perform examinations of naval spent nuclear fuel are described in more detail in the section of this attachment devoted to equipment. Destructive analyses are performed at the Expended Core Facility or at other laboratories, but all material subjected to such analysis must be removed from the spent fuel modules at the Expended Core Facility.

The last steps of spent fuel handling performed at ECF are staging the module for shipment and loading the module into the shipping cask used to transport spent fuel from ECF to ICPP. The spent fuel may be temporarily stored in the racks in the ECF water pools until a cask becomes available to transfer the material to ICPP.

B.2.3 Shipment of Fuel to the Idaho Chemical Processing Plant

A lead-filled, stainless steel shipping cask is used to transport naval and prototype spent fuel modules from ECF to ICPP. The cask is removed from its transport truck and lowered into the ECF water pool until it rests on the floor of the pool. The closure head is removed, and inserts are placed in the cask to provide proper spacing of fuel and to maintain proper positioning during transport of the modules. The modules are inserted into the cask, the closure head is reinstalled, and the cask is lifted from the water. The cask is drained, the exterior is decontaminated, and the cask is loaded onto the truck for shipment. The transport of the cask to ICPP is described in Attachment A.

B.2.4 Library of Naval Reactor Components

As the first modules of a given fuel design are received at the Expended Core Facility for examination, selected key operating components are retained in "library" storage in the water pools to provide a source of reference. These older components are kept to ensure that there will be a representative item available to assist in diagnosis of problems which may occur in any operating power plant in the fleet. The items chosen for this library are usually those that have been in service the longest so that they display the most pronounced effects of use. As the various fuel design types are replaced in fleet service by newer designs, fuel components related to the fuel design being retired are removed from library storage and shipped to ICPP.

B.3 HANDLING OF IRRADIATED TEST SPECIMENS

The irradiated materials program evaluates small specimens of materials for use in naval reactor systems. The specimens are loaded in sample holders, and the holders are placed in test assemblies at ECF. The assemblies are irradiated at ATR, and returned to ECF for disassembly. The specimens are cleaned, examined, reloaded in a test assembly, and returned to the ATR for continued irradiation. A typical specimen undergoes several cycles of irradiation and examination over several months or years. Examinations include nondestructive and destructive tests. Destructive tests have historically included sectioning of specimens for mechanical testing and metallography. Metallographic work was performed in the ECF hot cells in the past and is planned to be performed on specimens in the future.

After completion of the final examination, specimens are shipped to ICPP for storage or to the INEL Radioactive Waste Management Complex for disposal. Other specimens are shipped to either the Bettis Atomic Power Laboratory near Pittsburgh, Pennsylvania, or the Knolls Atomic Power Laboratory near Schenectady, New York for more detailed examinations.

B.4 DESCRIPTION OF MAJOR ITEMS OF EQUIPMENT

The normal method for moving the fuel in the water pools to designated examination equipment areas is by use of one of five bridge cranes which move on rails located on the tops of the walls of the water pools. The fuel is handled remotely. All fuel movements are controlled by trained personnel, and accountability is maintained both by computer and by personnel using fuel transfer forms.

B.4.1 Water Pool Equipment

ECF has unique equipment in the water pools that has been designed for remote operation underwater to perform specific examinations on naval spent nuclear fuel and irradiated test specimens. Special consideration was given during equipment design to provide for remote repair and replacement of components. A description of the water pool spent nuclear fuel and irradiation test examination equipment is presented below.

B.4.1.1 Water Pool Band Saws. There are two underwater band saws in the ECF water pools. These band saws are used to remove the non-fuel bearing structural material from the top and bottom of fuel cells in preparation for inspection. The fuel region of the fuel cell remains intact during the cutting procedure.

B.4.1.2 Water Pool Milling Machines. Three milling machines in the water pools are used to separate spent nuclear fuel components into smaller sections for examination in the shielded cells. The fuel region of the fuel cell remains intact during the machining. The mills are used to section spent fuel into pieces which can be handled in the shielded cells for examinations, such as gamma radiation measurement, or for obtaining smaller specimens for metallurgical analysis or fuel depletion measurement. The mill head of the largest milling machine can be remotely interchanged with a band saw attachment to convert the machine into a cutoff saw.

B.4.1.3 Universal Inspection Station. This equipment is used to obtain dimensional measurements using specially designed probes that are inserted in the fuel module. This equipment can position and rotate the probe in any orientation by a dedicated computer. This information is used to assess dimensional changes in the fuel module.

B.4.1.4 Vertical Inspection Gage. The vertical inspection gage is used for obtaining dimensional measurements or to trace the contour of the external surfaces of fuel cell assemblies or control rods. This information can be used to provide a three-dimensional image of the fuel cell or control rod at the end of fuel life to determine the effects of fuel element changes on the overall fuel cell assembly dimensions over fuel life and the effects of radiation on control rod dimensions over fuel life.

B.4.1.5 Video Visual Equipment. Underwater television cameras and lighting can be set up in any zone in the water pools to obtain images of the external surfaces of the fuel cell assemblies and control rods. These visual inspections are used to search for anomalies such as excessive corrosion or wear on external surfaces. The bottom end of the fuel cell assemblies can also be inspected for flow blockage, corrosion, and wear.

B.4.1.6 Assembly and Disassembly Tables. These tables are used to assemble and disassemble irradiated test assemblies that are inserted in the ATR. There are two identical assembly and disassembly tables installed side by side in the water pools. Each is mounted on a tilt platform that is used to rotate the table from a horizontal position for test assembly and disassembly to a vertical position for loading and unloading the test assembly.

B.4.1.7 Headwork Station. The Headwork Station provides containment and shielding for the mechanical connection and disconnection of components to and from the unirradiated portion of the assembly and disassembly of irradiations tests for the ATR. There are two independent work stations; each consists of an elevator platform which raises the top unirradiated portion of the test above the water surface. A containment is positioned above the water surface to prevent the spread of contamination while the examination is performed above the water.

B.4.1.8 Fuel Storage Racks. Storage racks are required at ECF since, at times, fuel is received into the facility faster than fuel can be prepared and shipped out of the facility. Racks are also used to store the small amount of naval spent nuclear fuel selected for retention as library specimens for future reference and study. Ensuring that the racks are conservatively designed to withstand any credible accident and continue to provide adequate nuclear separation are the major criteria for storage racks.

The basic configuration of a fuel storage rack is a rectangular structural array of storage ports. Each port has a square opening, but depth is variable. All storage ports in use at ECF are stainless steel. Stainless steel is used exclusively to resist corrosion during the life of the storage racks. The storage ports are designed to withstand the weight of the heaviest fuel module which can be placed in the port, and the frame assembly is designed to support the entire weight of all the fuel ports fully loaded with the heaviest fuel type.

All the fuel racks are designed to maintain their structural integrity during a design basis earthquake and to withstand the impact of a fuel module dropped onto the fuel racks. Analyses of all fuel racks in the event of seismic activity has demonstrated that they will not collapse during the postulated earthquake. ECF also performed a full analysis of the strength of the ports if a fuel module were dropped over the fuel racks, including the kinetic energy which the dropping fuel module would impart to the rack. It was determined that all fuel racks at ECF were adequately designed to withstand the energy of dropped fuel. The analysis also identified that some equipment handled at ECF was heavy enough that the racks might be deformed if the equipment were dropped. Thus, operating rules and procedures prohibit the movement of large loads over the fuel racks to ensure that no accidental damage to the racks can occur.

Fuel storage racks were also designed to prevent arrangement of the modules into a potentially critical configuration. The fuel racks are designed so that each port separates the module it contains from every other module by a distance great enough to prevent criticality under the most limiting conditions possible. To assure that only one piece of fuel is placed in a port, all fuel storage ports are equipped with lids which can be locked and sealed. Finally, the frame assemblies of all fuel storage racks are covered with stainless steel sheeting to prevent fuel from inadvertently being placed between fuel storage ports.

B.4.2 Water Pool to Shielded Cell Transfer Systems

Components that have been removed from spent nuclear fuel cells or test assemblies can be transferred into the shielded cells using one of the three available water pool to shielded cell transfer systems. The transfer systems use carts that are driven through underwater tunnels.

B.4.3 Shielded Cell Examination Equipment

ECF has specialized equipment installed in the shielded cells which is designed to perform examinations on fuel elements and components removed from spent fuel cell assemblies and test specimens that have been irradiated in the ATR. A description of the major shielded cell equipment follows.

B.4.3.1 Electronic Balances. These are commercially available electronic balances that have been modified to operate remotely in the shielded cells. Components on these balances that are known to deteriorate from exposure to radiation have been replaced using materials that are less susceptible to radiation damage. The equipment is interfaced with computer data acquisition systems to aid the operators in tracking and reducing the data. These balances are used primarily to assess weight changes that result from corrosion testing of materials in the ATR.

B.4.3.2 Descale Tanks. Corrosion removal is performed for test specimens that have been irradiated in the ATR and structural components and fuel elements removed from spent nuclear fuel modules. These tanks use heat, chemicals, and ultrasound to dislodge corrosion that has accumulated on the specimens or components. The corrosion removal aids in visual examination of these specimens.

B.4.3.3 Bridgeport Milling Machine. This is a high-precision milling machine that has been modified for remote operation in the ECF shielded cells. The mill is controlled by a programmable controller located in the shielded cell gallery. The Bridgeport mill is used for precise machining of non-fuel components removed from spent nuclear fuel cell assemblies.

B.4.3.4 Specimen Coordinate Automated Measuring Machine. The specimen coordinate automated measuring machine is a fully automated unit specifically designed to perform three-dimensional measurements on irradiated test specimens and structural components removed from spent nuclear fuel cells. The equipment is completely computer controlled and has an accuracy of 0.00005 inch (50 microinches). The information obtained from this equipment is used to assess the effect of radiation on material growth and fuel burnup on swelling of specimens.

B.4.3.5 Fiducial Automated Measuring Machine. This machine is used to measure the distance between scribe marks that are put on some types of specimens during fabrication. The machine accurately measures the position of the scribe marks in relation to other fiducial marks on the specimen. These data are used to assess the effects of radiation on specimen growth and distortion, as well as the effect of fuel depletion on fuel element swelling.

B.4.3.6 Gamma Scan System. This system measures gamma radiation emitted by fission products to identify isotopes present in the fuel as a result of fuel depletion. The system is controlled by a dedicated computer which positions the specimen, provides for data acquisition and evaluation, and provides an output of the isotopes detected by the system at each location along the axes of the specimen.

B.4.3.7 Alpha Box. The Alpha Box is a carbon steel containment inside the shielded cells. It provides isolation within the shielded cells for fuel cutting to prevent the spread of fission products. This is the only location in the facility where cutting through the fuel region of spent nuclear fuel is allowed.

B.5 FACILITY DESIGN AND INTEGRITY REQUIREMENTS

B.5.1 Flood

A flood at ECF due to overflow of any source of surface water within the INEL boundaries is a low probability event. With the construction of the INEL flood control diversion system in 1958, the threat of a flood from overflowing of the Big Lost River, the primary source of surface water at the INEL, has become very small.

The maximum water elevation postulated at ECF would be caused by a hypothetical Probable Maximum Flood resulting from failure of the Mackay Dam, located approximately 35 miles northwest of the INEL. The hypothetical flood could result in a maximum water level approximately 3 feet above the floor elevation of the ECF building. This flood is postulated to result from water flowing over the top of the Mackay Dam and causing it to fail due to high water levels. This flood is highly unlikely. (Koslow and Van Haaften 1986)

Dam failure due to other causes, such as seismic activity, is more likely. Although the Mackay Dam survived the 1983 Borah Peak earthquake without damage, it was built without seismic design criteria. Additionally, it is not clear how resistant the dam structure is to seismic events. A fault segment runs within 6 kilometers of the Mackay Dam.

Flooding of the ECF building is possible should the Mackay Dam fail. Flooding of the ECF building would not create a nuclear criticality hazard. Flooding of the building could result in the release of water containing low levels of radioactive contamination to the environment and damage to equipment in flooded areas. Following the dam break, it would take over 16 hours for the flood water to reach NRF. This is adequate time to complete emergency procedure preparations, such as filling and placing sandbags, for the expected flood conditions.

B.5.2 Earthquake

The ECF building structure was built in accordance with the Uniform Building Code for each particular phase of construction. Water Pit No. 1, Water Pit No. 2, and Water Pit No. 3 were built to "Zone 2" earthquake requirements which were judged to be appropriate under the U.S. Geologic Survey classification of the area at the time of their construction. Water Pit No. 4 and its two transfer canals were built to the more restrictive "Zone 3" earthquake requirements in effect at the time they were built.

A seismic assessment has been performed for the ECF using the actual characteristics of the existing facility. Based on this assessment, a design basis seismic event at ECF could have a peak ground acceleration of 0.24 g (Rizzo 1994). This peak ground acceleration is derived on the basis that a moment magnitude 6.9 seismic event centered near Howe on the Lemhi fault would cause a rupture of approximately 34 kilometers along the Lemhi fault. The Howe epicenter is the epicenter located closest to ECF, and 6.9 was the moment magnitude of the Borah Peak earthquake in 1983. This approach for postulating the location of the seismic event is consistent with the Nuclear

Regulatory Commission methodology used for commercial power plants. The beyond design basis seismic event was based on a scenario resulting in a peak ground acceleration of 0.4 g at ECF.

B.5.3 Tornado

A tornado at ECF is a low probability event. The document "Technical Basis for Interim Regional Tornado Criteria," WASH-1300, provides the technical basis for Nuclear Reactor Commission Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants." The WASH-1300 document identifies the probability of occurrence of a tornado at ECF to be 7.8 x 10^{-5} per year based on historical records. Regulatory Guide 1.76 identifies the maximum wind speed appropriate to ECF to be 240 mph. Data collected by Dr. T. Fugita of the University of Chicago performed at the request of the DOE for the period between 1950 and 1976 indicate the probability of a tornado with winds of that speed occurring at the INEL is about 1.3 x 10^{-9} per year. Based on a threshold wind speed for tornado damage of 75 mph (refer to P. L. Doan, "Tornado Considerations for Nuclear Power Plant Structures," Nuclear Safety, Volume 11, No. 4) and a probability of 0.80 for the occurrence of tornado-induced wind speeds greater than or equal to 75 mph (WASH-1300, Table 3), the probability of a damaging tornado occurring at ECF is 7.8 x 10^{-5} per year x 0.80 = 6.2 x 10^{-5} per year.

A tornado could not affect the fuel storage area in ECF in such a way that the fuel would be rearranged into a critical configuration. The article by Doan cited above analyzes the effects of tornados for the general case of spent fuel in water pools and concludes "... massive loss of water due to either tornado-induced wind forces or tornado-generated missiles cannot happen. It is credible, however, that a couple of feet of water could be lost owing to the combination of water splashing, water entrainment, and pressure differentials. The spent fuel at the bottom of the water pools would, however, remain completely covered.... By the same token, the radiation dose level above the water surface would not increase by any meaningful amount."

B.5.4 Fires

The entire ECF facility is protected against fires by one of several types of sprinkler systems. A large, intense fire in fuel handling areas is a low probability event because of the nature of the materials of construction in these areas, the amounts and kinds of material present, and the fire protection system. Most of the spent fuel is under many feet of water, providing additional protection against a fire which might involve fuel. Fires at other locations in the facility would be extinguished by the sprinkler system and by manual fire protection equipment (e.g., fire extinguishers or fire hoses). An extensive fire involving the ECF building structure is highly unlikely because it has been constructed of non-combustible or fire-resistive material to the greatest extent possible, in accordance with applicable Atomic Energy Commission, Energy Resource and Development Administration, and DOE design criteria.

B.5.5 Loss of Water Pool Water

Loss of all water in a section of the water pool is extremely unlikely. However, should a heavy object be dropped onto a water pool floor, a crack could develop. If this were to occur, the cracked water pool area would be isolated and drained in a controlled manner to one of the retention basins before a substantial loss of water to the environment would occur. Even in the event that severe damage to a water pool floor were to result in the loss of substantial amounts of water pool water, no nuclear criticality hazard would result and no melting of fuel would occur.

B.6 CRITICALITY CONTROL

There has never been an inadvertent criticality at the Expended Core Facility. This is the result of strict application of the following principles.

A fundamental principle of nuclear safety is Criticality Control. When a mass of nuclear fuel reaches a condition at which its atoms are capable of undergoing a self-sustaining chain reaction, or splitting (fissioning) into new elements, the result is called a criticality. Nuclear fission releases energy in the form of radiation and heat. Controlled criticality within a shielded reactor vessel produces energy within a confined space without harm to personnel or the environment. Although the water pools, the shielded cells, and the ECF building are designed to shield and contain radiation and radioactive contamination, an uncontrolled criticality (or nuclear excursion) within ECF is unacceptable, and comprehensive measures are taken to prevent such an occurrence. Criticality control at ECF could be described more accurately as "absolute criticality prevention." Conditions are identified, equipment or processes are designed, rules and procedures are formulated, and personnel are trained to prevent occurrence of an accidental criticality.

Safety analyses are performed on all fuel types and system designs where all single plausible and unlikely accidents are considered. Conservatism is employed in establishing limits and controls, and spent fuel is handled to the more restrictive as-built values. Then a "double accident criterion" is applied to all fuel handling equipment and procedures. The double accident criterion states "Fuel must be handled and equipment designed so that acceptable margins to criticality exist after two most limiting, unlikely, independent, and concurrent accidents. In this context, two errors in a routine administrative procedure are considered to be a single accident, not two." As a result of application of this criterion to equipment and procedures at ECF, the amount of fuel which may be handled in any operation is typically restricted to one quarter of the minimum amount which could achieve criticality minus a safe margin to criticality.

All nuclear fuel operations must be performed in accordance with approved criticality control procedures. Nuclear safety analyses are carefully reviewed by the responsible management and two independent nuclear safety committees. Naval Reactors must approve each analysis before it is used. Strict reviews and approvals are also applied to implementation of safety analyses in fuel handling procedures.

The successful criticality control program at ECF is also due to thorough training and supervision of fuel handling personnel. Employees are educated concerning the principles of criticality, associated hazards, and prevention. A system of checks to ensure that the rules and limits are strictly observed is employed. It includes detailed training documentation, qualification and testing standards, a self-assessment (audit) program, and an array of accountability and nuclear safety drills.

B.7 PROPOSED DRY CELL FACILITY

The Dry Cell Facility consists of a shielded, radiologically controlled area with remotely operated equipment. The facility is designed for a 40-year life, built of structural steel and concrete, and would be integral with the existing ECF building.

The major element of the Dry Cell Facility is a large reinforced concrete shielded cell with interior dimensions of 22 feet wide by 84 feet long by 21 feet high, containing all the equipment necessary to inspect and disassemble fuel modules. The facility will have the capability to prepare and load one fuel module per shift in a shipping cask. Based on a two shift per day operation (500 shifts per year), and a 25-percent maintenance downtime, the Dry Cell Facility yearly capacity is expected to be 375 modules. Shielded decontamination and repair cells will be attached to the main shielded cell to allow remote decontamination and repair of equipment used throughout ECF. Artist's views of the Dry Cell Facility and the associated Cask Loading System are shown in Figures B-5 and B-6.

The dry cell design incorporates 4-foot thick, radiation shielding walls constructed of high-density and normal-density concrete. The shielding is designed to limit radiation levels in normally occupied areas around the cell to 0.1 millirem per hour or less. At the INEL Site boundary, there would be no measurable elevation above the naturally occurring background radiation levels. The dry cell design meets the latest seismic requirements and includes negative pressure air ventilation for radiological contamination control. Shielded lead glass windows and viewing aids are provided as required at the workstations. Power, lighting, and a fire suppression system are also provided.

The Dry Cell Facility is also designed to facilitate decontamination and decommissioning of the facility at some future date. This is achieved by including cell liner contamination barriers, no fixed embedded piping, a minimum of cracks and crevices, smooth surfaces, and wall penetrations large enough to be radiologically surveyed to verify decontamination effectiveness.

B.8 REFERENCES

Koslow, K. N. and D. H. Van Haaften, 1986, *Flood Routing Analysis for a Failure of Mackay Dam,* EGG-EP-7184, EG&G Idaho, Inc., Idaho Falls, Idaho, June.

Rizzo (Paul C. Rizzo Associates), 1994, *Natural Phenomena Hazards - Expended Core Facility, Idaho National Engineering Laboratory,* Monroeville, Pennsylvania, June.

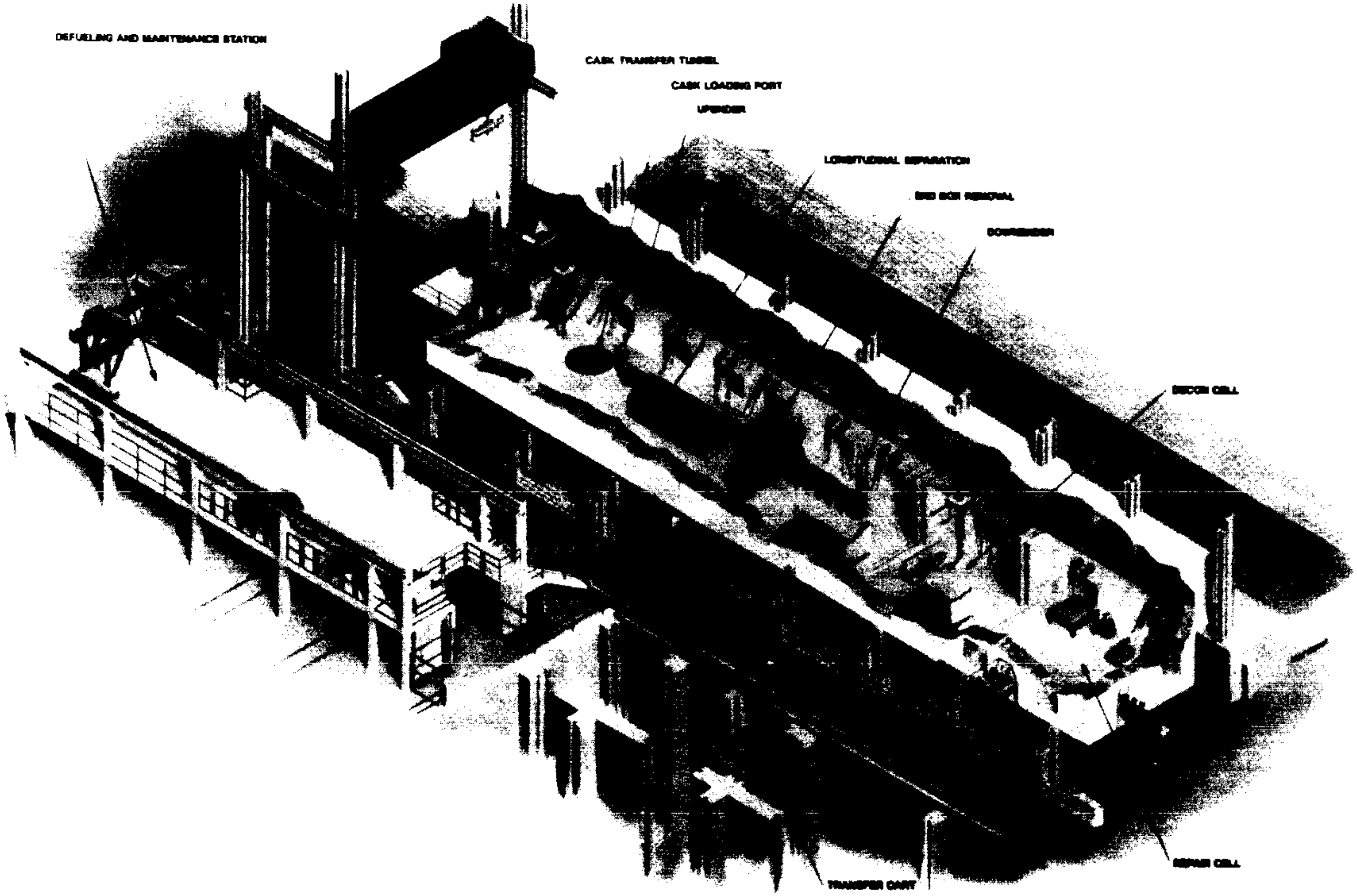

Figure B-5. Proposed ECF Dry Cell Facility.

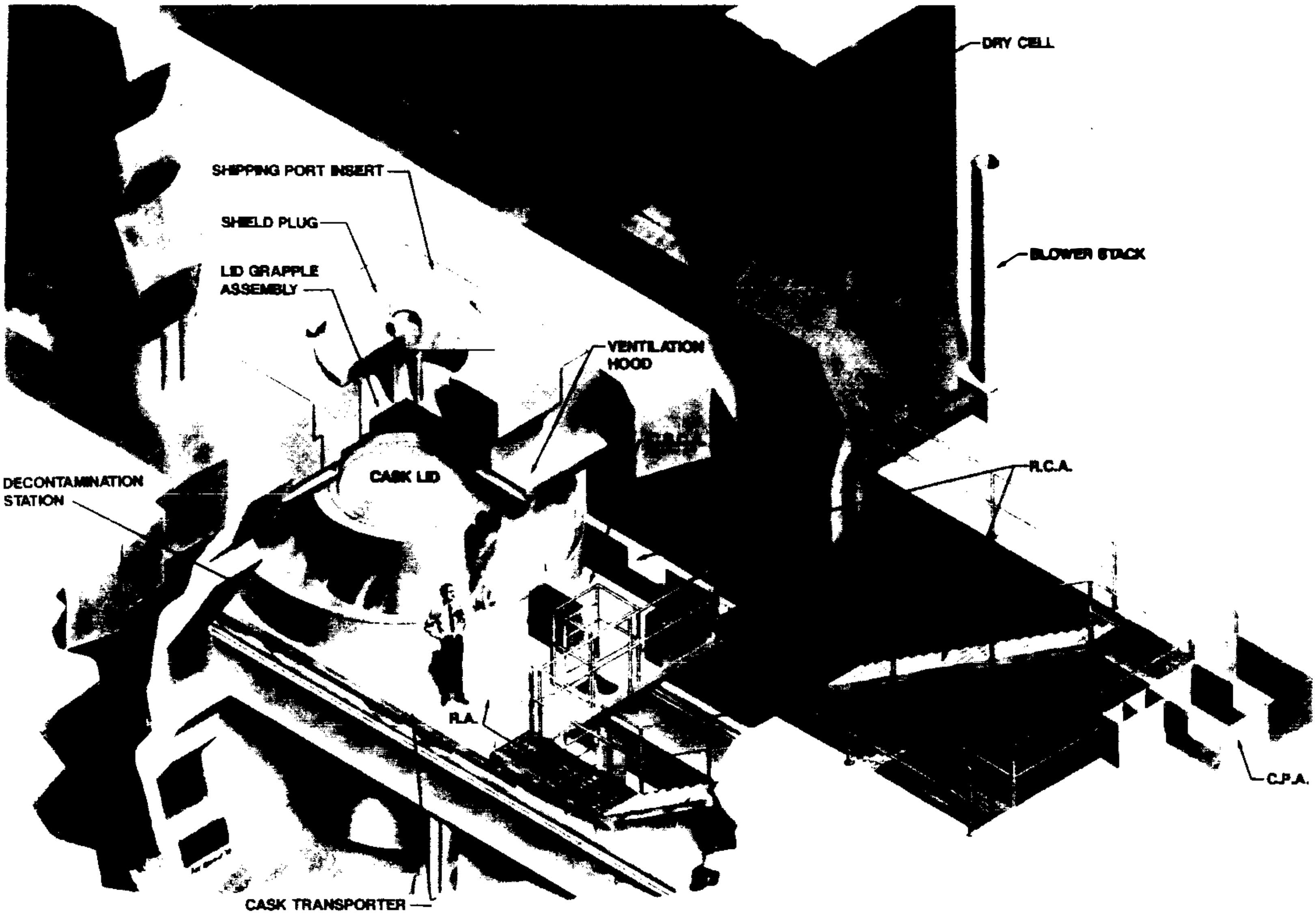

Figure B-6. ECF Dry Cell Facility Cask Loading System.

ATTACHMENT C - COMPARISON OF STORAGE IN NEW WATER POOLS VERSUS DRY CONTAINER STORAGE

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ATTACHMENT C

COMPARISON OF STORAGE IN NEW WATER POOLS VERSUS DRY CONTAINER STORAGE

C.1 INTRODUCTION

This attachment discusses the advantages and disadvantages of water pools versus dry container storage should construction of additional interim storage be required. The discussion considers the generic safety aspects of water pools and dry container storage based on evaluations performed by the Nuclear Regulatory Commission (NRC) and the Department of Energy (DOE) as well as experience with naval spent nuclear fuel.

C.2 WATER POOLS

During the last four decades, the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) has demonstrated the safety and reliability of water pools under the control of the Naval Reactors Program. Water pools have historically been the method of choice for interim storage and fuel handling because: (1) water has a high thermal capacity for the removal of heat from the fuel, (2) the transparency of water facilitates the inspection and movement of the fuel, (3) water is an excellent gamma and neutron shield, (4) water is easy to purify and recycle, and (5) water provides a means to prevent release of radioactive material into the air.

The safety of spent fuel storage in a water pool can be considered in terms of three generic criteria. They are: (1) the integrity of spent fuel under water pool storage conditions, (2) the structure and component safety of the facility, and (3) the potential risks of accidents and acts of sabotage at the spent fuel facility.

The NRC conducted an extensive investigation into the storage of spent fuel and documented the findings in the Waste Confidence Decision (NUREG 1984). Based on the technical evaluations cited in that document, the NRC found that the Zircaloy cladding which encases spent fuel is highly resistant to failure under pool storage conditions and concluded that Zircaloy-clad commercial fuel satisfied the first generic criterion. This conclusion is consistent with the extensive experience with naval spent nuclear fuel. Naval fuel is Zircaloy clad and thus is highly resistant to corrosion in water. In addition, a Navy fuel assembly has much higher mechanical integrity than commercial fuel since it is designed for military application and is capable of withstanding shock loadings which may be encountered in battle conditions.

The NRC also conducted an extensive evaluation of the structural and component safety of water pools. The NRC found no reason why spent fuel storage pools would not be capable of performing their cooling and storage functions for a number of years past the design life of 40 years if the water pools are properly maintained; therefore, the second generic criterion would be satisfied. This conclusion is consistent with the naval fuel experience of over 35 years of operation of the ECF.

The risk of major accidents at spent fuel storage pools resulting in off-site consequences is remote because of the secure and stable character of the spent fuel in the storage pool environment, and the absence of driving forces (i.e., high pressure or temperature) which might result in dispersal of radioactive material (NUREG 1984). The consequences of terrorist attacks on a spent fuel storage pool would be limited by the realities that the radioactive content of spent fuel is in the form of material encapsulated in high-integrity metal cladding and stored underwater in a reinforced concrete structure. Under these conditions, the radioactive content of spent fuel is relatively invulnerable to dispersal to the environment (NUREG 1984).

These considerations led the NRC to conclude that storage pools can be designed to safely withstand accidents caused either by natural or man-made phenomena such that there would be no impact to the environment. Therefore, the third generic criterion would be satisfied.

The NRC concluded that all areas of safety and environmental concern (e.g., maintenance of systems and components, prevention of material degradation, protection against accidents and sabotage) have been addressed for water pools, and that spent fuel can be stored with no environmental impact. This conclusion is supported by the Organization for Economic Co-Operation and Development of the Nuclear Energy Agency (NEA 1993).

C.3 DRY CONTAINER STORAGE

Dry container storage technologies have been in use in the United Kingdom since 1972 (MOCSG 1993). In the United States, demonstration projects have been underway since 1982. In dry container storage, multiple barriers prevent gaseous as well as particulate fission product releases. Two separate barriers must fail before fission products can be released: (1) the fuel cladding, and (2) the outer secondary seal. In addition, dry storage systems provide metal or concrete shielding to reduce the external radiation to acceptable limits.

The NRC concluded that dry container storage involves a simpler technology than that represented by water storage systems. Water storage relies to a certain extent upon active systems such as pumps, renewable filters, and cooling systems to maintain safe storage. Favorable water chemistry must also be maintained to retard corrosion. Dry container storage uses convective circulation of an inert atmosphere in a sealed dry system so there is little opportunity for corrosion (NUREG 1984).

The NRC also found that dry container storage of spent fuel in dry wells, vaults, silos, and metal casks is relatively invulnerable to sabotage and the forces of nature, because of the weight and size of the sealed, protective enclosures, which may include 100-ton steel casks, large concrete-lined casks, and surface concrete silos (NUREG 1980).

The NRC concluded that for dry interim storage, all areas of safety and environmental concern (e.g., maintenance of systems and components, prevention of material degradation, protection against accidents and sabotage) have been addressed and shown to present no more potential for adverse impact on the environment and the public health and safety than storage of spent fuel in water pools. This conclusion is supported by the Organization for Economic Co-Operation and Development of the Nuclear Energy Agency (NEA 1993).

As stated earlier, naval fuel uses Zircaloy cladding and has a much higher mechanical integrity than commercial fuel since naval fuel is designed for military application. Therefore, the generic conclusions reached for commercial spent fuel are directly applicable to naval spent fuel.

C.4 NON-RADIOLOGICAL CONSEQUENCES OF SPENT FUEL STORAGE

The NRC concluded (NUREG 1984) that "there are no significant non-radiological consequences due to the extended storage of spent fuel which could adversely affect the environment." The construction of an interim spent fuel storage facility (i.e., the construction of a water pool, a concrete pad, a building, rail spur, etc.) would have little impact on the environment. The amount of heat given off by spent fuel decreases with time as the fuel ages and decays radioactively, and the amount of additional energy and water needed to maintain spent fuel storage is also small.

C.5 LAND UTILIZATION

With the use of water pool storage or dry container storage at an existing shipyard, land already devoted to industrial use is planned to be used for the spent fuel storage facility. The amount of land required for storage at specific shipyards is addressed in Attachment D.

C.6 COST

The use of alternate sites other than INEL would involve the construction of additional storage facilities. Both water pools and dry container storage could be used, with little environmental impact; therefore, the relative cost between these two options could be relevant. Conceptual cost estimates have been prepared for each storage option at each location that is being evaluated. These cost comparisons are found in Attachments D and E.

C.7 SUMMARY

Based on the above discussion, both a new water pool and dry container storage would be suitable for the interim storage of spent naval fuel with no important radiological or non-radiological environmental impact. If a facility would be required to be used for the inspection of spent fuel, as well as storage, then a water pool offers an advantage since water is an inexpensive and convenient form of transparent shielding. If it were not necessary for a new facility to be used to inspect spent fuel, then the cost of the facility and the amount of land required could be factors in selecting an option.

C.8 REFERENCES

MOCSG (The Midwestern Office of the Council of State Governments), 1993, *Report on Interim Storage of Spent Nuclear Fuel,* DOE/CH/10402--22, April.

NEA (Nuclear Energy Agency), 1993, *The Safety of the Nuclear Fuel Cycle,* Organization for Economic Co-Operation and Development.

NUREG (U.S. Nuclear Regulatory Commission), 1980, *Dry Storage of Spent Nuclear Fuel,* NUREG/CR-1223, April.

NUREG (U.S. Nuclear Regulatory Commission), 1984, "Waste Confidence Decision," *Federal Register,* Volume 49, No. 171, August 31.

ATTACHMENT D - DESCRIPTION OF STORAGE OF NAVAL SPENT NUCLEAR FUEL AT SERVICING LOCATIONS (SHIPYARDS AND PROTOTYPES)

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DESCRIPTION OF STORAGE OF NAVAL SPENT NUCLEAR FUEL AT SERVICING LOCATIONS (SHIPYARDS AND PROTOTYPES)

D.1 STORAGE OF NAVAL SPENT NUCLEAR FUEL IN CONTAINERS AT SHIPYARDS AND PROTOTYPES

D.1.1 Introduction

This attachment examines the alternative of storing naval spent nuclear fuel at shipyard and prototype sites where the fuel is removed from the reactor plant. Water pool storage, immobile dry storage containers, and dry storage in shipping containers are evaluated for each shipyard and prototype location. Under the No Action alternative, naval spent nuclear fuel would be stored in shipping containers. For the other alternatives where naval spent nuclear fuel would be stored at shipyard and prototype sites, the storage mode would be selected by the Record of Decision. Attachment C has addressed the generic safety of water pool and dry storage and concluded that both methods would be suitable for the interim storage of naval spent nuclear fuel with very little environmental impact. This attachment addresses the design requirements, operational considerations, costs, and land requirements for the Puget Sound Naval Shipyard, Pearl Harbor Naval Shipyard, Norfolk Naval Shipyard, Portsmouth Naval Shipyard, and the Kesselring Site.

The interim storage facilities for naval spent nuclear fuel at shipyards and prototype locations would be designed to comply with applicable requirements. The storage facilities would be monitored and maintained in compliance with Naval Reactors Program requirements for radiation protection of workers and the public and the environment. Specifically, exposure to workers at the storage site would be maintained as low as reasonably achievable and would be controlled to Naval Reactors Program radiation exposure standards. As with current naval practices, no measurable increase in radiation levels at the site boundary would result from the storage of naval spent nuclear fuel at any alternate site.

D.1.2 Shipping Containers

D.1.2.1 Container Design Features. Shipping containers and immobile dry storage containers position the spent naval fuel modules within sealed structures designed to physically constrain, support, and remove residual heat from the fuel in an environment that prevents corrosion of the fuel. The massive size of the containers provides not only strength, but also shielding against exposure to radiation from the spent fuel within.

The shipping containers might be M-140 shipping containers with long-lived seals suitable for storage of spent nuclear fuel for the duration of the period covered by this Environmental Impact Statement (EIS). A description of the M-140 shipping container is provided in Attachment A. This container is already certified to meet the requirements of the U.S. Nuclear Regulatory Commission, contained in 10CFR71, for the transportation of naval spent nuclear fuel. With installation of a long-lived seal, the M-140 container could be qualified for storage for 40 years. The shipping containers could either be positioned on railcars at the storage site or on concrete pads. The process of designing the shipping container long-lived seal would commence with the Record of Decision if this option were selected. The cost associated with the design and recertification of the shipping container would range from approximately $1 million to $5 million. The cost to manufacture each shipping container would be about $5 million. Some uncertainties in estimated costs exist due to the fact that a detailed design for the shipping container long-lived seal is not yet available.

If the Record of Decision were to choose shipping containers, a more detailed evaluation would need to be performed to determine whether it is more appropriate to modify the M-140 shipping container design or whether a new container design should be used. Since the M-140 was designed as a shipping container, the modifications that would need to be made to convert an M-140 to accommodate interim storage might involve substantial new design work and recertification for shipping.

About 500 additional containers with holding capacity equivalent to the M-140 container would need to be fabricated to cover the projected reactor servicing from 1995 through 2035. If an alternative using the shipping containers were to be chosen, an expanded manufacturing vendor base would need to be developed to meet the projected container requirements. With the current manufacturing capabilities, 3 years are required to build an M-140 container and the output capacity is about 6 containers per year.

The shipping containers loaded during the period preceding the Record of Decision would also need to be modified to meet the storage container design criteria. An evaluation would be performed to determine whether these modifications could be safely made with spent nuclear fuel present in the containers. In the event that the spent nuclear fuel must be removed from the shipping containers, the containers would be unloaded and the spent nuclear fuel would be transferred into modified shipping containers at a suitable facility under controls which would protect workers, the public, and the environment. The unloading of spent nuclear fuel from the original shipping containers and reloading into modified shipping containers would introduce additional spent nuclear fuel handling, transportation, and risks.

D.1.2.2 Operations. The process of loading spent nuclear fuel into shipping containers for storage would be similar to that used for loading M-140 shipping containers. During reactor refueling operations, spent nuclear fuel is normally loaded into M-140 shipping containers that are filled with water. The spent nuclear fuel is staged in this configuration for sufficient time to ensure that heat produced by radioactive decay of fission products is adequately dissipated. When the water is removed from the M-140 container, the loaded M-140 can be shipped. After water is drained from the shipping container, it would be transported to the storage site. The water is processed for reuse. The transportation procedures would be essentially unchanged from current procedures except that containers would be moved to the interim storage site instead of being shipped to the Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL) for inspection. For railcar storage, the railcar would be positioned in the storage area. For cases where the shipping container is stored on a concrete pad, the container would be off-loaded from the railcar or truck, positioned, and then secured to the pad (if securing would be required). In order to accomplish this transfer, a large capacity crane would be needed at each site, and the site would need to be prepared as necessary to accommodate the mode of storage.

D.1.3 Immobile Dry Storage Containers

D.1.3.1 Container Design Features. There are currently no immobile dry storage containers designed for interim storage of naval spent nuclear fuel. The container design would be similar to that of containers which are presently certified by the Nuclear Regulatory Commission for storage of spent nuclear fuel from commercial reactors. The design, approval, and construction of an immobile dry storage container would commence with the Record of Decision if this option were selected. This effort could require up to 5 years to complete.. The cost associated with the design and approval of the immobile storage container would be about $2 million. The cost to construct each immobile dry storage container would be about $2 million. These estimates are based on costs of commercially available containers with contingencies added to account for additional design features that may be required.

Two concepts for storing naval spent nuclear fuel in immobile dry storage containers have been developed in order to provide a baseline for assessing the impacts. Other dry storage approaches (such as dry storage vaults) exist and would be considered in more detail if the Record of Decision were to choose the immobile dry container storage alternative. The first approach (referred to as the minimum fuel loading concept) is based on the number of spent fuel assemblies stored in the immobile dry storage container being about the same as that which is loaded into M-140 shipping containers. This approach results in the need for about 500 immobile dry storage containers. The second approach (referred to as the maximum fuel loading concept) maximizes the number of fuel assemblies that would be stored in the immobile dry storage containers. The number of containers required for the second approach is about 300.

The minimum fuel loading concept results in a container with a comparatively simpler design, less maintenance, and lower unit costs (~$1.9 million/container). Under the maximum fuel loading concept, the container would need to be equipped with additional active cooling features such as water circulation to ensure that the heat produced by radioactive decay of fission products is adequately removed. These additional cooling features would be needed for a period of several years after the spent nuclear fuel is removed from the reactor vessel. For the minimum fuel loading concept, additional active cooling features such as recirculating water would not be required to remove heat. As with the shipping containers, an expanded vendor base would be necessary in order to construct the immobile dry storage containers at the rate they would be needed.

Figures D-1 and D-2 provide conceptual layouts of candidate immobile dry storage containers for naval spent nuclear fuel.

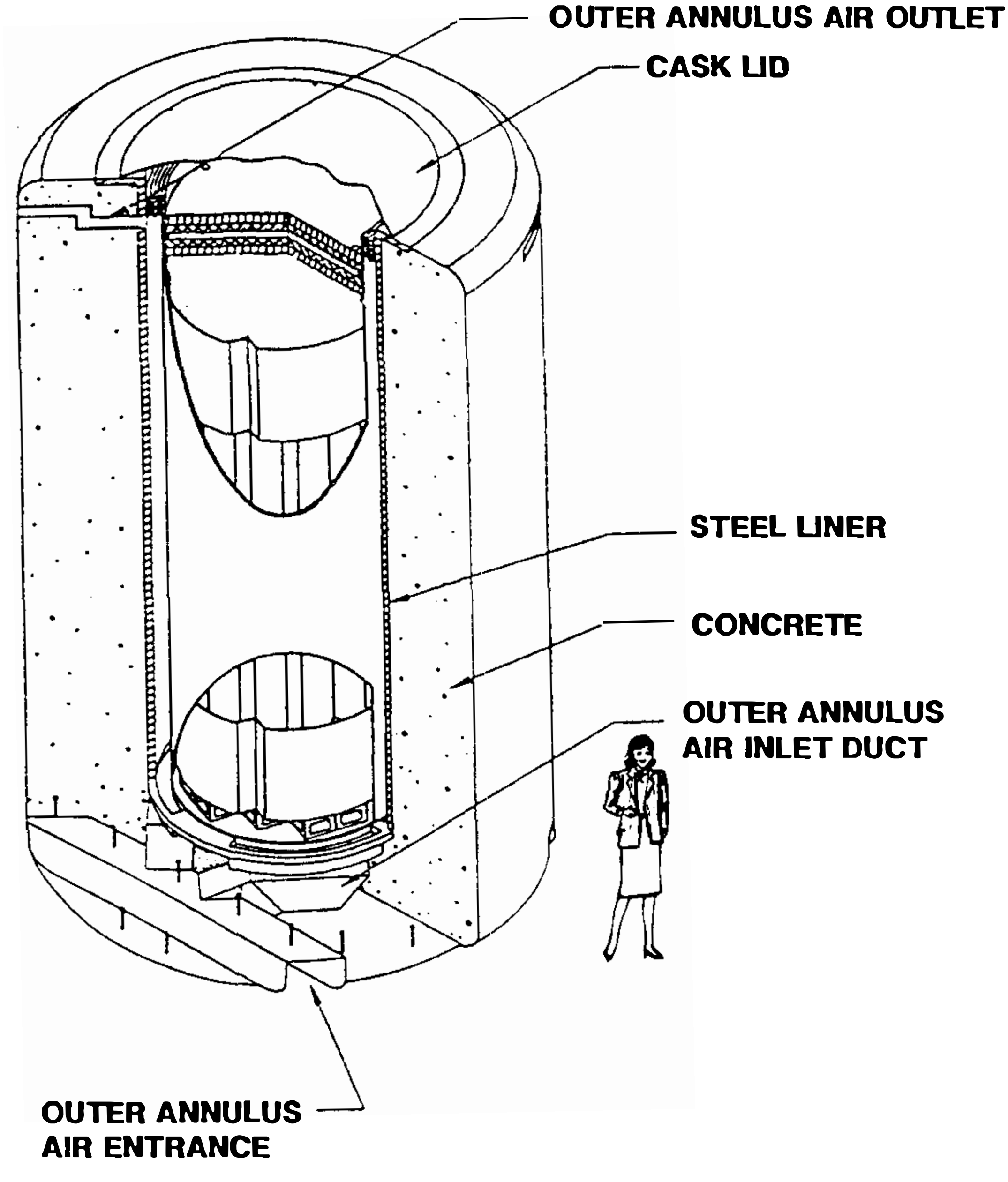

Figure D-1. Conceptual concrete immobile dry storage container for naval spent nuclear fuel.

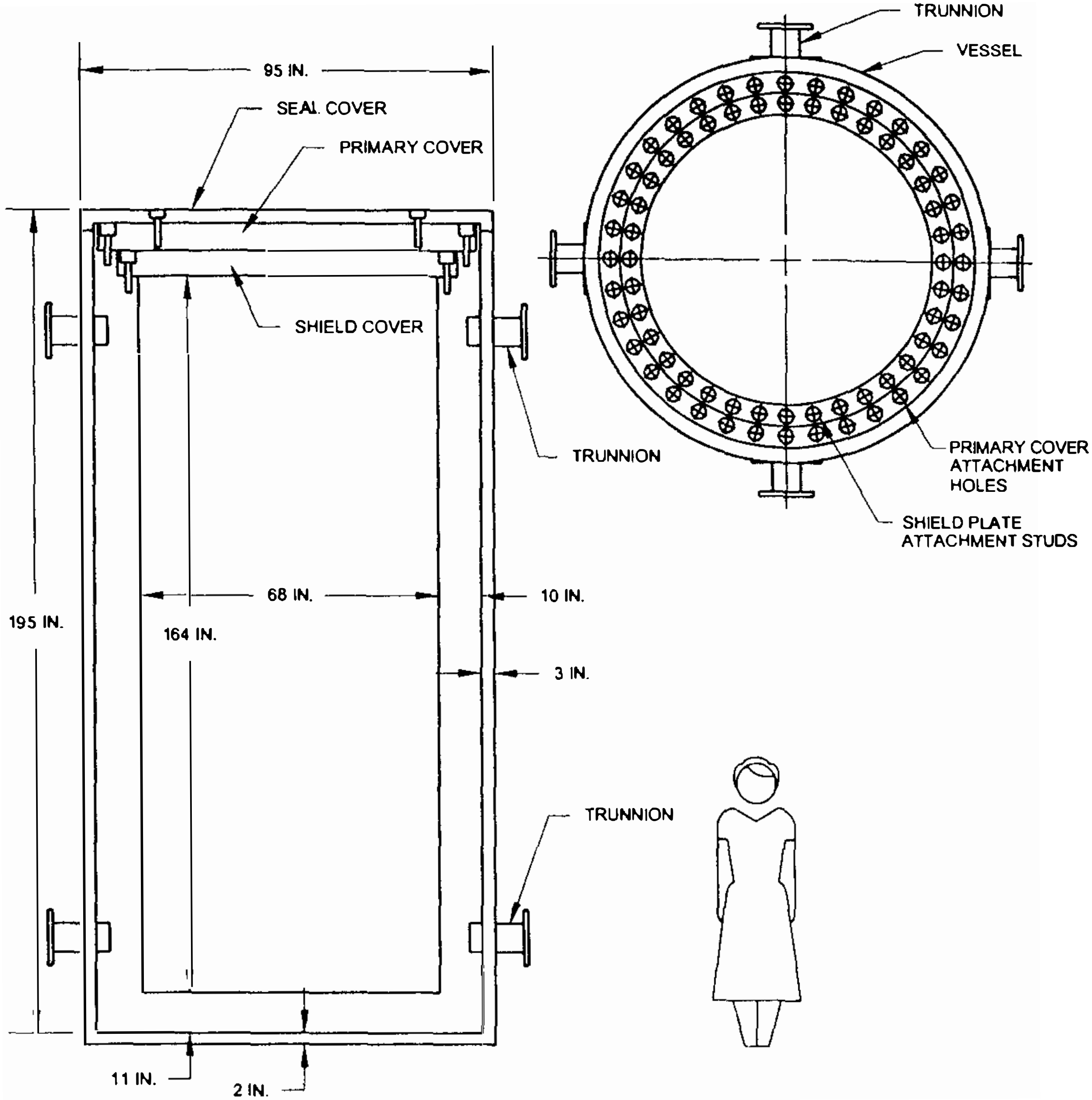

Figure D-2. Conceptual vertical metal immobile dry storage container for naval spent nuclear fuel.

The dimensions of the immobile dry storage container that would be used for naval spent nuclear fuel would be approximately the same as the M-140 shipping container (i.e., approximately 10 to 16 feet high and 8 to 10 feet wide). The fuel spacing within the container and the container itself would be designed to prevent any nuclear chain reaction, to ensure that decay heat is adequately dissipated, and to ensure that the spent fuel would be protected from hazards associated with natural phenomena or human activities for each storage site.

D.1.3.2 Operations. Operations commence following the defueling of the reactor, after fuel modules are in a suitable holding container such as an M-130 or M-140 shipping container. The immobile dry storage container would be positioned at the storage location. Transfer of a spent fuel module from the holding container to the dry storage container would be accomplished one fuel module at a time using a shielded transfer container. All fuel transfers would be conducted in strict accordance with procedures which would have been written, reviewed, and approved by personnel trained, qualified, and specifically authorized to perform such work. The transfer container would be landed on the holding container, and a module would be withdrawn from the holding container. The module would be secured and the loaded transfer container closed, moved into position over the dry storage container, and landed. The transfer container would be reopened and the module lowered and seated in the immobile storage container. The transfer container would then be removed. This process would be repeated until the container is filled with spent fuel modules. The container would then be sealed.

Transfers of spent nuclear fuel to the immobile dry storage container would be conducted in accordance with Naval Reactors Program requirements for radiation protection. Radiological containment devices would be used where necessary to prevent radioactivity from spreading to the workplace and from becoming airborne. The transfer and storage containers would contain radiation shielding that minimizes radiation exposure to the workers during transfer and storage operations and ensures that radiation levels at the site perimeter are indistinguishable from natural background.

D.1.4 Water Pool Storage

D.1.4.1 Water Pool Design Features. If the Record of Decision were to choose the alternative of storing naval spent nuclear fuel in water pools, five water pools could be constructed, one at each designated storage site. Each water pool facility would be designed, built, and operated in accordance with DOE Order 6430.1A and consistent with the intent of Nuclear Regulatory Commission requirements in 10CFR72 and associated Regulatory Guides. The siting, design, construction, and approval of a water pool storage facility would commence with the Record of Decision and could take 6 to 9 years to complete. The design and construction of each water pool facility would also conform with local construction standards for each site.

Water pools operate by holding spent fuel modules in a deep pool of water. The water provides cooling for the spent fuel, a transparent medium for work activities, and protection from radiation (see Attachment C). The structural materials of the fuel modules and naval fuel cladding, as well as temperature and chemistry control of the water, would result in the spent fuel being highly resistant to corrosion. Corrosion-resistant racks below the water surface would be used to support and position the fuel modules in place for handling and to prevent a critical mass being formed. The water depth would be sufficient to provide shielding to protect workers and the environment during module movement and storage.

D.1.4.2 Operations. The naval spent nuclear fuel would be transferred to the water pool in a suitable container, such as an M-130 or M-140 shipping container. The fuel modules would then be transferred into the water pool using equipment and procedures that are similar to well-proven procedures used at ECF for unloading spent nuclear fuel from shipping containers. The spent nuclear fuel modules would be individually lowered and secured in the storage racks located on the water pool floor. The use of a water pool for storage of naval spent nuclear fuel would provide an opportunity for limited visual inspection of the exterior of the fuel modules after removing them from the naval vessels. This opportunity would not exist to the same extent for the dry storage container alternatives.

D.1.5 Design Basis Considerations for Storage Containers and Water Pools

The design of both the shipping and immobile dry storage containers would be in accordance with DOE Order 6430.1A and consistent with the intent of Nuclear Regulatory Commission requirements for independent spent fuel storage installations found in 10CFR72 and associated Regulatory Guides. Attachment F describes the exposures which would be expected during normal operational exposures and the exposures calculated for hypothetical accidents that might occur during interim storage of spent fuel at each shipyard and prototype location. The accidents that would be used to establish the requirements for the design of the interim storage facilities are discussed below.

D.1.5.1 Design Basis Considerations for Storage Containers.

(1) **Natural Phenomena.** The fuel spacing within the container and the container itself would be designed to prevent a nuclear criticality, to ensure that heat produced by radioactive decay of fission products is adequately dissipated, and to ensure that the container would safely survive hazards associated with natural phenomena such as storms or flooding for each storage site. The shipping containers and the immobile dry storage containers would be designed to withstand the most severe design basis seismic event expected for the storage sites. The seismic analysis would evaluate the internal and external structures of the containers and the components associated with stability of the containers. The containers and associated components would be designed to protect the environment during other natural phenomena such as tornado winds, tornado missiles, hurricanes, volcanic activity, design basis floods, and very large waves. If the Record of Decision involves the need for new facilities for the interim storage of naval spent nuclear fuel, detailed site-specific seismic evaluations would be conducted for those sites, and the results would be incorporated into the design of new facilities. The construction of any new facilities for naval spent nuclear fuel management would meet strict seismic standards for the interim storage of naval spent nuclear fuel. The design and construction of these facilities to seismic standards which take into consideration the seismic character of the area would ensure that structures could withstand a major seismic event. The adequacy of the storage facility would be documented in a safety assessment report for each location.

(2) **Man-made Hazards.** The containers would be arranged to allow access for routine inspections, maintenance, and emergencies. This includes sufficient accessibility for pressure, temperature, and radiological monitoring as well as for fire fighting equipment and ambulances.

The containers would be designed to withstand a fire without losing fission product containment. Flammable liquids and gases as well as explosive materials would be prohibited in the storage area with the exception of fuel in motor vehicles needed to support operations. Combustible materials such as wood, paper, and plastic would be kept to a minimum in the spent nuclear fuel storage areas.

The fuel spacing within the container and the container itself would be designed to prevent nuclear criticality, to ensure that the heat produced by radioactive decay is adequately dissipated, and to ensure that it would safely survive credible man-made accidents for each storage site. Other man-made hazards such as truck accidents, airplane crashes, and objects dropped by cranes would also be addressed in the safety assessment report.

D.1.5.2 Design Basis Considerations for Water Pools.

(1) **Natural Phenomena.** The spent nuclear fuel spacing within the water pool and the water pool itself and the building support structures would be designed to prevent criticality, to ensure that heat produced by radioactive decay is adequately dissipated, and to ensure that it would protect the fuel from the hazards associated with the design basis natural phenomena for each storage site (i.e., seismic, tornados, missiles generated by a tornado, hurricanes, volcanic activity, maximum expected floods, and very large waves). The water pools would be equipped with spent fuel storage racks for restraining the modules. The racks would be designed to safely survive the above hazards. If the Record of Decision involves the need for new facilities for the interim storage of naval spent nuclear fuel, detailed site-specific seismic evaluations would be conducted for those sites, and the results would be incorporated into the design of new facilities. The construction of any new facilities for naval spent nuclear fuel management would meet strict seismic standards for the interim storage of naval spent nuclear fuel. The design and construction of these facilities to seismic standards which take into consideration the

seismic character of the area would ensure that structures could withstand a major seismic event. The adequacy of the water pool facility would be documented in a safety assessment report for each location.

(2) **Man-made Hazards.** The water pool facility would be designed to withstand fire without damage to the spent fuel within the water. Flammable liquids and gases as well as explosive materials would be prohibited in the vicinity of the storage area with the exception of incidental quantities of flammable solvents necessary to support operations. Combustible materials such as wood, paper, and plastic would be kept to a minimum in the water pool facility.

The fuel spacing within the water pool would be designed to prevent criticality, and to ensure that it would safely survive credible man-made accidents for each storage site. Other man-made hazards such as truck accidents, airplane crashes, and crane drop accidents would also be addressed in the safety assessment report.

D.1.6 Shipyard and Prototype Locations

This section describes conceptual locations at the shipyard and prototype sites where storage facilities could be located to service refuelings and defuelings of naval ships. This section also lists land requirements for each storage method at each location, the construction cost for each method, and the associated operating cost.

D.1.6.1 Land Requirements. This section provides a summary of the land required for each of the storage methods at each of the locations where refueling and defueling are planned from 1995 through 2035.

These locations are the Portsmouth Naval Shipyard, the Puget Sound Naval Shipyard, the Pearl Harbor Naval Shipyard, the Norfolk Naval Shipyard, and the Kesselring Site. A map of each of these sites is provided in Figures D-3 through D-7, indicating a possible storage location at each of these facilities.

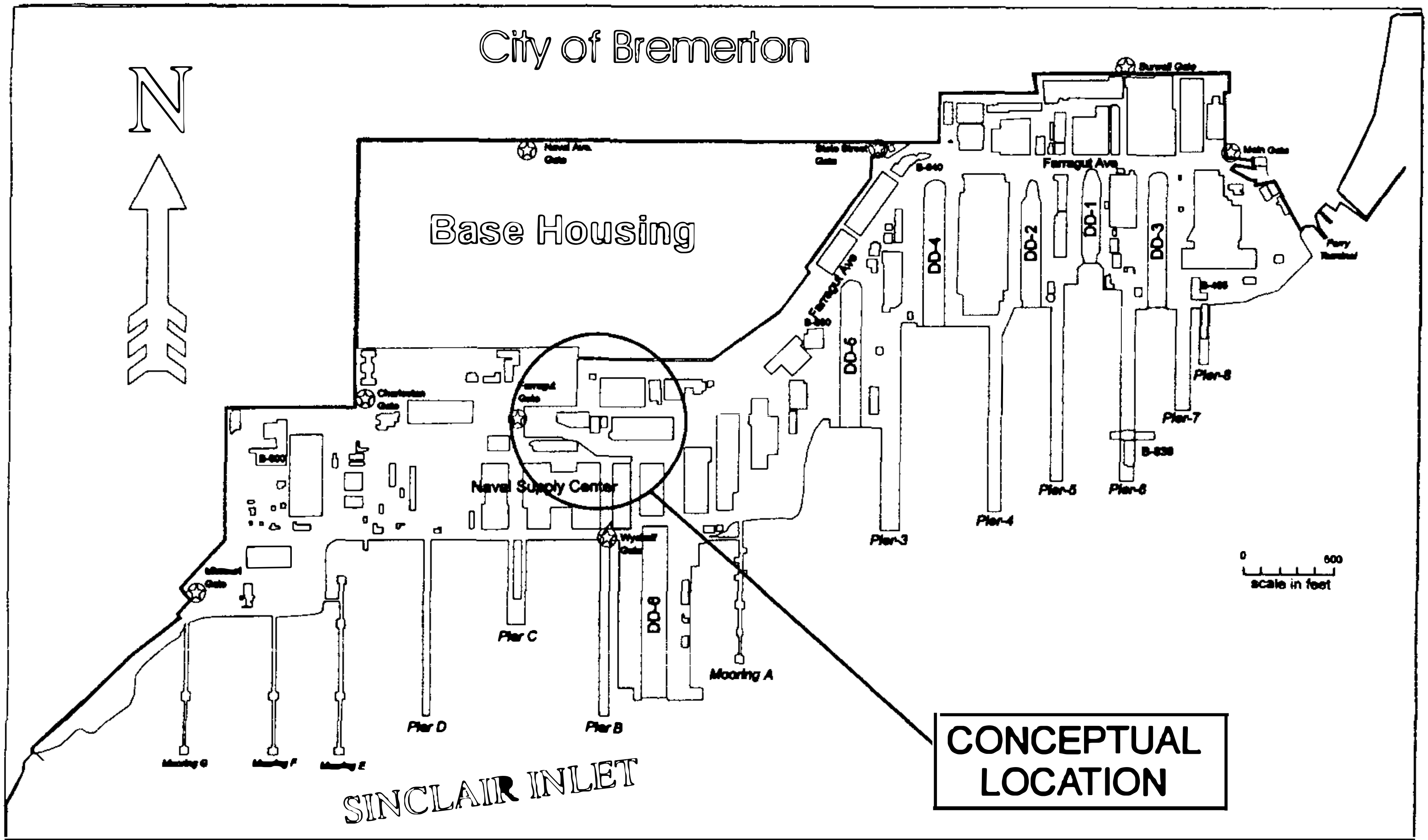

Figure D-3. Conceptual location of the interim storage site at Puget Sound Naval Shipyard.

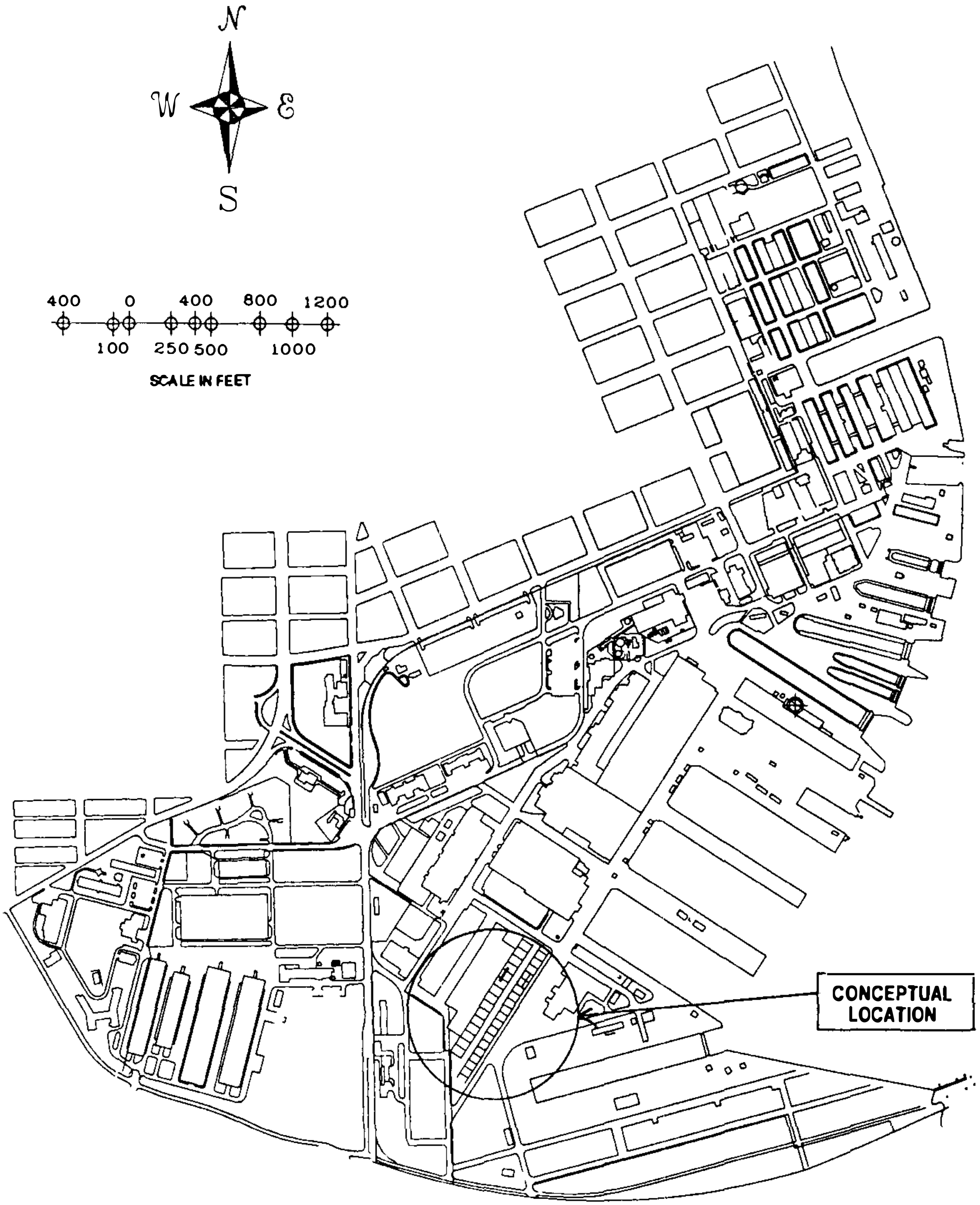

Figure D-4. Conceptual location of the interim storage site at Norfolk Naval Shipyard.

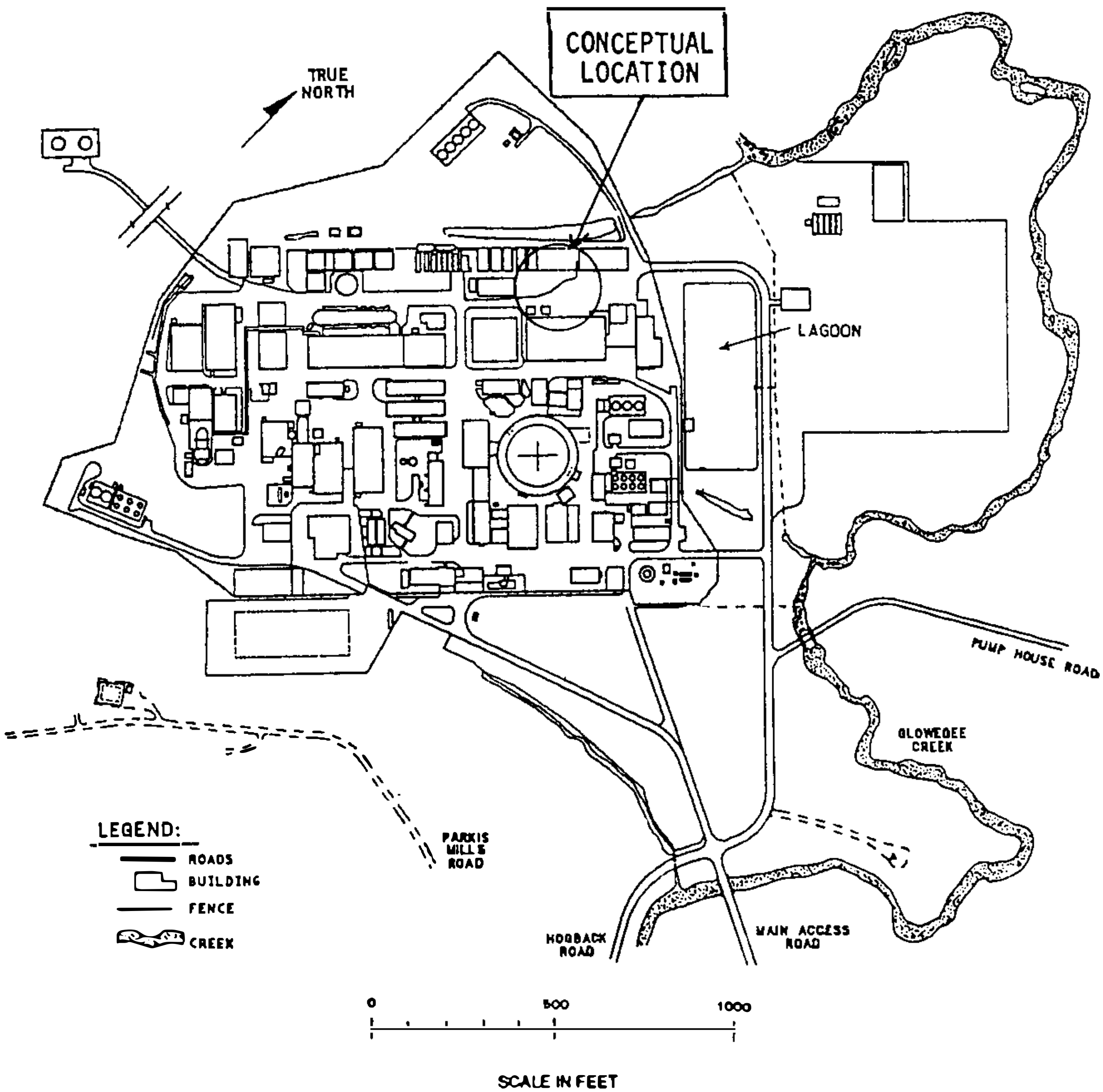

Figure D-5. Conceptual location of the interim storage site at Kesselring Prototype Site.

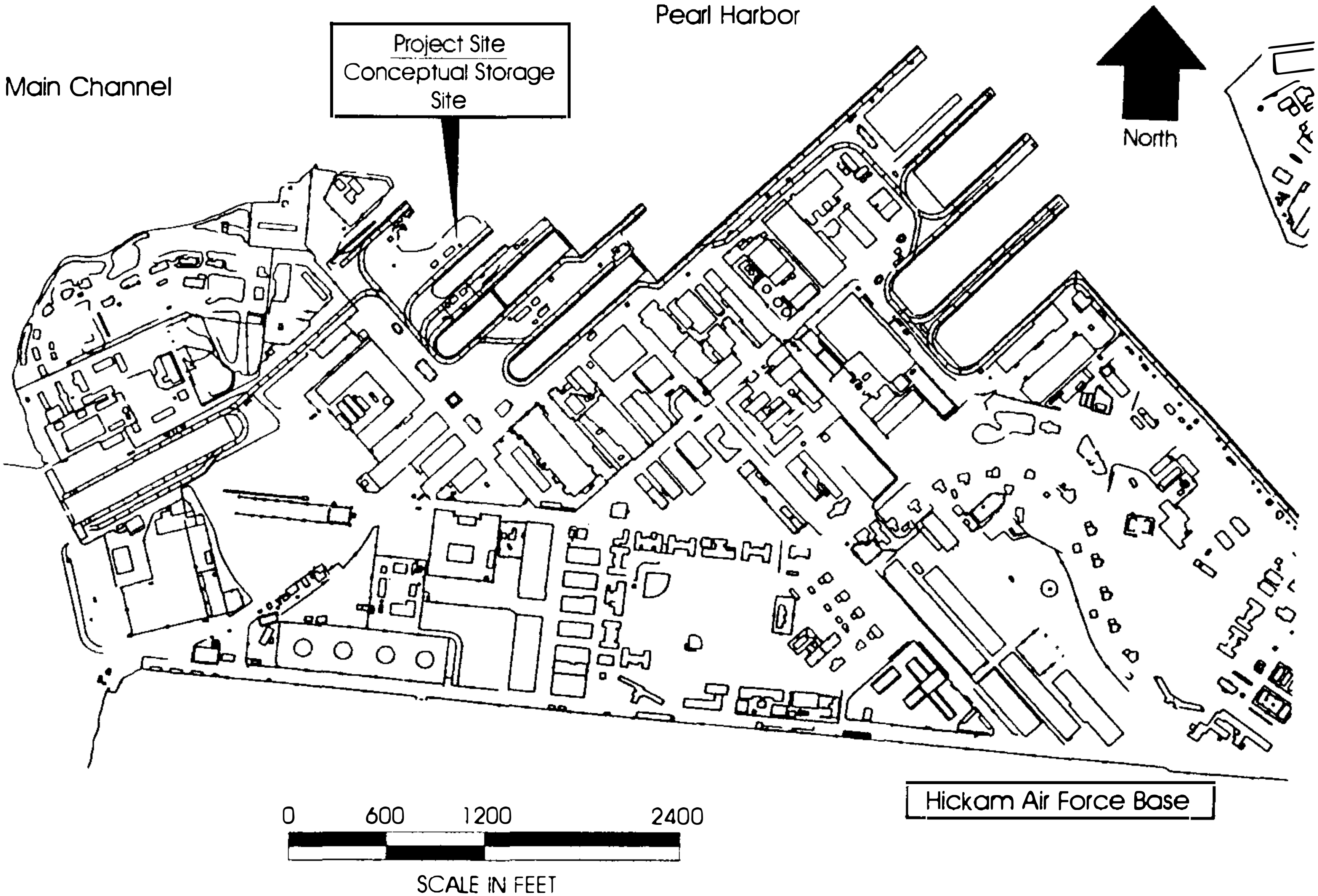

Figure D-6. Conceptual location of the interim storage site at Pearl Harbor Naval Shipyard.

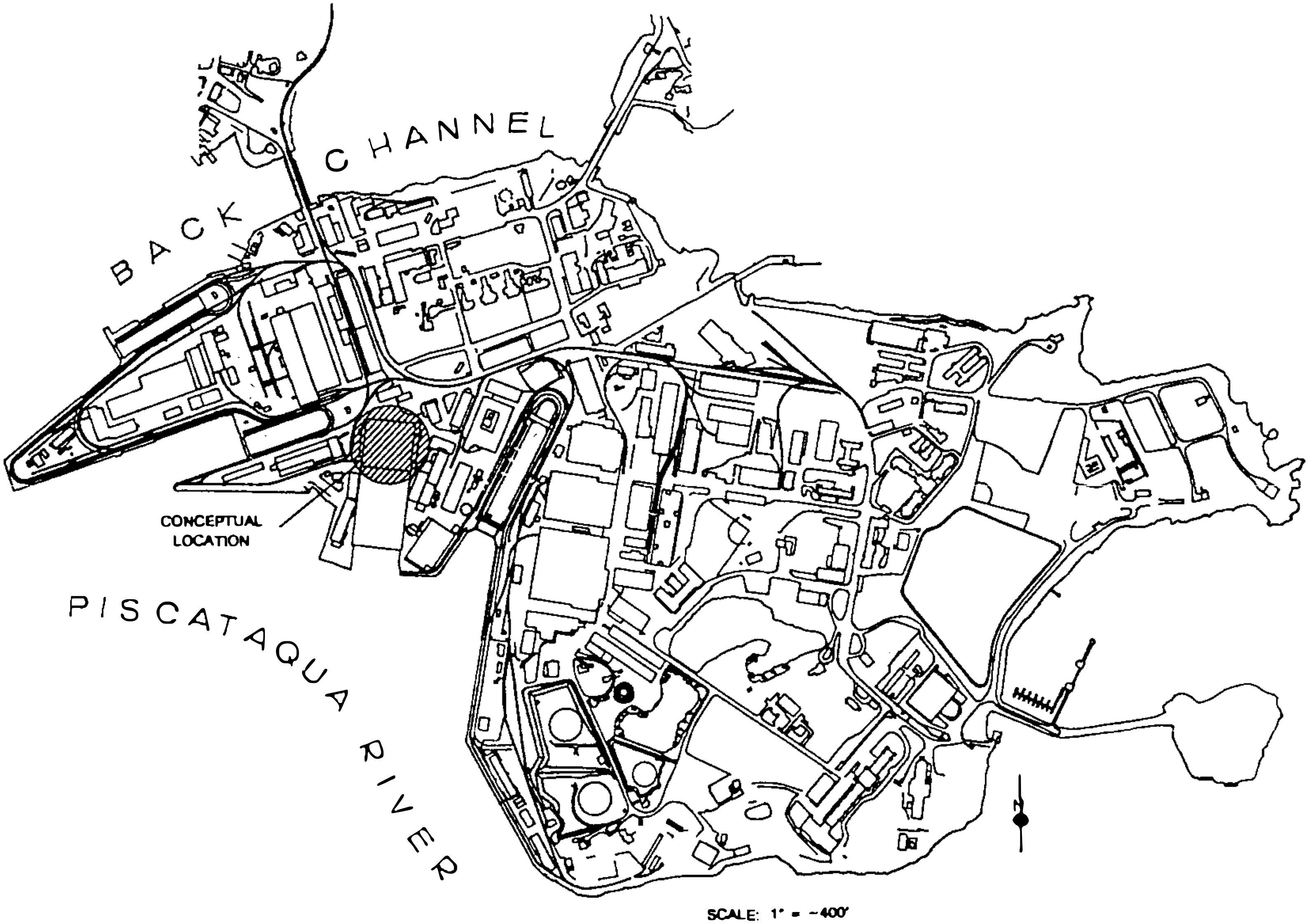

Figure D-7. Conceptual location of the interim storage site at Portsmouth Naval Shipyard.

Table D-1 provides a summary of the amount of land needed for each of the storage methods at each of the locations where storage of naval spent nuclear fuel could be located. It should be noted that the number of containers and land required could be slightly less than identified in Table D-1 as a result of actions taken during the transition period. As shown in Table D-1, storage utilizing shipping containers on railcars would typically require dedication of the most land.

Table D-1. Square feet of land required for storage facility.

Location	Number of Immobile Dry Storage Containers[1]	Number of Shipping Containers	Immobile Dry Storage Containers[2] (ft^2)	Shipping Containers on Concrete Pad[3] (ft^2)	Shipping Containers on Railcars (ft^2)	Water Pool Facility[4] (ft^2)
Portsmouth	27-51	61	10,000-19,000	18,000	72,000	20,000
Puget Sound	153-206	219	57,000-77,000	64,000	260,000	33,000
Pearl Harbor	21-30	42	8,000-11,000	12,000	50,000	20,000
Norfolk	132-219	247	49,000-82,000	72,000	293,000	31,000
Kesselring	5-6	6	1,900-2,000	1,700	7,100	17,000

(1) Range in required number of containers is due to options in conceptual design (see Section D.1.3.1).
(2) The immobile dry storage arrangement uses the containers stored on a concrete pad in double rows with one container diameter separation between adjacent containers. Each row is separated by a 15-foot wide accessway. Range in required land area is due to options in conceptual design.
(3) The shipping container arrangement uses the containers stored on a concrete pad in double rows with 4 feet between adjacent containers. Each row is separated by a 15-foot wide accessway.
(4) The water pool facility consists of a building that contains adequate space to house supporting equipment and facilities (approximately 17,000 ft^2) and a water pool with adjacent work areas of sufficient size to accommodate the amount of spent nuclear fuel expected to be stored in the facility until 2035.

D.1.6.2 Site Construction, Container, and Operating Costs. This section provides estimated costs associated with each alternative for storing spent nuclear fuel at the shipyard and prototype sites. The major cost factors include facility construction or site preparation costs, container costs, and operating costs over the lifetime of the facility. Cost estimates are based on 1995 dollars.

Table D-2 provides a summary of the estimated construction costs for each storage option at each shipyard and prototype location. The construction costs for immobile and shipping containers on concrete pads and shipping containers on railcars include estimated costs for concrete (labor and materials), rails (for railcars), or cranes for lifting and handling containers or fuel transfer containers (for concrete pad storage). The majority of the construction costs for concrete pad storage options

Table D-2. Estimated site construction costs (millions of dollars).

Location	Immobile Dry Storage Containers on Concrete Pad	Shipping Containers on Concrete Pad	Shipping Containers on Railcars	Construction and Installation of Water Pools
Portsmouth	11-12	10	2	96
Puget Sound	15-16	13	5	141
Pearl Harbor	10-11	9	1	95
Norfolk	14-17	14	6	135
Kesselring	10	8	1[1]	89
Total	60-66	54	15	556

[1]Estimate does not include costs associated with establishing railroad extension from the access railroad to the storage site.

are associated with the need for a high-capacity crane. Water pool construction costs include estimates of costs for construction of the water pool, building structure, and associated support equipment. The table shows that construction costs for a water pool facility exceed those of other alternatives, and that shipping containers on railcars involves the lowest construction costs. However, the water pool facility construction costs represent a complete facility ready to hold spent nuclear fuel for interim storage. The construction costs in Table D-2 for the other storage modes represent completed site construction without the cost of the containers (see Table D-3) to hold the spent nuclear fuel.

Table D-3 provides a summary of the estimated costs to build shipping containers and immobile dry storage containers through 2035. The table shows that the immobile dry storage containers are the least expensive containers, and that the cost to build shipping containers to rest on concrete pads is slightly lower than to rest on railcars. The difference in cost between the two shipping container options is due to the cost of a dedicated railcar during storage. The shipping container costs in Table D-3 would be reduced by about 13 percent due to actions taken during the transition period (these actions are described in Section 3.8) to ship containers from the shipyards to ECF. Consequently, the total costs for shipping containers on concrete pads and shipping containers on railcars considering the transition period would be about 2615 and 2760 million dollars, respectively.

Table D-3. Estimated container cost (millions of dollars).

Location	Immobile Dry Storage Containers on Concrete Pad[1]	Shipping Containers on Concrete Pad	Shipping Containers on Railcars[2]
Portsmouth	55-100	319	337
Puget Sound	314-406	1145	1209
Pearl Harbor	43-59	220	232
Norfolk	271-431	1292	1363
Kesselring	10-12	31	33
Total	693-1008	3007	3174

[1]Range in container costs due to options in conceptual designs (see Sections D.1.2.1 and D.1.3.1). The lower end of the range represents container costs for the maximum fuel loading option (which requires fewer containers).

[2]Includes the cost of an equal number of railcars and containers required for this option.

Table D-4 provides the estimated costs to operate a naval spent nuclear fuel storage area. The operating costs include estimates of cost for personnel to monitor the facility, handle the spent nuclear fuel when it arrives at the facility, and maintain the facility. These estimates do not include the costs associated with eventual preparation of spent fuel for shipment to a site for disposition. Disposition preparation costs cannot be estimated at this time because the method for preparing the spent fuel has not been defined. Table D-4 shows that the lowest operating costs are associated with shipping containers on concrete pads and that water pool storage requires the highest operating costs.

Table D-4. Estimated operating costs through the year 2035 (millions of dollars).

Location	Immobile Dry Storage Containers on Concrete Pad	Shipping Containers on Concrete Pad	Shipping Containers on Railcars[2]	Water Pool
Portsmouth	11	3	8	180
Puget Sound	23	4	24	206
Pearl Harbor	11	3	6	180
Norfolk	21	4	27	206
Kesselring	9	2	3	124
Total	75	16	68	896[1]

[1]For comparison, the estimated operating cost (personnel to monitor and handle fuel and maintain the facility) for the ICPP Building 666 for the same period is 232 million dollars.

[2]Includes cost to replace or refurbish railcar after prolonged storage.

D.1.6.3 Total Construction and Operating Costs. Table D-5 is a compilation of the data contained in Tables D-1 through D-4, and calculated based on the entire 40-year period from the Record of Decision (1995 through 2035). This table shows that the total costs associated with the use of immobile dry storage containers are the lowest of all the storage options considered except for storage at Puget Sound and Norfolk where the largest amounts of spent fuel would be stored. In these cases, the total costs for using water pool storage are within the same range of approximation as immobile dry container storage.

Table D-5. Total costs through the year 2035 (millions of dollars).

Location	Immobile Dry Storage Containers on Concrete Pad[(1)]	Shipping Containers on Concrete Pad	Shipping Containers on Railcars	Water Pool
Portsmouth	77-123	332	347	276
Puget Sound	352-445	1162	1238	347
Pearl Harbor	64-81	232	239	275
Norfolk	306-469	1310	1396	341
Kesselring	29-31	41	37	213
Total Cost	828-1149	3077	3257	1452

[(1)]Range in total costs due to options in conceptual design (see Section D.1.3.1). The lower cost is associated with the maximum loading concept.

D.1.7 Time Required to Implement Each Storage Method

If the Record of Decision were to choose one of the alternatives involving storage of naval spent nuclear fuel at shipyards and prototype sites, some period of time would be required after the decision to fully implement the selected storage alternative. This section examines the time required to implement each storage method.

D.1.7.1 Container Storage. Implementation of the alternatives involving use of immobile dry storage containers and shipping containers could be viewed as a three-phase process. The first phase would cover the time required to design the container or container modification, to review and accept the design, to approve the container, to establish contracts for container fabrication, and fabricate the first container. During this phase, the shipyards and prototype sites where the containers would be stored would also construct or modify the container storage location as appropriate for the alternative chosen. For immobile dry storage containers, this phase would take about 5 years, if 2 years are required to design and accept the container design, 1 year is needed for approval of the container, and 2 years are required to build the container. For containers designed for both storage and shipping, this process would take about 5 years, based on 1 year to design the modifications, 1 year to approve the container, and 3 years to build the container.

The second phase would involve establishing funding. This will take approximately 3 years to complete. The third phase of the implementation period would involve fabrication of the remaining required containers. The estimate of the number of containers is based on the projected schedule for naval vessel refuelings and current estimates of the amount of spent nuclear fuel that would be placed into the containers. Although production rates for immobile dry storage containers and shipping containers are unknown, they can be approximated from existing production rates for M-140 shipping containers. With current manufacturing capabilities, 3 years are required to build an M-140 container, and the manufacturing capacity is about six containers per year. This production rate would need to be accelerated to 18 to 24 containers per year by increasing the number of manufacturers and by making fabrication process improvements. If the production rate of immobile dry storage containers and shipping containers is the same as that of M-140 containers and production rates can be increased as noted above, the supply of immobile dry storage or shipping containers would meet the demand for these containers at some point after the first several years. During the transition period, when an insufficient number of containers would be available to store all the spent fuel planned to be removed from U.S. Navy nuclear-powered vessels, some other means of storing naval spent nuclear fuel would be needed. As described in Section 3.8 of this EIS, it is expected that a transition period of 3 years of shipping followed by 3 years of allowing naval spent nuclear fuel to be stored in shipping containers at shipyards would provide the necessary storage space.

D.1.7.2 Water Pool Storage. If 6 to 9 years would be required to design, approve, and construct a water pool facility and this process would be initiated for each location within a year after the Record of Decision, water pools would be available for storage of naval spent nuclear fuel about 7 to 10 years following the Record of Decision. During the transition period, when water pools would be under construction at selected locations, some other means of spent nuclear fuel storage would be needed, such as the method described in Section 3.8.

D.1.8 Summary

Table D-6 summarizes the major advantages and disadvantages of the spent nuclear fuel storage alternatives previously discussed in this attachment.

Table D-6. Comparison of naval spent nuclear fuel storage alternatives.

Storage Mode	Advantages	Disadvantages
1. Shipping Container		
A. Storage on Railcars	1. Least amount of container handling after arrival at storage location.	1. Railcars must be refurbished or replaced after prolonged storage.
	2. Eliminates the need to remove spent fuel modules from the transfer container upon arrival at the storage site.	2. Requires the largest land area of the storage options, except for Kesselring.
		3. Shipping containers are more expensive than immobile dry storage containers and water pools (water pools cost more when small fuel quantities are stored such as at Kesselring).
B. Storage on Concrete Pads	1. Eliminates the need to remove spent fuel modules from the transfer container upon arrival at the storage site.	1. More container handling required compared to railcar storage option (if containers will not need to be removed from railcar).
	2. Concrete pads are less expensive than railcar storage if railcars must be replaced or refurbished.	2. Higher total cost than immobile dry storage containers and water pools* (*when large quantities of fuel are stored).

Table D-6 (Cont).

Storage Mode	Advantages	Disadvantages
2. Immobile Dry Storage Containers	1. Lowest total costs of all the storage options.	1. The maximum fuel loading concept requires that the containers be filled with water for cooling purposes for several years after removal from the reactor. This requires additional maintenance and slightly increases risk of low-level contamination spillage during accidents. 2. Must remove spent fuel from transfer container and load it into immobile container.
3. Water Pool Storage	1. Has a lower total cost than shipping containers, except for Pearl Harbor and Kesselring which have less containers. 2. Provides opportunity for conducting visual examinations.	1. Has the highest operating costs of all the storage options. 2. Must remove spent fuel from transfer container and load into water pool.

D.2 INSPECT HIGH PRIORITY FUEL AT PUGET SOUND NAVAL SHIPYARD

D.2.1 Introduction

This section of the attachment discusses the alternative of inspecting a limited amount of naval spent nuclear fuel at Puget Sound Naval Shipyard (hereafter referred to as Puget Sound) to provide information on nuclear fuel performance for use in the development of advanced nuclear reactors. The inspections would be performed at the shipyard's existing Water Pit Facility. The limited amount of fuel inspected would be stored at Puget Sound following inspection, and all other spent fuel would be stored in a facility at or near the refueling or defueling sites until the time that permanent geologic storage becomes available.

D.2.2 Water Pit Facility Description

The Water Pit Facility is located at the west side of Dry Dock 5, within the industrial zone of Puget Sound. This zone consists of facilities involved in ship construction and repair, dry docking, and conversions. The area is bounded by Decatur Avenue on the north, the waterfront on the south, the Naval Supply Center on the west, and the main gate on the east. The Water Pit Facility is located approximately 411 meters (1350 feet) from the nearest shipyard public property boundary. Figure D-8 illustrates the layout of the Water Pit Facility.

The Water Pit Facility was originally constructed to provide the shipyard with the capability to refuel nuclear-powered aircraft carriers, with the work for the first such refueling at Puget Sound expected to commence in approximately 2006. To date, the facility water pool has been used for refueling equipment demonstrations and testing.

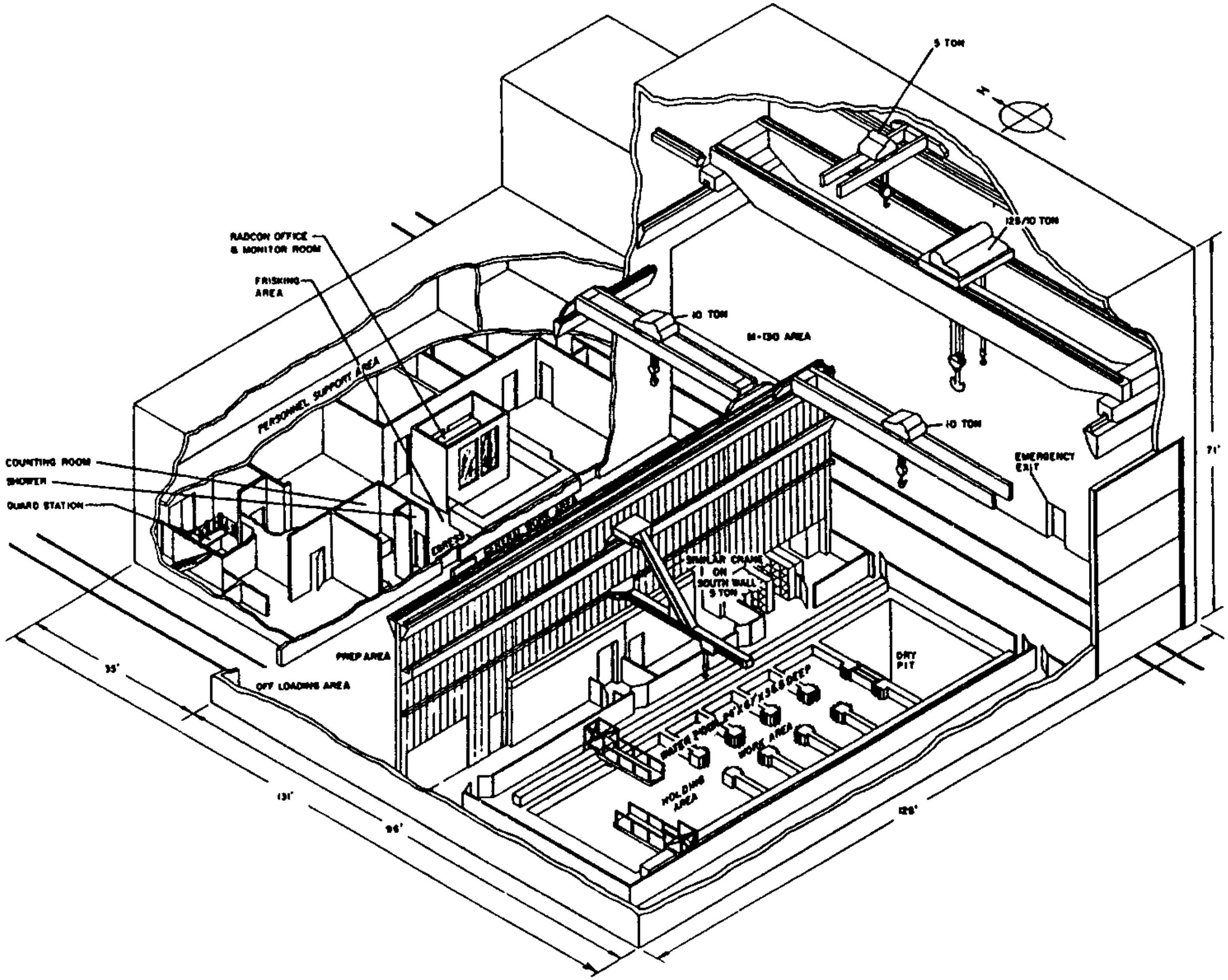

Figure D-8. Puget Sound Naval Shipyard Water Pit Facility.

The following key features of the Water Pit Facility are presented in terms of the facility's original aircraft-carrier refueling mission. Because of these design features, the facility is also considered suitable for limited naval spent fuel inspection operations.

1. A water pool for disassembly, assembly, and holding of fuel cells. The layout of the water pool is described below.

2. A work area for unpackaging, inspection, and preparation of new fuel clusters and associated equipment

3. An area for loading of shipping containers

4. A general use work area to support miscellaneous refueling support operations.

The Water Pit Facility is divided into two distinctive structures. The high bay structure is a radiologically controlled area containing the water pool and general work areas discussed above. This structure is designed to withstand the effects of design basis natural phenomena and of postulated failures of adjoining or adjacent structures without damage to the water pool or components in the water pool. The high bay walls are constructed of concrete to a height of 3.7 meters (12 feet) above ground level. The second structure is the Personnel Support Building which houses offices and other support areas. This structure is designed to meet the requirements of established naval facilities standardized criteria for structural design.

The water pool measures 7.3 meters (24 feet) wide x 20.4 meters (67 feet) long x 11.1 meters (36.5 feet) deep with a water depth of 10.5 meters (34.5 feet). It includes four work areas on each side of the pool at the east end to support refueling operations and a fuel holding area at the west end of the pool. Three of the four work areas are a nominal 2.1 meters (7 feet) x 2.1 meters (7 feet) and the fourth area is a nominal 2.6 meters (8.5 feet) x 2.1 meters (7 feet). The transfer aisle down the center of the pool is provided for all fuel and non-fuel movements. The water pool design includes provisions for isolation gates for each work area, for the fuel holding area, and for the dry pit. This isolation gate arrangement provides the capability to separate the various areas of the water pool if required. The dry pit, measuring 7.3 meters (24 feet) wide x 4.9 meters (16 feet) long x 11.1 meters (36.5 feet) deep, permits expansion of the water pool as needed.

D.2.3 Limited Inspection Operations

If future naval spent fuel examinations could not be accomplished at current capacity, the capacity which was available would be used to best advantage. Only naval spent nuclear fuel identified as having the greatest scientific value would be selected for detailed examination. Generally, this is spent nuclear fuel which is the first of a kind design or which has a characteristic of special interest.

Naval nuclear-powered ships would continue to be refueled and defueled at various shipyards across the country. Most of the spent fuel would be stored in a facility at or near the refueling and defueling sites until the time that permanent geologic storage becomes available. Those few fuel cells identified as high priority would be transported by railcar to Puget Sound in standard shielded shipping containers. Following its receipt in the Water Pit Facility's railcar work area, a shipping container would be prepared for fuel cell removal (dust cover removed, leveled, filled with water, containment installed, access plug removed). The fuel cells would be removed from the shipping container, one at a time, and transferred to the water pool in a shielded transfer container. The cells would be discharged into the pool and placed in the holding racks to await examination work. Upon completion of examination work, the spent fuel would be stored at Puget Sound as described in Section D.1. Storage facilities would have to be designed and certified to accommodate module sections resulting from spent fuel examinations as well as intact modules.

The following major items of water pool equipment (or equivalent) are considered necessary to support a high-priority naval spent nuclear fuel examination program. Also necessary are the relatively small and portable cameras and light sources for visual inspections. This equipment would support those spent fuel examinations currently performed in the ECF water pools at INEL as described in Section B.4.1 of Attachment B and summarized below.

EQUIPMENT ITEM	PURPOSE	FLOOR SPACE REQUIRED
Bandsaw/ Upender	Remove non-fuel structurals above & below fuel region to provide access for inspection and to rotate cells between vertical and horizontal orientations	46.4 m^2 (500 ft^2) 8.2 m x 5.6 m (27 ft x 18.5 ft)
Universal Inspection Station	Measure fuel cell dimensions	7.5 m^2 (81 ft^2) 2.7 m x 2.7 m (9 ft x 9 ft)
Vertical Inspection Gage	Trace contour of surfaces of fuel cell assemblies and control rods	16.7 m^2 (180 ft^2) 3.0 m x 5.5 m (10 ft x 18 ft)
Milling Machine	Section fuel cells into subassemblies, preassemblies, and elements for other examinations	11.1 m^2 (120 ft^2) 3.7 m x 3.0 m (12 ft x 10 ft)

Based on floor space requirements, the Water Pit Facility water pool and dry pit could not accommodate spent nuclear fuel examinations without removal of work area partition walls and without removal of the aircraft carrier refueling equipment. As a result, Puget Sound would no longer have the capability to refuel nuclear-powered aircraft carriers. Expansion of the Water Pit Facility to accommodate simultaneous refueling and examination operations is undesirable due to the proximity of other shipyard facilities.

Puget Sound does not have a shielded cell examination capability. Two options were considered for implementing such a capability:

1. Transfer fuel sections from Puget Sound to a shielded cell facility at another Naval Reactors site such as the Knolls Atomic Power Laboratory near Schenectady, New York, or the Bettis Atomic Power Laboratory near Pittsburgh, Pennsylvania. This would require additional shipments of spent fuel sections across the country. The spent fuel would be transported in shipping casks which would have to be certified for this purpose.

2. Construct shielded cells at Puget Sound. These cells would necessarily be sited some distance from the Water Pit Facility since sufficient space is not available either within the facility or adjacent to it in the industrial zone of the shipyard. In addition, a means

of transferring items for examination between the water pool and the shielded cells would have to be implemented. Shielded cask movements via truck and cart movements via underground tunnel are two possible means of transfer. This option is undesirable because it involves construction of a new facility but does not provide direct communication between the water pool and shielded cells.

Based on the above discussion, the alternative of examining a limited amount of naval spent nuclear fuel would include a full range of water pool visual and dimensional inspections at the Puget Sound Water Pit Facility and a full range of shielded cell examinations at another Naval Reactors site. This alternative would therefore include all INEL-ECF capabilities as described in Sections B.4.1 and B.4.3 of Attachment B.

D.2.4 Advantages and Disadvantages of this Alternative

Advantages

1. Portions of the naval spent nuclear fuel examination program could be moved from INEL-ECF without having to construct new facilities. A full range of water pool inspections could be accomplished at Puget Sound. A full range of shielded cell examinations could be accomplished at another Naval Reactors site.

Disadvantages

1. The small size of the water pool complicates placement of inspection equipment. As a result, the equipment would be limited in nature and would require removal of water pool work area partition walls and removal of aircraft carrier refueling equipment. As a result, Puget Sound would no longer have the capability to refuel nuclear-powered aircraft carriers.

2. Transferring items for examination between the water pool and shielded cells would involve additional spent fuel shipments across the country and would require design and certification of a container for this purpose.

D.2.5 Facility Support Systems

The systems which were intended to support the aircraft carrier refuelings will also support the limited naval spent fuel inspection efforts. These include the water pool fluid systems, the heating and ventilation systems, and the normal and emergency electrical power systems.

D.2.6 Radiation Sources

The primary sources of radiation in the Water Pit Facility would be the spent fuel and the associated irradiated components which are handled during inspection operations. Radiation results from the fission products which reside in the fuel region of the depleted clusters and are contained by the fuel cladding. The cladding around the fuel region would not be penetrated by any fuel cell cutting or sectioning operation in the Water Pit Facility. Irradiated non-fuel components are also sources of radiation, as are corrosion products which reside on all external surfaces. Handling operations could cause some of the corrosion products to become detached from the surfaces. Therefore, in addition to direct radiation, contamination must be considered in the control of radiation sources.

The water pool water is treated by the filtration and purification system to maintain the waterborne radioactivity as low as reasonably achievable, typically less than 1×10^{-6} microcurie Co-60/ml. This level of activity is below the concentration limit in 10CFR20, Attachment B, Table 2 for liquid effluents released to the general environment. The vessels and piping in the filter system then become potential radiation sources. The water must be considered a source even though its radiation level will be very low. The waterborne radioactive material causes equipment in the pools to become radiation sources, the water pool floor to become contaminated, and a radioactive scum ring to form on the walls of the water pool at the water surface. Even considering all of these sources contributing to the ambient radiation level in the water pool area, the controls which are exercised will ensure that the overall source is minimal and the occupational exposure remains as low as reasonably achievable.

There would normally be no airborne radioactivity generated by the handling of the cells in the water pool. However, very low levels of airborne activity (approximately 1×10^{-12} microcurie Co-60/ml) have been detected near the surfaces of other water pools. This level of activity is below the concentration limit in 10CFR20, Attachment B, Table 2 for airborne effluents released to the general environment. The presence of even low-level airborne contamination will eventually lead to the ventilation system ductwork and HEPA filters becoming sources of radiation. This would occur over a very long period of time and the radiation levels would be controlled to a very low level. As noted above, the controls which are exercised will ensure that the occupational exposure remains as low as reasonably achievable.

D.2.7 Radiological Protection Features

The facility is designed to protect workers and the general public from radiological risk. Controls are such that workers receive much less than the allowable limits for radiation and radioactivity. The ventilation system is designed to mitigate the consequences of an accidental release of radionuclides within the Water Pit Facility building and to limit the atmospheric release at the stack. The double-walled (reinforced concrete, stainless steel liner) water pool is designed to prevent leakage under design earthquake force loading conditions. The radioactive fluid systems will maintain zero liquid discharge to the environment during Water Pit Facility operations.

D.2.8 Estimated On-Site Dose Assessment

The occupational radiation exposure for workers performing limited spent fuel inspections in the Water Pit Facility is expected to be consistent with that of ECF workers performing similar operations at INEL. As discussed in Section 5.2.12.1, radiation exposures to ECF workers at INEL have averaged approximately 100 mrem per year. The person-rem per year for the Water Pit Facility will vary with the manning level which is dependent on the spent fuel inspection activity occurring in the facility. However, the maximum manning level is anticipated not to exceed 60 people.

D.2.9 Seismic Design

Structural loadings due to seismic activity were determined as follows. Building floor response spectra for the horizontal and vertical directions were obtained from a three-dimensional damping mass spring model of the high bay which included soil-structure interaction, subjected to a 0.35 g ground acceleration value resulting from the seismic design analysis. The high bay superstructure and substructure were analyzed using the floor response spectra in separate finite element computer models. The superstructure model was subjected to structural loads which included a 113.5-metric ton (125-ton) load lifted by the large overhead crane. The combined forces of these loads with the seismic loads were applied to the substructure model at the column base plate locations. The substructure model was subjected to the design earthquake response spectra. This method was repeated for other combinations of structural loads with wind or tornado loads. Members were checked and designed for the maximum stress from any of the loading combinations. In addition, the water pool is designed to contain the pool water under design earthquake force loading conditions.

ATTACHMENT E - DESCRIPTION OF RECEIPT, HANDLING, AND EXAMINATION OF NAVAL SPENT NUCLEAR FUEL AT ALTERNATE DOE FACILITIES

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ATTACHMENT E

DESCRIPTION OF RECEIPT, HANDLING, AND EXAMINATION OF NAVAL SPENT NUCLEAR FUEL AT ALTERNATE DOE FACILITIES

E.1 DISCUSSION

This attachment describes the options for establishing new or modified facilities that essentially duplicate the capabilities of the existing Expended Core Facility (ECF) at the Idaho National Engineering Laboratory (INEL). Also discussed herein are the differences from the existing facility, which is described in detail in Attachment B.

The capabilities of the ECF at INEL include detailed examinations of spent nuclear fuel from naval reactors and test specimens from the Advanced Test Reactor (ATR) at the INEL Test Reactor Area. It would be possible to provide ECF capabilities at an alternate DOE facility (Savannah River Site, Hanford Site, Oak Ridge Reservation, or Nevada Test Site) by constructing an entirely new facility. At Savannah River or Hanford, ECF capabilities could also be provided by modifying an existing facility. The preferred locations for siting an ECF at Savannah River, Hanford, Oak Ridge, and the Nevada Test Site are described in Sections 4.3.1, 4.4.1, 4.5.1, and 4.6.1, respectively. The main advantage of new construction is that the facility can provide all capabilities currently available at the ECF at INEL without limitations. The new construction water pool and shielded cell complex would be constructed in such a manner as to duplicate, as much as possible, the capabilities of the ECF at INEL. The existing ECF is highly capable, having been designed to accomplish the tasks required by the Naval Nuclear Propulsion Program. Key disadvantages of new construction, bowever, are higb cost and the time necessary to initiate and complete construction.

Modification of an existing facility at Savannah River or Hanford which has at least some of the features that are required in a functional ECF would enable reductions in cost and time to achieve full capability, depending on how many facility modifications are required. A disadvantage, however, is that some of the methods currently in use at the ECF at INEL may also require modification to effectively and promptly utilize an existing facility, and such modifications may compromise the capabilities of the examination facility. The existing facility that can be made a part of the Savannah River Site is the Barnwell Nuclear Fuel Plant (hereafter referred to as the Barnwell Plant) which is unused and available following acquisition from its present private corporate owners. The existing facility on the Hanford Site is the Fuels and Materials Examination Facility (FMEF) which is unused and available immediately. Sections E.2 and E.3 describe the modifications to existing facilities or to current processes that would be needed to provide the complete range of ECF capabilities at the Barnwell Plant and the FMEF. Section E.4 provides a discussion of how naval spent fuel and test specimen examination work would proceed through the interim period as this work is being transferred from the ECF at INEL to the ECF location at the alternate DOE facility.

Receipt and handling of naval spent fuel at the new ECF location at the alternate DOE facility would be similar to receipt and handling of spent fuel at the ECF at INEL as described in Section B.2 of Attachment B. Following all examinations at the new ECF, most of the spent fuel would be loaded in the water pool into shipping casks for transport to the long-term fuel storage location at the same DOE facility. The spent fuel would remain at this location until the time that ultimate disposition is possible.

The new ECF would also duplicate the capabilities of the ECF at INEL with respect to the assembly, disassembly, and examination of ATR irradiation test specimens.

E.2 USE OF THE BARNWELL PLANT AT SAVANNAH RIVER FOR ECF WORK

The Barnwell Plant is not owned by DOE but could be acquired and incorporated into the Savannah River Site property. It has a water pool complex with about 433 square meters (4660 square feet) of surface area (see Figure E-1) that can be utilized with minor modifications to perform unloading of naval fuel transport casks in a manner virtually identical to that employed at the ECF at INEL. An overhead crane running the length of the water pool would have to be added. However, providing naval spent nuclear fuel and test specimen examination capabilities comparable to the ECF at INEL would entail an expansion of the Barnwell Plant water pool to at least two times its present size. The design of the Barnwell Plant facility provides for such an expansion in an easterly direction while the existing water pool remains functional in a reduced capacity mode.

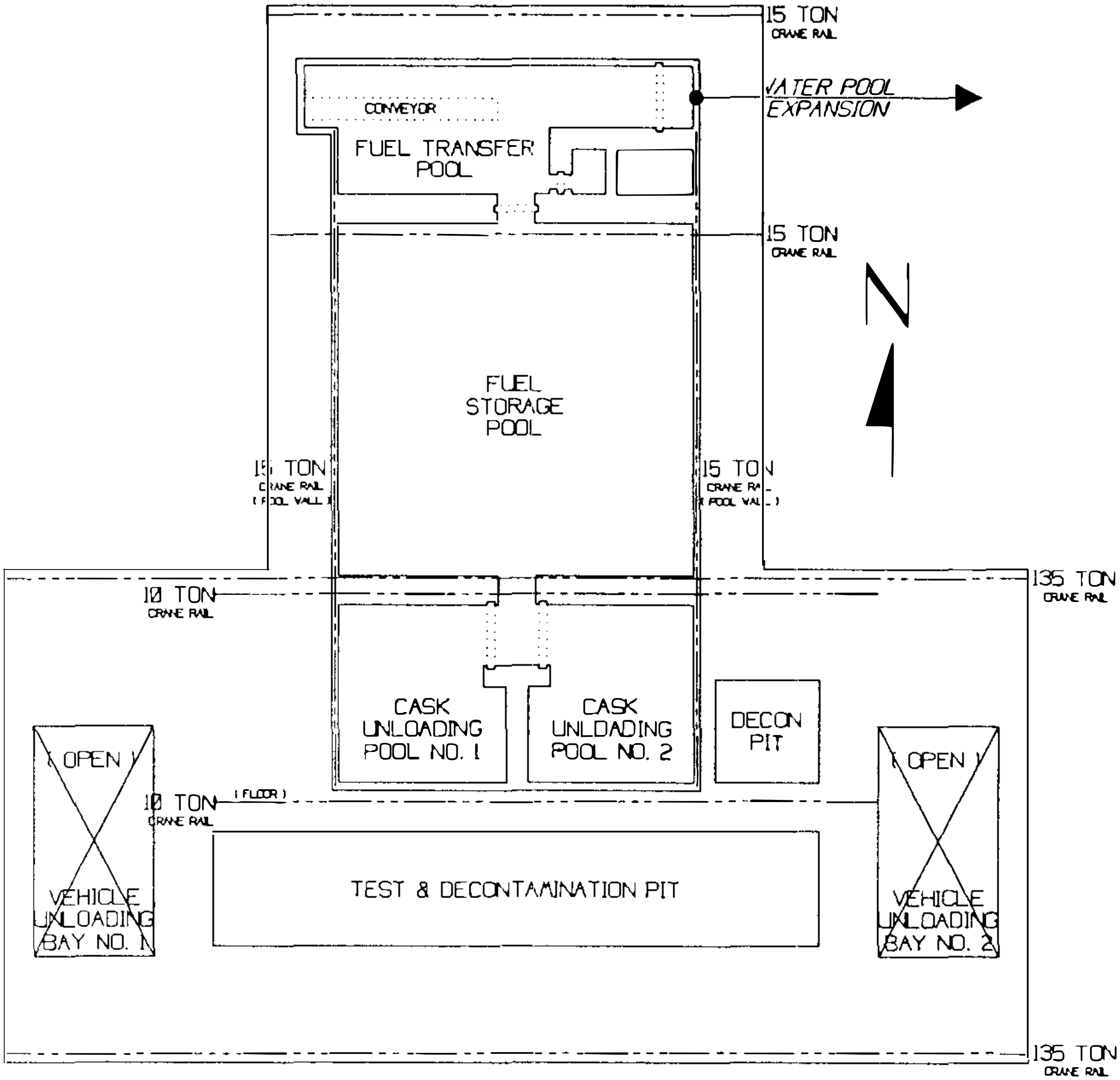

Figure E-1. Plan view of the Barnwell Plant Fuel Receiving and Storage Station.

It is envisioned that the full ECF shielded cell capabilities could be provided at the Barnwell Plant using a combination of the three remote maintenance cells and the eight sample and analytical cells. Material would be transferred from the water pool to the remote maintenance cells via a conveyor. The crane equipment maintenance gallery and the upper level of the remote process cell are connected by a shielded door; these cells are connected to the remote maintenance and scrap cell below by hatches (see Figure E-2). Additional work stations (viewing window and manipulator ports) would have to be added to service these cells. The remote maintenance cells are connected to the sample and analytical cells above via a waste chute which would have to be upgraded to improve transfer capability between these cell areas. Methods would have to be developed for material movement from one shielded cell elevation to another. The combined length of the ECF shielded cells at INEL is less than 57.9 meters (190 feet). The combined length of the Barnwell Plant remote maintenance cells and sample and analytical cells is greater than 67.1 meters (220 feet), so that sufficient cell work space should be available. There are also five contact maintenance cells available, although at present they have no workstations and are not connected to each other, to any other cell area, or to the water pool. An alternative to the Barnwell Plant water pool expansion would be to use the contact maintenance cells for some of the operations presently performed in the ECF water pool at INEL. Varying amounts of existing equipment and piping in the Barnwell Plant shielded cells would have to be removed and disposed.

Once modified, the Barnwell Plant would provide the full range of water pool and shielded cell examination capabilities. However, the arrangement of the cells in the fuel handling area could make material movement within the facility more difficult than material movement at the ECF at INEL. As a result, throughput in the Barnwell Plant could be adversely affected.

E.3 USE OF THE FUELS AND MATERIALS EXAMINATION FACILITY AT HANFORD FOR ECF WORK

The FMEF on the DOE Hanford Site in Washington currently has a large shielded cell complex that is suitable for ECF-type shielded cell operations with several modifications. Those modifications primarily entail the logistics associated with installing the equipment in the cells and transporting items for examination to and from this equipment.

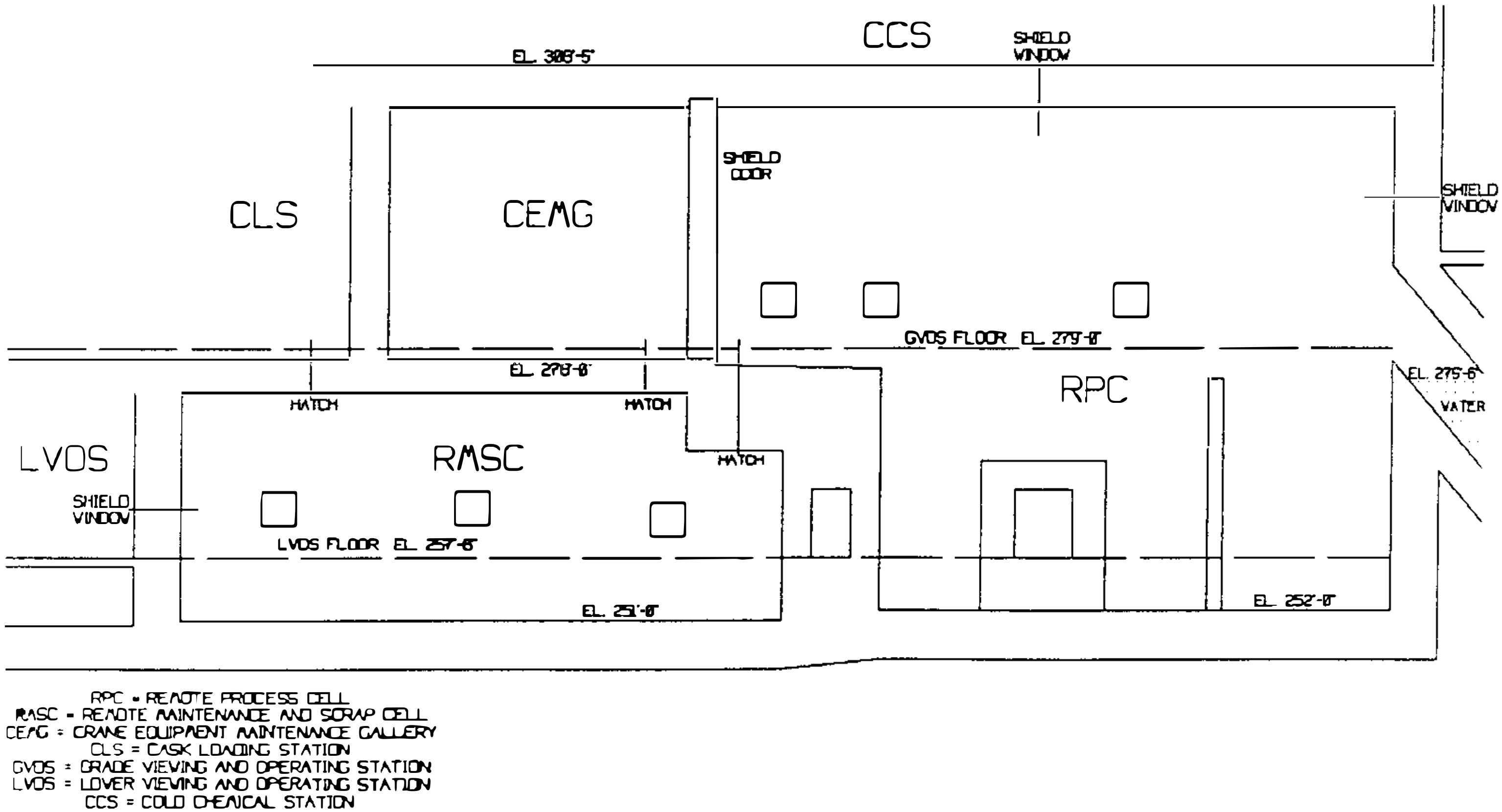

Figure E-2. Elevation looking north in the Barnwell Plant fuel handling area.

At present, there is no water pool at FMEF. One means of providing this portion of ECF capabilities would be to establish a dry cell facility. The FMEF main process cell, decontamination cell, and upper process cell were evaluated for such a facility (see Figure E-3). Conceptually, material would be transferred from shielded casks in the shipping and receiving crane bay into the decontamination cell via a ceiling port. At present, there are only small penetrations between the decontamination cell and main process cell; this would have to be upgraded to facilitate material transfer. The combined surface area of the three cells is about 706 square meters (7600 square feet), compared to at least 866 square meters (9320 square feet) for the conceptual expanded Barnwell Plant water pool discussed previously. This suggests that the full ECF water pool capabilities could not be provided in the dry cell facility. In addition, one or more of the process cells is intended for inclusion in the shielded cell complex (see next paragraph). Removal of decay heat from spent fuel and irradiation test specimens in temporary dry storage would have to be evaluated. It is concluded that duplication of ECF spent fuel and test specimen examination capabilities at FMEF would require construction of a new water pool at least two times the present size of the Barnwell Plant water pool. The location of the pool and the means for transferring items between the pool and the shielded cell complex would have to be evaluated.

It is envisioned that the full ECF shielded cell capabilities could be provided at FMEF using a combination of the main process cell and the 14 process support cells. The main process cell is connected to the process support cells below by hatches (see Figure E-3). There appear to be sufficient workstations (viewing window and manipulator ports) servicing all cells. Methods would have to be developed for material movement from one sbielded cell elevation to the other. The combined length of the FMEF main process cell and process support cells is greater than 76.2 meters (250 feet), so that sufficient cell work space should be available. The decontamination cell and upper process cell would be available in support of shielded cell operations. The FMEF shielded cells are essentially empty.

Once modified, the FMEF would provide the full range of water pool and shielded cell examination capabilities. However, the arrangement of the cells in the fuel handling area and the separation of the water pool and shielded cells would make material movement within the facility more difficult than material movement at the ECF at INEL. As a result, throughput in the FMEF could be adversely affected.

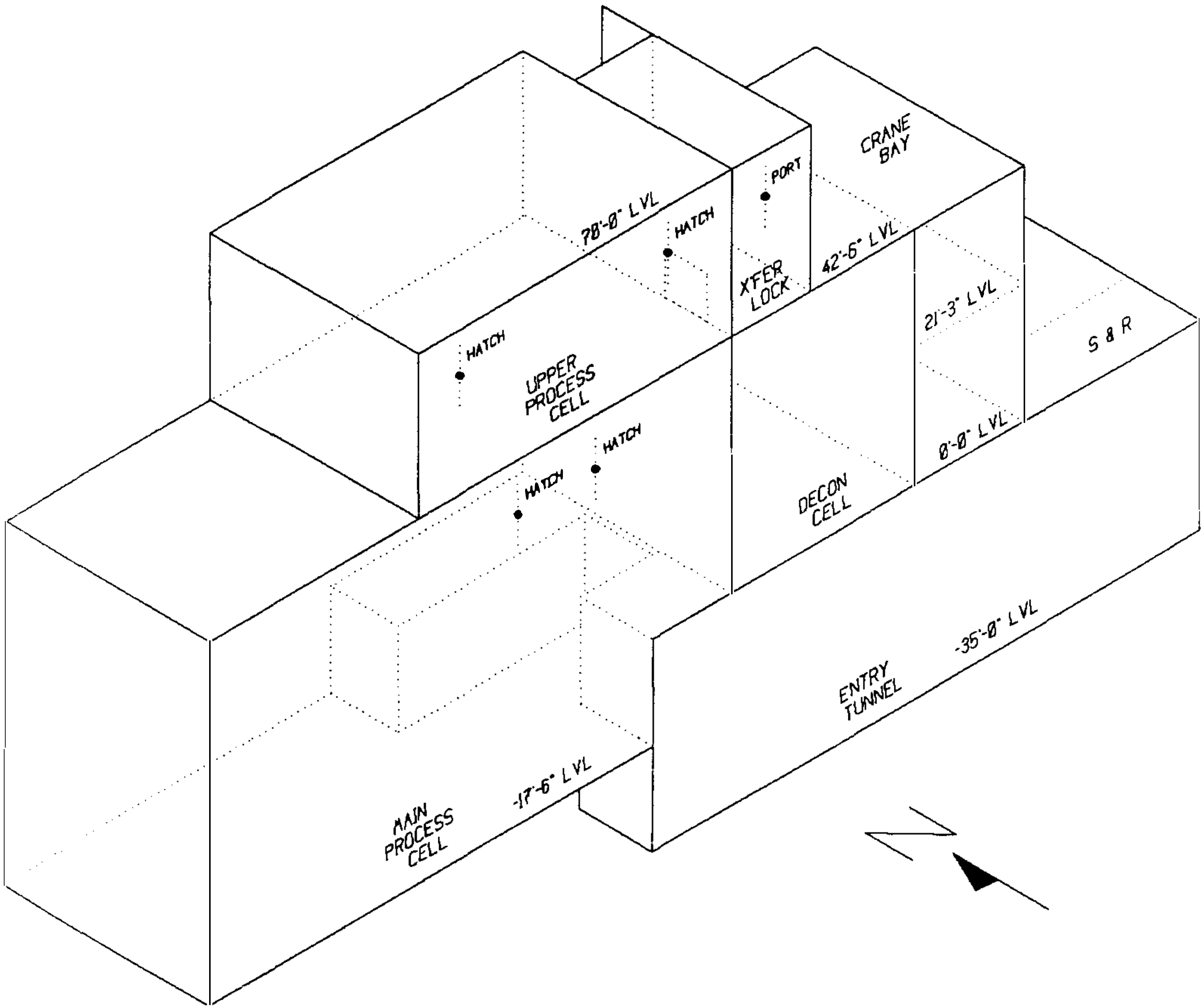

Figure E-3. FMEF fuel handling area.

E.4 INTERIM OPERATIONAL PERIOD

A transitional period will exist between the date that the Record of Decision is issued and the date that the alternative selected can be fully implemented (unless the selected alternative maintains ECF operations at INEL). This transition period would be approximately 6 years. If it is desired that all ECF work be completely transferred to an alternate DOE facility, then actions would have to be taken to minimize the disruption in examination capability for naval spent nuclear fuel and ATR test specimens. This section discusses how this will be accomplished if the alternate DOE facility option is selected in the Record of Decision.

The Barnwell Plant would have to be acquired by the DOE from its present private corporate owners. It is estimated that less than $800 million in acquisition, modification, and construction costs would complete the Barnwell Plant for ECF usage.

The FMEF at Hanford is already owned by the DOE but it appears to require a greater amount of design effort to be a fully functional ECF since a large water pool would need to be constructed and tied in to the shielded cell complex in order to initiate fuel receipt. It is estimated that less than $800 million in modification and construction costs would complete the FMEF for ECF usage.

During the transitional period between the Record of Decision and full implementation of the selected alternative, shipments of naval spent nuclear fuel to the ECF at INEL would continue, pending construction of storage and examination facilities at the new site. All naval spent nuclear fuel would then be transferred to the new site.

ATTACHMENT F - ANALYSIS OF NORMAL OPERATIONS AND ACCIDENT CONDITIONS

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ATTACHMENT F

ANALYSIS OF NORMAL OPERATIONS AND ACCIDENT CONDITIONS

This attachment presents estimated environmental consequences, event probabilities, and risk (a product of probability and consequence) for both normal operations and postulated accident scenarios related to the storage and examination of naval spent nuclear fuel. Normal operations and accidents are evaluated to estimate the potential for releases of both radioactive material and toxic chemicals. The results of these analyses are presented in terms of the health effects to facility workers and the public predicted due to the release of radioactive materials and toxic chemicals into the environment. Effects on environmental factors are also presented, based on the amount of land which could be impacted due to postulated accidents.

Analysis results are presented for several different Department of Energy (DOE) and naval shipyard locations which are being considered as alternative sites for future naval spent nuclear fuel storage and examination. The DOE facilities evaluated include the Idaho National Engineering Laboratory (INEL), Savannah River Site, Hanford Site, Nevada Test Site, Oak Ridge Reservation (hereafter referred to as Oak Ridge), and Kenneth A. Kesselring Site. Puget Sound Naval Shipyard, Pearl Harbor Naval Shipyard, Norfolk Naval Shipyard, and Portsmouth Naval Shipyard have also been evaluated for naval spent nuclear fuel operations.

SUMMARY

Analyses of normal operations and design basis and beyond design basis hypothetical accidents were performed to estimate the potential consequences due to release of radioactive materials and toxic chemicals. The analysis results for radiological operations have been summarized by the locations and alternatives being considered in the Environmental Impact Statement.

Historical Accidents

The Naval Nuclear Propulsion Program has an outstanding nuclear safety record. In over 4500 reactor-years of operation and more than 300 refuelings and defuelings of Naval reactors, there has never been a nuclear reactor accident, criticality accident, transportation accident, or any release of radioactivity having a significant effect on the environment.

Summary of Naval Spent Nuclear Fuel (SNF) Alternatives

Alternative	Description of SNF Activity
No Action	SNF retained at shipyards and Kesselring. Dry storage in containers only.
Decentralization No Examination	SNF retained at shipyards and Kesselring. Either dry containers or water pool storage would be used.
Decentralization Limited Examination	SNF retained at shipyards and Kesselring. Either dry containers or water pool storage would be used. Limited SNF shipments to Puget Sound Naval Shipyard for examination.
Decentralization Full Examination	All SNF shipped to INEL-ECF for examination. All SNF returned to origin for storage in either dry containers or water pools.
Planning Basis	SNF would be received, examined, and stored at INEL as in past years. The proposed dry cell facility would be completed at ECF.
Regionalization or Centralization	SNF would be received, examined, and stored at either INEL, Hanford, Savannah River, Nevada Test Site, or Oak Ridge.

Normal Operations

Table F-1 presents the estimated number of fatal cancers per year to the general population living within a 50-mile radius of each facility due to radiological releases from normal operations. The results in this table were calculated using the methods described in Section F.1.3. The number of fatal cancers is very low at all locations and for all alternatives.

The ISC2 computer code (EPA 1992b) was used to estimate the concentration of chemicals released during normal operations. The results show that for INEL, Hanford, Savannah River, the Nevada Test Site, the Barnwell Plant, and Oak Ridge, no ambient air quality standards would be exceeded; therefore, no adverse effects are expected. Heating boilers and emergency diesel generators already exist at the Navy shipyard locations and thus selection of these alternate locations would not result in a measurable increase in emissions.

Hypothetical Accident Evaluations

Several hypothetical accidents were analyzed at each facility for each of the alternatives. The results are summarized in Tables F-2 and F-3. The results in these tables were calculated using the methods described in Section F.1.3. Both fatal cancers from the maximum foreseeable accident at each location and the most severe risk from a facility accident at each location are presented. Risk is defined as the product of the consequences of an event multiplied by the probability of that event. The risks associated with the accidents analyzed have not been added together in order to avoid creating the impression that all risks have been calculated. The risks presented in this appendix cover the complete range of accidents which might make a detectable contribution to overall risk and additional analyses would not be expected to result in increases in calculated risk. The facility accident which results in the highest risk is a drained water pool at INEL, Hanford, Puget Sound, Portsmouth, and Kesselring. For Savannah River, Pearl Harbor, Norfolk, the Nevada Test Site, and Oak Ridge, an airplane crash into a dry storage area or a dry cell facility results in the greatest risk. As was the case for the normal operations evaluation, the accident risk is very low at all locations and for all alternatives.

Table F-4 presents a summary of the risk of fatal cancers by alternative for normal operations and most severe facility accident for each alternative. Consistent with the detailed tables, this summary table shows that all alternatives and all locations associated with spent fuel examination have very low risk.

Tables F-5 through F-8 present a summary by alternative of the impacts from all naval spent nuclear fuel facility radiological accidents which were analyzed.

A shipping accident in Puget Sound, at a location in the shipping lane approximately 2 miles from Seattle, was also analyzed using the methods described in this Attachment. This hypothetical accident results in a fire onboard the ship which involves spent nuclear fuel shipping containers. When compared to the facility accidents analyzed at Puget Sound Naval Shipyard, this shipping accident has a slightly lower risk of fatal cancers than the most severe facility accident at the shipyard.

The EPI computer code (Homann 1988) was used to estimate the concentration of chemicals released in the event of two postulated accident conditions. One postulated accident involved a chemical spill and fire at ECF and the alternate DOE sites and the other postulated accident involved a diesel fuel fire at ECF, the alternate DOE sites, and the shipyard locations. The chemical

Table F-1. Number of fatal cancers per year from normal operations (fatalities per year to general population located within 50-mile radius of site).

DRY STORAGE AT NAVAL NUCLEAR PROPULSION PROGRAM SITES, WATER POOL STORAGE AT DOE SITES										
		No Action	Decentralization-No Examination	Decentralization-Puget Sound Exam	Decentralization-INEL Exam	Planning Basis/ Regionalization/ Centralization-INEL	Regionalization/ Centralization-Hanford	Regionalization/ Centralization-Savannah River	Regionalization/ Centralization-Nevada Test Site	Regionalization/ Centralization-Oak Ridge
INEL		0.00	0.00	0.00	8.50×10^{-7}	8.50×10^{-7}	0.00	0.00	0.00	0.00
Hanford		0.00	0.00	0.00	0.00	0.00	4.00×10^{-6}	0.00	0.00	0.00
Savannah River		0.00	0.00	0.00	0.00	0.00	0.00	1.80×10^{-5}	0.00	0.00
Nevada Test Site		0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00×10^{-8}	0.00
Oak Ridge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00×10^{-5}
Puget Sound		1.20×10^{-6}	1.20×10^{-6}	6.62×10^{-5}**	1.20×10^{-6}	0.00	0.00	0.00	0.00	0.00
Pearl Harbor		9.30×10^{-9}	9.30×10^{-9}	9.30×10^{-9}	9.30×10^{-9}	0.00	0.00	0.00	0.00	0.00
Portsmouth		2.30×10^{-7}	2.30×10^{-7}	2.30×10^{-7}	2.30×10^{-7}	0.00	0.00	0.00	0.00	0.00
Norfolk		2.10×10^{-5}	2.10×10^{-5}	2.10×10^{-5}	2.10×10^{-5}	0.00	0.00	0.00	0.00	0.00
Kesselring		4.10×10^{-12}	4.10×10^{-12}	4.10×10^{-12}	4.10×10^{-12}	0.00	0.00	0.00	0.00	0.00
	Total	2.24×10^{-5}	2.24×10^{-5}	8.74×10^{-5}	2.33×10^{-5}	8.50×10^{-7}	4.00×10^{-6}	1.80×10^{-5}	9.00×10^{-8}	5.00×10^{-5}
WATER POOL STORAGE AT ALL SITES*										
INEL		0.00	0.00	0.00	8.50×10^{-7}	8.50×10^{-7}	0.00	0.00	0.00	0.00
Hanford		0.00	0.00	0.00	0.00	0.00	4.00×10^{-6}	0.00	0.00	0.00
Savannah River		0.00	0.00	0.00	0.00	0.00	0.00	1.80×10^{-5}	0.00	0.00
Nevada Test Site		0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00×10^{-8}	0.00
Oak Ridge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.0×10^{-5}
Puget Sound		1.20×10^{-6}	6.50×10^{-5}	6.50×10^{-5}	6.50×10^{-5}	0.00	0.00	0.00	0.00	0.00
Pearl Harbor		9.30×10^{-9}	7.00×10^{-5}	7.00×10^{-5}	7.00×10^{-5}	0.00	0.00	0.00	0.00	0.00
Portsmouth		2.30×10^{-7}	2.30×10^{-5}	2.30×10^{-5}	2.30×10^{-5}	0.00	0.00	0.00	0.00	0.00
Norfolk		2.10×10^{-5}	1.40×10^{-4}	1.40×10^{-4}	1.40×10^{-4}	0.00	0.00	0.00	0.00	0.00
Kesselring		4.10×10^{-12}	4.10×10^{-5}	4.10×10^{-5}	4.10×10^{-5}	0.00	0.00	0.00	0.00	0.00
	Total	2.24×10^{-5}	3.39×10^{-4}	3.39×10^{-4}	3.40×10^{-4}	8.50×10^{-7}	4.00×10^{-6}	1.80×10^{-5}	9.00×10^{-8}	5.00×10^{-5}

*Under No Action alternative, dry storage at Naval Nuclear Propulsion Program sites

**Includes dry storage and water pool examination under this alternative

Table F-2. Number of fatal cancers from a maximum foreseeable accident (fatalities per accident over a 50-year period to general population within a 50-mile radius of site).

		No Action	Decentralization-No Examination	Decentralization-Puget Sound Exam	Decentralization-INEL Exam	Planning Basis/ Regionalization/ Centralization-INEL	Regionalization/ Centralization-Hanford	Regionalization/ Centralization-Savannah River	Regionalization/ Centralization-Nevada Test Site	Regionalization/ Centralization-Oak Ridge
DRY STORAGE AT NAVAL NUCLEAR PROPULSION PROGRAM SITES, WATER POOL STORAGE AT DOE SITES										
INEL		0.00	0.00	0.00	1.70×10^{-2}	1.70×10^{-2}	0.00	0.00	0.00	0.00
Hanford		0.00	0.00	0.00	0.00	0.00	4.70×10^{-2}	0.00	0.00	0.00
Savannah River		0.00	0.00	0.00	0.00	0.00	0.00	4.80	0.00	0.00
Nevada Test Site		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80×10^{-1}	0.00
Oak Ridge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.40
Puget Sound		1.7×10^{-2}	1.7×10^{-2}	5.1×10^{-1}**	1.7×10^{-2}	0.00	0.00	0.00	0.00	0.00
Pearl Harbor		2.60×10^{1}	2.60×10^{1}	2.60×10^{1}	2.60×10^{1}	0.00	0.00	0.00	0.00	0.00
Portsmouth		9.00	9.00	9.00	9.00	0.00	0.00	0.00	0.00	0.00
Norfolk		1.6×10^{1}	1.6×10^{1}	1.6×10^{1}	1.6×10^{1}	0.00	0.00	0.00	0.00	0.00
Kesselring		7.50	7.50	7.50	7.50	0.00	0.00	0.00	0.00	0.00
	Max	2.60×10^{1}	2.60×10^{1}	2.60×10^{1}	2.60×10^{1}	1.70×10^{-2}	4.70×10^{-2}	4.80	1.80×10^{-1}	8.40
WATER POOL STORAGE AT ALL SITES*										
INEL		0.00	0.00	0.00	1.70×10^{-2}	1.70×10^{-2}	0.00	0.00	0.00	0.00
Hanford		0.00	0.00	0.00	0.00	0.00	4.70×10^{-2}	0.00	0.00	0.00
Savannah River		0.00	0.00	0.00	0.00	0.00	0.00	4.80	0.00	0.00
Nevada Test Site		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80×10^{-1}	0.00
Oak Ridge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.40
Puget Sound		1.7×10^{-2}	5.1×10^{-1}	5.1×10^{-1}	5.1×10^{-1}	0.00	0.00	0.00	0.00	0.00
Pearl Harbor		2.60×10^{1}	1.10	1.10	1.10	0.00	0.00	0.00	0.00	0.00
Portsmouth		9.00	3.40×10^{-1}	3.40×10^{-1}	3.40×10^{-1}	0.00	0.00	0.00	0.00	0.00
Norfolk		1.6×10^{1}	6.0×10^{-1}	6.0×10^{-1}	6.0×10^{-1}	0.00	0.00	0.00	0.00	0.00
Kesselring		7.50	2.50×10^{-1}	2.50×10^{-1}	2.50×10^{-1}	0.00	0.00	0.00	0.00	0.00
	Max	2.60×10^{1}	1.10	1.10	1.10	1.70×10^{-2}	4.70×10^{-2}	4.80	1.80×10^{-1}	8.40

*Under No Action alternative, dry storage at Naval Nuclear Propulsion Program sites

**Includes dry storage and water pool examination under this alternative

Table F-3. Most severe risk from a facility accident (probability of fatalities per year per accident to general population within a 50-mile radius of site).

DRY STORAGE AT NAVAL NUCLEAR PROPULSION PROGRAM SITES, WATER POOL STORAGE AT DOE SITES										
		No Action	Decentralization-No Examination	Decentralization-Puget Sound Exam	Decentralization-INEL Exam	Planning Basis/ Regionalization Centralization-INEL	Regionalization/ Centralization-Hanford	Regionalization/ Centralization-Savannah River	Regionalization/ Centralization-Nevada Test Site	Regionalization/ Centralization-Oak Ridge
INEL		0.00	0.00	0.00	1.70×10^{-7}	1.70×10^{-7}	0.00	0.00	0.00	0.00
Hanford		0.00	0.00	0.00	0.00	0.00	4.70×10^{-7}	0.00	0.00	0.00
Savannah River		0.00	0.00	0.00	0.00	0.00	0.00	9.60×10^{-6}	0.00	0.00
Nevada Test Site		0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.20×10^{-8}	0.00
Oak Ridge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.40×10^{-6}
Puget Sound		1.7×10^{-7}	1.7×10^{-7}	5.10×10^{-6}**	1.7×10^{-7}	0.00	0.00	0.00	0.00	0.00
Pearl Harbor		2.60×10^{-4}	2.60×10^{-4}	2.60×10^{-4}	2.60×10^{-4}	0.00	0.00	0.00	0.00	0.00
Portsmouth		9.00×10^{-7}	9.00×10^{-7}	9.00×10^{-7}	9.00×10^{-7}	0.00	0.00	0.00	0.00	0.00
Norfolk		1.6×10^{-5}	1.6×10^{-5}	1.6×10^{-5}	1.6×10^{-5}	0.00	0.00	0.00	0.00	0.00
Kesselring		7.50×10^{-7}	7.50×10^{-7}	7.50×10^{-7}	7.50×10^{-7}	0.00	0.00	0.00	0.00	0.00
	Max	2.60×10^{-4}	2.60×10^{-4}	2.60×10^{-4}	2.60×10^{-4}	1.70×10^{-7}	4.70×10^{-7}	9.60×10^{-6}	7.2×10^{-8}	8.40×10^{-6}
WATER POOL STORAGE AT ALL SITES*										
INEL		0.00	0.00	0.00	1.70×10^{-7}	1.70×10^{-7}	0.00	0.00	0.00	0.00
Hanford		0.00	0.00	0.00	0.00	0.00	4.70×10^{-7}	0.00	0.00	0.00
Savannah River		0.00	0.00	0.00	0.00	0.00	0.00	9.60×10^{-6}	0.00	0.00
Nevada Test Site		0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.20×10^{-8}	0.00
Oak Ridge		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.40×10^{-6}
Puget Sound		1.7×10^{-7}	5.1×10^{-6}	5.1×10^{-6}	5.1×10^{-6}	0.00	0.00	0.00	0.00	0.00
Pearl Harbor		2.60×10^{-4}	1.10×10^{-5}	1.10×10^{-5}	1.10×10^{-5}	0.00	0.00	0.00	0.00	0.00
Portsmouth		9.00×10^{-7}	3.40×10^{-6}	3.40×10^{-6}	3.40×10^{-6}	0.00	0.00	0.00	0.00	0.00
Norfolk		1.6×10^{-5}	6.0×10^{-6}	6.0×10^{-6}	6.0×10^{-6}	0.00	0.00	0.00	0.00	0.00
Kesselring		7.50×10^{-7}	2.50×10^{-6}	2.50×10^{-6}	2.50×10^{-6}	0.00	0.00	0.00	0.00	0.00
	Max	2.60×10^{-4}	1.10×10^{-5}	1.10×10^{-5}	1.10×10^{-5}	1.70×10^{-7}	4.70×10^{-7}	9.60×10^{-6}	7.20×10^{-8}	8.40×10^{-6}

*Under No Action alternative, dry storage at Naval Nuclear Propulsion Program sites

**Includes dry storage and water pool examination under this alternative

Table F-4. Risk of fatal cancers by alternative (probability of fatalities per year per accident to general population within a 50-mile radius of site).

	No Action	Decentralization-No Examination	Decentralization-Puget Sound Exam	Decentralization-INEL Exam	Planning Basis/ Regionalization Centralization-INEL	Regionalization/ Centralization-Hanford	Regionalization/ Centralization-Savannah River	Regionalization/ Centralization-Nevada Test Site	Regionalization/ Centralization-Oak Ridge
Normal Operations Risk Dry Storage At Navy Sites, Water Pool Storage At DOE Sites	2.24×10^{-5}	2.24×10^{-5}	8.74×10^{-5}	2.33×10^{-5}	8.50×10^{-7}	4.00×10^{-6}	1.80×10^{-5}	9.00×10^{-8}	5.00×10^{-5}
Normal Operations Risk Water Pool Storage At All Sites	2.24×10^{-5}	3.39×10^{-4}	3.39×10^{-4}	3.40×10^{-4}	8.50×10^{-7}	4.00×10^{-6}	1.80×10^{-5}	9.00×10^{-8}	5.00×10^{-5}
Most Severe Risk From A Facility Accident Dry Storage At Naval Nuclear Propulsion Program Sites, Water Pool Storage At DOE Sites	2.60×10^{-4} (1)	2.60×10^{-4} (1)	2.60×10^{-4} (1)	2.60×10^{-4} (1)	1.70×10^{-7} (2)	4.70×10^{-7} (2)	9.60×10^{-6} (1)	7.20×10^{-8} (1)	8.40×10^{-6} (1)
Most Severe Risk From A Facility Accident Water Pool Storage At All Sites	2.60×10^{-4} (1)	1.10×10^{-5} (2)	1.10×10^{-5} (2)	1.10×10^{-5} (2)	1.70×10^{-7} (2)	4.70×10^{-7} (2)	9.60×10^{-6} (1)	7.2×10^{-8} (1)	8.40×10^{-6} (1)

(1) Accident initiator - Airplane crash
(2) Accident initiator - Drained water pool

Table F-5. Impacts from naval spent nuclear fuel facility radiological accidents for the No Action alternative.

Accident Description	Probability (per year)	Consequences to Public (fatalities per accident)	Risk to Public (fatalities)	Dose to Worker (rem)	Dose to MOI (rem)
DRY STORAGE ACCIDENTS					
Mechanical Damage					
Puget Sound	1.0×10^{-5}	1.7×10^{-2}	1.7×10^{-7}	5.6×10^{-2}	3.9×10^{-2}
Pearl Harbor	1.0×10^{-5}	3.0×10^{-2}	3.0×10^{-7}	5.6×10^{-2}	2.1×10^{-2}
Norfolk	1.0×10^{-5}	1.8×10^{-2}	1.8×10^{-7}	5.6×10^{-2}	8.1×10^{-2}
Portsmouth	1.0×10^{-5}	1.0×10^{-2}	1.0×10^{-7}	5.6×10^{-2}	4.2×10^{-2}
Kesselring	1.0×10^{-5}	7.4×10^{-3}	7.4×10^{-8}	5.6×10^{-2}	8.1×10^{-3}
Airplane Crash					
Pearl Harbor	1.0×10^{-5}	26	2.6×10^{-4}	92	19
Norfolk	1.0×10^{-6}	16	1.6×10^{-5}	92	72
Portsmouth	1.0×10^{-7}	9.0	9.0×10^{-7}	92	38
Kesselring	1.0×10^{-7}	7.5	7.5×10^{-7}	92	7.7

Table F-6. Impacts from naval spent nuclear fuel facility radiological accidents for Decentralization alternatives.

Accident Description	Probability (per year)	Consequences to Public (fatalities per accident)	Risk to Public (fatalities)	Dose to Worker (rem)	Dose to MOI (rem)
WET STORAGE AND EXAMINATION ACCIDENTS					
*Information applicable only for full examinations at INEL.					
Drained Water Pool					
*INEL	1.0×10^{-5}	1.7×10^{-2}	1.7×10^{-7}	2.1	1.7×10^{-2}
Puget Sound	1.0×10^{-5}	5.1×10^{-1}	5.1×10^{-6}	2.1	1.4
Pearl Harbor	1.0×10^{-5}	1.1	1.1×10^{-5}	2.1	7.9×10^{-1}
Norfolk	1.0×10^{-5}	6.0×10^{-1}	6.0×10^{-6}	2.1	3.0
Portsmouth	1.0×10^{-5}	3.4×10^{-1}	3.4×10^{-6}	2.1	1.6
Kesselring	1.0×10^{-5}	2.5×10^{-1}	2.5×10^{-6}	2.1	2.9×10^{-1}
Accidental Criticality					
*INEL	1.0×10^{-5}	6.4×10^{-3}	6.4×10^{-8}	8.0	9.2×10^{-3}
Puget Sound	1.0×10^{-5}	2.8×10^{-1}	2.8×10^{-6}	8.0	1.3
Pearl Harbor	1.0×10^{-5}	6.0×10^{-1}	6.0×10^{-6}	8.0	6.7×10^{-1}
Norfolk	1.0×10^{-5}	3.5×10^{-1}	3.5×10^{-6}	8.0	2.7
Portsmouth	1.0×10^{-5}	1.5×10^{-1}	1.5×10^{-6}	8.0	1.4
Kesselring	1.0×10^{-5}	1.1×10^{-1}	1.1×10^{-6}	8.0	2.3×10^{-1}
Mechanical Damage					
*INEL	1.0×10^{-5}	5.3×10^{-6}	5.3×10^{-11}	5.2×10^{-4}	2.6×10^{-6}
Puget Sound	1.0×10^{-5}	7.2×10^{-5}	7.2×10^{-10}	5.2×10^{-4}	1.7×10^{-4}
Pearl Harbor	1.0×10^{-5}	1.5×10^{-4}	1.5×10^{-9}	5.2×10^{-4}	9.3×10^{-5}
Norfolk	1.0×10^{-5}	8.0×10^{-5}	8.0×10^{-10}	5.2×10^{-4}	3.5×10^{-4}
Portsmouth	1.0×10^{-5}	5.6×10^{-5}	5.6×10^{-10}	5.2×10^{-4}	1.9×10^{-4}
Kesselring	1.0×10^{-5}	6.0×10^{-5}	6.0×10^{-10}	5.2×10^{-4}	3.6×10^{-5}
Airplane Crash					
Pearl Harbor	2.0×10^{-5}	4.6×10^{-2}	9.2×10^{-7}	1.6×10^{-1}	2.8×10^{-2}
Norfolk	4.0×10^{-7}	2.4×10^{-2}	9.6×10^{-9}	1.6×10^{-1}	1.1×10^{-1}
Kesselring	2.0×10^{-7}	1.8×10^{-2}	3.6×10^{-9}	1.6×10^{-1}	1.1×10^{-2}
HEPA Filter Fire					
*INEL	5.0×10^{-4}	5.3×10^{-5}	2.7×10^{-8}	2.4×10^{-3}	2.5×10^{-5}
Puget Sound	5.0×10^{-4}	6.4×10^{-4}	3.2×10^{-7}	2.4×10^{-3}	1.6×10^{-3}
Pearl Harbor	5.0×10^{-4}	1.2×10^{-3}	6.0×10^{-7}	2.4×10^{-3}	8.7×10^{-4}

Table F-6. Impacts from naval spent nuclear fuel facility radiological accidents for Decentralization alternatives. (Cont)

Accident Description	Probability (per year)	Consequences to Public (fatalities per accident)	Risk to Public (fatalities)	Dose to Worker (rem)	Dose to MOI (rem)
Norfolk	5.0×10^{-4}	6.9×10^{-4}	3.5×10^{-7}	2.4×10^{-3}	3.3×10^{-3}
WET STORAGE AND EXAMINATION ACCIDENTS					
*Information applicable only for full examinations at INEL.					
Portsmouth	5.0×10^{-4}	3.9×10^{-4}	2.0×10^{-7}	2.4×10^{-3}	1.7×10^{-3}
Kesselring	5.0×10^{-4}	3.3×10^{-4}	1.7×10^{-7}	2.4×10^{-3}	3.5×10^{-4}
Minor Water Pool Leak					
*INEL	1.0×10^{-1}	1.3×10^{-8}	1.3×10^{-9}	N/A	2.5×10^{-9}
Puget Sound	1.0×10^{-1}	4.2×10^{-9}	4.2×10^{-10}	N/A	3.2×10^{-10}
Pearl Harbor	1.0×10^{-1}	4.6×10^{-10}	4.6×10^{-11}	N/A	1.3×10^{-10}
Norfolk	1.0×10^{-1}	1.8×10^{-9}	1.8×10^{-10}	N/A	2.7×10^{-10}
Portsmouth	1.0×10^{-1}	1.4×10^{-9}	1.4×10^{-10}	N/A	1.3×10^{-10}
Kesselring	1.0×10^{-1}	8.5×10^{-9}	8.5×10^{-10}	N/A	6.0×10^{-9}
DRY STORAGE ACCIDENTS					
Mechanical Damage					
Puget Sound	1.0×10^{-5}	1.7×10^{-2}	1.7×10^{-7}	5.6×10^{-2}	3.9×10^{-2}
Pearl Harbor	1.0×10^{-5}	3.0×10^{-2}	3.0×10^{-7}	5.6×10^{-2}	2.1×10^{-2}
Norfolk	1.0×10^{-5}	1.8×10^{-2}	1.8×10^{-7}	5.6×10^{-2}	8.1×10^{-2}
Portsmouth	1.0×10^{-5}	1.0×10^{-2}	1.0×10^{-7}	5.6×10^{-2}	4.2×10^{-2}
Kesselring	1.0×10^{-5}	7.4×10^{-3}	7.4×10^{-8}	5.6×10^{-2}	8.1×10^{-3}
Airplane Crash					
Pearl Harbor	1.0×10^{-5}	26	2.6×10^{-4}	92	19
Norfolk	1.0×10^{-6}	16	1.6×10^{-5}	92	72
Portsmouth	1.0×10^{-7}	9.0	9.0×10^{-7}	92	38
Kesselring	1.0×10^{-7}	7.5	7.5×10^{-7}	92	7.7
DRY CELL ACCIDENTS					
Mechanical Damage					
*INEL	1.0×10^{-4}	3.5×10^{-4}	3.5×10^{-8}	1.0×10^{-1}	2.2×10^{-4}
Loss of Shielding					
*INEL	1.0×10^{-5}	3.0×10^{-19}	3.0×10^{-24}	7.2×10^{-5}	9.3×10^{-17}

Table F-7. Impacts from naval spent nuclear fuel facility radiological accidents for Planning Basis, Centralization at INEL, and Regionalization at INEL alternatives.

Accident Description	Probability (per year)	Consequences to Public (fatalities per accident)	Risk to Public (fatalities)	Dose to Worker (rem)	Dose to MOI (rem)
WET STORAGE AND EXAMINATION ACCIDENTS					
Drained Water Pool					
INEL	1.0×10^{-5}	1.7×10^{-2}	1.7×10^{-7}	2.1	1.7×10^{-2}
Accidental Criticality					
INEL	1.0×10^{-5}	6.4×10^{-3}	6.4×10^{-8}	8.0	9.2×10^{-3}
Mechanical Damage					
INEL	1.0×10^{-5}	5.3×10^{-6}	5.3×10^{-11}	5.2×10^{-4}	2.6×10^{-6}
HEPA Filter Fire					
INEL	5.0×10^{-4}	5.3×10^{-5}	2.7×10^{-8}	2.4×10^{-3}	2.5×10^{-5}
Minor Water Pool Leak					
INEL	1.0×10^{-1}	1.3×10^{-8}	1.3×10^{-9}	N/A	2.5×10^{-9}
DRY STORAGE ACCIDENTS					
Mechanical Damage					
INEL	1.0×10^{-5}	4.9×10^{-4}	4.9×10^{-9}	5.6×10^{-2}	4.6×10^{-4}
DRY CELL ACCIDENTS					
Mechanical Damage					
INEL	1.0×10^{-4}	3.5×10^{-4}	3.5×10^{-8}	1.0×10^{-1}	2.2×10^{-4}
Loss of Shielding					
INEL	1.0×10^{-5}	3.0×10^{-19}	3.0×10^{-24}	7.2×10^{-5}	9.3×10^{-17}

Table F-8. Impacts from naval spent nuclear fuel facility radiological accidents for Regionalization or Centralization at other DOE sites alternatives.

Information applicable only to DOE site selected for Regionalization or Centralization.

Accident Description	Probability (per year)	Consequences to Public (fatalities per accident)	Risk to Public (fatalities)	Dose to Worker (rem)	Dose to MOI (rem)
WET STORAGE AND EXAMINATION ACCIDENTS					
Drained Water Pool					
Savannah River	1.0×10^{-5}	1.1×10^{-1}	1.1×10^{-6}	2.1	1.6×10^{-2}
Hanford	1.0×10^{-5}	4.7×10^{-2}	4.7×10^{-7}	2.1	6.3×10^{-3}
Nevada Test Site	1.0×10^{-5}	1.9×10^{-3}	1.9×10^{-8}	2.1	3.3×10^{-2}
Oak Ridge	1.0×10^{-5}	1.8×10^{-1}	1.8×10^{-6}	2.1	5.2
Accidental Criticality					
Savannah River	1.0×10^{-5}	4.5×10^{-2}	4.5×10^{-7}	8.0	9.4×10^{-3}
Hanford	1.0×10^{-5}	1.6×10^{-2}	1.6×10^{-7}	8.0	2.8×10^{-3}
Nevada Test Site	1.0×10^{-5}	7.0×10^{-4}	7.0×10^{-9}	8.0	2.0×10^{-2}
Oak Ridge	1.0×10^{-5}	8.8×10^{-2}	8.8×10^{-7}	8.0	4.7
Mechanical Damage					
Savannah River	1.0×10^{-5}	2.0×10^{-5}	2.0×10^{-10}	5.2×10^{-4}	2.2×10^{-6}
Hanford	1.0×10^{-5}	8.6×10^{-6}	8.6×10^{-11}	5.2×10^{-4}	9.8×10^{-7}
Nevada Test Site	1.0×10^{-5}	5.6×10^{-7}	5.6×10^{-12}	5.2×10^{-4}	4.6×10^{-6}
Oak Ridge	1.0×10^{-5}	3.4×10^{-5}	3.4×10^{-10}	5.2×10^{-4}	5.9×10^{-4}
Airplane Crash					
Savannah River	2.0×10^{-6}	6.1×10^{-3}	1.2×10^{-8}	1.6×10^{-1}	6.4×10^{-4}
Oak Ridge	1.0×10^{-6}	1.0×10^{-2}	1.0×10^{-8}	1.6×10^{-1}	1.8×10^{-1}
Nevada Test Site	4.0×10^{-7}	1.7×10^{-4}	6.8×10^{-11}	1.6×10^{-1}	1.3×10^{-3}
HEPA Filter Fire					
Savannah River	5.0×10^{-4}	1.3×10^{-4}	6.5×10^{-8}	2.4×10^{-3}	2.1×10^{-5}
Hanford	5.0×10^{-4}	5.3×10^{-5}	2.7×10^{-8}	2.4×10^{-3}	7.0×10^{-6}
Nevada Test Site	5.0×10^{-4}	5.7×10^{-6}	2.9×10^{-9}	2.4×10^{-3}	4.3×10^{-5}
Oak Ridge	5.0×10^{-4}	2.2×10^{-4}	1.1×10^{-7}	2.4×10^{-3}	5.7×10^{-3}
Minor Water Leak					
Savannah River	1.0×10^{-1}	1.3×10^{-9}	1.3×10^{-10}	N/A	7.9×10^{-10}
Hanford	1.0×10^{-1}	1.7×10^{-10}	1.7×10^{-11}	N/A	9.9×10^{-12}
Nevada Test Site	1.0×10^{-1}	1.4×10^{-9}	1.4×10^{-10}	N/A	2.5×10^{-9}

Table F-8. Impacts from naval spent nuclear fuel facility radiological accidents for Regionalization or Centralization at other DOE sites alternatives. (Cont)

Information applicable only to DOE sites selected for Regionalization or Centralization.

Accident Description	Probability (per year)	Consequences to Public (fatalities per accident)	Risk to Public (fatalities)	Dose to Worker (rem)	Dose to MOI (rem)
Oak Ridge	1.0×10^{-1}	3.9×10^{-9}	3.9×10^{-10}	N/A	1.5×10^{-9}
DRY STORAGE ACCIDENTS					
Mechanical Damage					
Savannah River	1.0×10^{-5}	3.0×10^{-3}	3.0×10^{-8}	5.6×10^{-2}	4.9×10^{-4}
Hanford	1.0×10^{-5}	1.3×10^{-3}	1.3×10^{-8}	5.6×10^{-2}	1.7×10^{-4}
Nevada Test Site	1.0×10^{-5}	5.3×10^{-5}	5.3×10^{-10}	5.6×10^{-2}	8.8×10^{-4}
Oak Ridge	1.0×10^{-5}	5.1×10^{-3}	5.1×10^{-8}	5.6×10^{-2}	1.4×10^{-1}
Airplane Crash					
Savannah River	3.0×10^{-7}	2.8	8.4×10^{-7}	92	4.7×10^{-1}
Oak Ridge	3.0×10^{-7}	4.7	1.4×10^{-6}	92	120
DRY CELL ACCIDENTS					
Mechanical Damage					
Savannah River	1.0×10^{-4}	1.4×10^{-3}	1.4×10^{-7}	1.0×10^{-1}	2.4×10^{-4}
Hanford	1.0×10^{-4}	5.3×10^{-4}	5.3×10^{-8}	1.0×10^{-1}	7.1×10^{-5}
Nevada Test Site	1.0×10^{-4}	3.7×10^{-5}	3.7×10^{-9}	1.0×10^{-1}	4.0×10^{-4}
Oak Ridge	1.0×10^{-4}	2.5×10^{-3}	2.5×10^{-7}	1.0×10^{-1}	5.8×10^{-2}
Loss of Shielding					
Savannah River	1.0×10^{-5}	3.0×10^{-16}	3.0×10^{-21}	7.2×10^{-5}	6.7×10^{-15}
Hanford	1.0×10^{-5}	4.9×10^{-24}	4.9×10^{-29}	7.2×10^{-5}	3.3×10^{-23}
Nevada Test Site	1.0×10^{-5}	3.7×10^{-37}	3.7×10^{-42}	7.2×10^{-5}	6.3×10^{-11}
Oak Ridge	1.0×10^{-5}	7.5×10^{-6}	7.5×10^{-11}	7.2×10^{-5}	1.2×10^{-2}
Airplane Crash					
Savannah River	2.0×10^{-6}	4.8	9.6×10^{-6}	160	8.2×10^{-1}
Oak Ridge	1.0×10^{-6}	8.4	8.4×10^{-6}	160	350
Nevada Test Site	4.0×10^{-7}	1.8×10^{-1}	7.2×10^{-8}	160	1.6

concentrations were then compared against Emergency Release Planning Guide (ERPG) levels as a means of evaluating their effects. ERPG values are specific for each substance and provide an estimate of the airborne concentration thresholds above which one can reasonably observe adverse effects. Exposure to an ERPG-1 level could result in a very mild effect whereas exposure to an ERPG-3 level could result in a life-threatening health effect. For the postulated accident involving a chemical spill and fire, on-site personnel (worker) could be exposed to concentrations of hydrochloric acid, phosgene, sulfuric acid, and sodium hydroxide above ERPG-3 levels which indicates a potential for long-term health effects. However, no member of the general public located off-site would be expected to be exposed to levels above ERPG-3 except for Oak Ridge where sulfuric acid and sodium hydroxide concentrations could exceed ERPG-3. For the postulated accident involving a diesel fuel fire, on-site personnel could be exposed to concentrations of sulfur dioxide and oxides of nitrogen above ERPG-3 levels. No member of the general public located off-site would be expected to be exposed to levels above ERPG-3 except for Oak Ridge where sulfur dioxide and oxides of nitrogen concentrations could exceed ERPG-3 and one shipyard location (Norfolk) where nitric oxide concentrations could exceed ERPG-3 under severe meteorological conditions. However, for both postulated accidents, the accident analyses did not include evacuation of on-site or off-site personnel and it is expected that chemical exposures would be below ERPG-3 levels because actions such as evacuation would be used to reduce the effects on the public and workers.

Fugitive Dust Analysis

The FDM computer code was used to estimate the fugitive dust concentrations that could result from the construction of a water pool facility at the alternate locations. It was determined that the release of fugitive dust would not result in any adverse effects for any of the alternate locations.

Other Impacts

The radiological impact of accidents on the environs of a facility was determined by examining the area that could be contaminated following such an event. Calculations using average meteorological conditions were performed for each accident scenario. These calculations determined the extent of the contamination which causes only a small increase in background radiation from naturally occurring sources. For most facilities and most accidents, the contaminated area was confined to the boundaries of the site. For a few cases, the casualty scenarios did result in contaminated land outside the site boundaries; however, the total land contaminated for those scenarios (inside and outside the boundary) was no more than 207 acres. The impact of this contamination would be temporary while the area was isolated and remediation efforts completed.

F.1 RADIOLOGICAL ISSUES FROM NAVAL SPENT NUCLEAR FUEL INSPECTIONS AND STORAGE

Naval spent nuclear fuel is currently examined and stored at the Naval Reactors Facility's Expended Core Facility (ECF) at the DOE Idaho National Engineering Laboratory (INEL). The INEL-ECF is a large laboratory facility used to receive, examine, and ship naval spent nuclear fuel and irradiated test specimen assemblies. Enclosed work areas at INEL-ECF include an array of interconnected reinforced concrete water pools which permit visual observation of naval spent nuclear fuel during handling and inspection while shielding workers from radiation. Adjacent to the water pools are shielded cells used for operations which must be performed dry. One of the water pools contains transfer canals that will link the water pools with a proposed Dry Cell Project, which would provide a location for preparation of spent fuel in a dry, enclosed environment.

The proposed Dry Cell Facility will consist of a shielded, radiologically controlled area built of structural steel and concrete with remotely operated equipment necessary to examine fuel modules.

The Organization for Economic Co-operation and Development (OECD) of the Nuclear Energy Agency (NEA) reported that extensive safety analysis has shown that pool storage of Zircaloy-clad fuel is a very safe option which can last for decades (NEA 1993). The external hazards, such as earthquakes and aircraft crashes, are potential threats for these facilities (loss of coolant) but appropriate siting, design, and additional shielding can cope with these hazards. Dry storage has not yet generally been carried out on a very large scale but it is anticipated that long-term storage in adequate canisters is a very safe practice even against earthquakes and aircraft crashes.

Several technologies are being used currently for the storage of spent fuel at reactor sites and at sites away from reactors. Both wet (pool) storage facilities and dry storage facilities (buildings and containers) are used on a commercial scale.

The safety of spent fuel storage has been extensively evaluated. The U.S. Nuclear Regulatory Commission (NRC) reported in the "Waste Confidence Decision" of 1984 that there is reasonable assurance that spent fuel can be stored safely and without significant environmental impact in reactor pools or in spent fuel storage installations (NUREG 1984). For both dry storage and wet storage, the NRC stated its belief that current storage technologies are capable of providing safe storage for at least 30 years beyond the active lifetime of the reactor facility. The NRC also concluded that the possibility of a major accident or sabotage at a spent fuel storage facility with radiological consequences for the public is extremely remote.

Considerable experience has been gained in the transport of spent fuel elements and in the consequent safety-related development of suitable transportation casks. This experience has made it possible to develop a concept for dry storage of spent fuel elements within transportation casks; dry storage containers generally have not been the transportation casks themselves.

The concept of a cask which could be used for both transportation and storage has been licensed in the United States in the framework of a policy of dry storage in Independent Spent Fuel Storage Installations (CFR 1993). According to this policy, the reactor operators are entitled to store the spent fuel elements, which have cooled in a pool for at least one year after discharge from the reactor, in specially licensed containers under dry conditions for 20 years or more. A number of storage casks have received official approval for that purpose.

F.1.1 Normal Operations

Current practice for examination of naval spent nuclear fuel at ECF includes removal of upper and lower non-fuel bearing structures, visual examination, measurement of key dimensions, collection of specimens, and loading into a shipping cask. Temporary storage of spent fuel at INEL-ECF is required since fuel is, at times, received into the facility faster than it can be examined and shipped out of the facility. In addition, a small amount of spent fuel is selected for retention as library specimens for future reference and examination. Routine releases to the atmosphere were evaluated at all locations based on measured releases from INEL-ECF. Each location was evaluated using releases equivalent to those of INEL-ECF. Each location's specific population and meteorology were then used to produce estimated consequences.

F.1.1.1 Water Pool Storage. Wet storage is a highly developed technique and it is the standard method used worldwide for storage of spent fuel. While in wet storage pools, temperatures, pressures, and radiation fluxes are lower than in the reactor, so there is no intrinsic driving force for the sudden release of a major fraction of the radioactive materials contained in the stored spent fuel.

The Zircaloy cladding of naval spent nuclear fuel is an efficient barrier against fission product release during handling and storage of spent fuel. Given adequate control of water purity, Zircaloy resists corrosion in water during the long-term storage conditions of fuel assemblies. At the end of its service life, the fuel is covered with a tightly adhering oxide layer formed at high temperatures which is a major factor that inhibits further corrosion during storage.

Direct exposure to radiation of persons working in storage facilities can occur during such activities as handling of fuel casks and fuel assemblies, handling of contaminated filters, and repair and maintenance work. Experience shows that, in common with other fuel cycle facilities, the risk of increased occupational exposure arises when any maintenance or unusual operations are carried out. Such increased exposures can, however, generally be minimized by good planning, adequate redundancy of critical components, paying particular attention to the design of those items that are liable to become contaminated from the point of view of repair and maintenance, and by the use of local shielding and equipment decontamination procedures. Systems and components that are important in this context include:

- pool water cooling and makeup systems;
- filter equipment for purification of pool water;
- ventilation systems;
- equipment for temperature, water level, and leakage measurement in the fuel pools;
- hoists and handling systems for fuel assemblies; and
- equipment for handling and storage of other wastes.

Shielding from radiation is normally assured by providing a minimum depth of water above the fuel elements in storage to reduce the exposure rates. Fuel transfer mechanisms have limit switches and mechanical stops to prevent the inadvertent raising of fuel to the water surface. A high-integrity pool structure is needed in order to guarantee adequate containment of the pool water, but a limited loss of water resulting in a substantial reduction of the shielding layer is unlikely to involve high risks of exposures to personnel above operational limits since adequate countermeasures can be taken in time.

Storage of naval spent nuclear fuel in water pools is an alternative being evaluated at all DOE and Navy shipyard locations discussed above. Source terms for all locations were based on actual releases reported by INEL-ECF in the past. Exposures due to downwind dispersion, water release, and direct radiation were calculated.

F.1.1.2 Dry Storage. Many thousands of spent fuel assemblies of different types have been stored for periods of time ranging from a couple of years to over 30 years in more than 20 different dry storage facilities. In general, the spent fuel behavior during storage has been excellent and no detrimental effects of dry storage on the integrity of the spent fuel have been detected (NEA 1993).

The dry storage of spent fuel is being used to a limited extent in several countries. In the United States, fuel was stored in dry wells at the INEL. Dry wells were used for the storage of a small amount of fuel at the Nevada Test Site as part of a large dry storage demonstration program. Storage started at the Climax deep dry wells (600 meters below the surface in granite) in 1979. In 1983, one fuel assembly underwent extensive non-destructive and destructive characterization. No problems requiring process changes were identified (NEA 1993).

Designs of metal casks for use in spent fuel storage have been in existence since the late 1970s. The casks are generally equipped with a double-lid system to ensure safe containment of contents. These casks have been subjected to a variety of tests and demonstrations since the early 1980s using both intact and consolidated fuel.

The DOE sponsored the demonstration of the storage of fuel in metal casks at the Morris storage facility in 1984 and 1985. The DOE entered into a cooperative agreement with Virginia Power, a United States' utility, to demonstrate the use of three types of metal casks. The Virginia Power Surry Nuclear Power Station has been licensed by the NRC for storage of spent fuel in metal casks.

Results of demonstration activities have shown the following (NEA 1993):

- radiation and thermal levels resulting from metal cask storage have been acceptable;
- no fuel failure has occurred during demonstration storage;
- no secondary wastes have arisen from the storage operation.

Storage of naval spent nuclear fuel in storage or shipping containers is an alternative being evaluated at all locations. Since no airborne releases are expected from routine dry storage activity, only the biological effects of direct radiation exposure to the on-site personnel and the public were determined.

F.1.1.3 Dry Cell Operations. The handling of naval spent nuclear fuel for research and development purposes in dry cells like the proposed Dry Cell Project was evaluated at selected DOE locations. The health effects due to routine airborne releases and direct radiation exposure were estimated.

F.1.2 Screening/Selection of Accidents for Detailed Examination

Accidents were considered for inclusion in detailed analyses if they were expected to contribute substantially to risk (defined as the product of the probability of occurrence of the accident times the consequence of the accident). Accidents were categorized into three types as either Abnormal Events, Design Basis Accidents, or Beyond Design Basis Accidents. These categories are characterized by their probability of occurrence as described further in Section F.1.3.7. Construction and industrial accidents are included in these categories.

In selecting accidents to include in detailed analyses, several considerations were utilized. Initiating events were reviewed including natural phenomena (earthquakes, volcanic activity, tornadoes, hurricanes and other natural events) and human initiated events (human error, equipment failures, fires, explosions, plane crashes, transportation accidents, and terrorism). Guiding principles were established, such as: the radioactive materials involved must be available in a dispersible form; there must be a mechanism available for release of such materials from the facility; and, there must be a mechanism available for off-site dispersion of the released materials. The pathways whereby members of the public can be affected from the nuclear aspects of spent fuel operations are direct exposure to radiation, inhalation of radioactive materials, or ingestion of radioactive materials. Recognizing these fundamental processes and pathways, accidents involving the following basic phenomena were identified:

- loss of shielding of radioactive materials,
- release of radioactive products to the environment due to overheating of fuel,
- release of radioactive products to the environment due to mechanical shock or damage or inadvertent breaching of fuel cladding or containment,

- an unplanned criticality,
- transportation accidents.

After the basic phenomena were identified, other references were consulted to ensure that all important accidents were considered. These included safety analysis reports, court decisions, other environmental impact statements, and summary documents such as the "Final Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Reactor Power Reactor Fuel" (NUREG 1979a) and "The Safety of the Nuclear Fuel Cycle" (NEA 1993).

Examining the kinds of accidents which could result in release of radioactive material to the environment or an increase in radiation levels shows that they can only occur if an accident produces severe conditions. Some types of accidents, such as procedure violations, spills of small volumes of water containing radioactive particles, or most other types of common human error, may occur more frequently than the more severe accidents analyzed. However, they do not involve enough radioactive material or radiation to result in a significant release to the environment or a meaningful increase in radiation levels. Stated another way, the very low consequences associated with these events produce smaller risks than those for the accidents analyzed, even when combined with a higher probability of occurrence. Consequently, they have not been included in the results presented in this Environmental Impact Statement.

Acts of terrorism are expected to result in consequences which are bounded by the results of accidents which were evaluated. Naval spent nuclear fuel is not considered to be attractive to terrorists due to the bulk of the fuel and containers and due to the high radiation fields involved with unshielded spent nuclear fuel. However, terrorist attacks on naval spent nuclear fuel during shipment were evaluated. The massive structure of the shipping containers used for naval spent nuclear fuel makes them an unlikely target of a terrorist attack. No such attacks have occurred in the nearly 40 years of rail shipments which have now travelled about 2 million kilometers. Thus, the probability of a terrorist attack on a shipment is judged to be no more than the probability of a rail accident which is listed in Section A.7.1.2.1 of Attachment A to Appendix D of this Environmental Impact Statement. The consequences of a terrorist attack are also judged to be no more severe than those listed for transportation accidents. Therefore, the same conclusions reached for transportation accidents apply to the risk to the extremely rugged shipping containers from terrorist attack during a shipment. In addition, during shipment, all naval spent nuclear fuel containers are accompanied by escorts who remain in contact with headquarters. In the event of an emergency, state and federal resources would be quickly summoned to stabilize the situation.

For an act of war, sabotage, or terrorist attack, it is likely the risk would be lower than calculated for the airplane crash because it should be less probable that a force would exist to disperse radioactive products into the atmosphere from a weapon as compared to the motive force of the fire assumed in the case of an airplane crash. For example, attacks on containers using anti-tank weapons would be less severe than the accidents analyzed because: (a) anti-tank weapons would cause a self-sealing penetration in the metal of a container, unlike that which is assumed from the airplane crash (impact from a 50-inch diameter engine rotor); (b) there is no explosive material inside the container, so it will not "blow up" as a tank would if hit by such a weapon (in a tank attack, the tank shells inside the turret detonate); (c) there would be no fire to disperse the radioactivity that is released when the container is breached, unlike an aircraft crash where the jet fuel will burn creating such a fire. The rugged design of containers and the thick walls of water pools, combined with the shock-absorbing nature of water with a free surface, reduce the effects of other types of explosive charges. It is not credible that a terrorist attack would result in a criticality or meltdown of spent nuclear fuel; however, in Section F.1.4.2.1.2, the consequences of a hypothetical criticality accident are presented. The risks associated with an accidental criticality are less than those associated with a drained water pool or an airplane crash into dry storage containers.

The effect of a terrorist attack or an act of sabotage is expected to be conservatively bounded by the limiting accident discussed at each facility under each alternative. For example, the most limiting accident involving naval spent nuclear fuel is described in this attachment to be an airplane crash into a shipping container at the Pearl Harbor Naval Shipyard. This accident would lead to 26 latent fatal cancers over the next 50 years in the population within 50 miles of the shipyard. Since the probability of the event is one chance in 100,000 per year, the risk would be 0.00026 latent fatal cancer fatalities per year or, in other words, about one chance in 4,000 of a single latent fatal cancer fatality over a year. This risk is shared among the approximately 820,000 people residing within 50 miles of the shipyard who would be expected to have over 2,000 cancer fatalities from all causes every year. For an act of war, sabotage, or terrorist attack, it is likely the risk would be lower than calculated because it should be less probable that a force would exist to disperse radioactive products into the atmosphere from a weapon as compared to the motive force of the fire assumed in the case of an airplane crash.

Accidents initiated at nearby facilities, by other activities unrelated to spent nuclear fuel handling or storage, or during construction of an ECF or dry cell type of facility, would not produce effects more severe than the sequences of events described. This is because naval spent nuclear fuel undergoing examination or in storage under the conditions of the alternatives evaluated would not need special conditions or uninterrupted operator attention to prevent overheating, failure of containment, or loss of shielding. Therefore, evacuation in response to an accident at some other facility would not compromise safety. This inherent safety, combined with the distance between naval spent nuclear fuel facilities and any other activities which might suffer a catastrophic accident, means that the accidents analyzed in this document produce conditions at a naval spent nuclear fuel facility which would be more severe than those for any hypothetical synergistic combination of events resulting from accidents at other, unrelated facilities. Therefore, such analyses have not been included in this evaluation.

The existence of common cause accidents at a facility has been considered. In general, only one spent nuclear fuel facility is located at a particular Navy site. However, it is possible for natural phenomena, like an earthquake, to produce more than one accident at some sites causing a situation resulting in the release of radioactive material into the atmosphere or an increase in radiation levels due to loss of shielding. However, the probability of two or more accidents having maximum consequences occur concurrently is less than the probability of the individual events. For example, if an earthquake affected the Naval Reactors Facility at INEL, a crane might fail causing damage to stored spent fuel, the water pool might drain, and shielding for the Dry Cell might be damaged. The impacts for this could conservatively be estimated by summing the consequences. A combined total of 2.8×10^{-2} fatal cancers are estimated. Similarly, consequences from spent nuclear fuel facilities within a DOE site could be combined to conservatively estimate site wide impacts. But again, the probability of a common cause event resulting in this number of consequences is lower than the probability of the individual accidents because the severity of impact will vary between facilities due to separation distances.

Several accident scenarios were developed for the handling and storage of naval spent nuclear fuel. All potential accidents were not evaluated, but cases which are considered to be more severe than all other reasonable accidents were analyzed. Each of these accident scenarios was evaluated at several locations using identical source terms. Like the evaluations for normal operations, population and meteorology data specific to each site were used to estimate site specific health effects.

F.1.2.1 Water Pool Storage. Six hypothetical accident scenarios were evaluated for naval spent nuclear fuel stored in water pools. These hypothetical sequences of events include a drainage of the water pool caused by an earthquake, an accidental criticality, mechanical damage due to operator error or crane failure, an airplane crash into the water pool facility, a fire in a high efficiency particulate air (HEPA) filter, and minor water pool leakage. Radiation exposure to on-site individuals, an individual at the site boundary, and the general population was estimated for airborne releases of radioactivity, water releases, and direct radiation exposure.

F.1.2.2 Dry Storage. Two hypothetical accident scenarios were evaluated for naval spent nuclear fuel stored in shipping containers. The first scenario postulates that a wind-driven missile crashes into storage casks, with mechanical damage causing a release of corrosion products into the environment. The second hypothetical scenario is based on an airplane crash into the dry storage area. Once again, radiation exposure to on-site individuals, an individual at the site boundary, and the general population was estimated for airborne releases, water releases, and direct radiation exposure.

F.1.2.3 Dry Cell Operations. Three hypothetical accidents were evaluated for naval spent nuclear fuel handled in dry cells at several locations. These scenarios include cutting into the fuel region or mechanical damage during examination work, partial loss of concrete shielding due to an earthquake, and an airplane crash into the dry cell facility. Once again, radiation exposure to on-site individuals, an individual at the site boundary, and the general population was estimated for airborne releases, water releases, and direct radiation exposure.

F.1.2.4 Shipboard Fire Involving Shipping Containers. Attachment A describes the historical practice of shipping naval spent nuclear fuel from Pearl Harbor Naval Shipyard to Puget Sound Naval Shipyard by ship where the containers are then transported to ECF by rail. Since 1962, there have been 17 shipments containing a total of 20 shipping containers. Even though there have not been any accidents involving these shipments, hypothetical accidents were evaluated near the Pearl Harbor and Puget Sound shipyards. The scenario involves a collision of the spent nuclear fuel ship with another ship which results in a fire. The radiation exposure to nearby individuals and the general population was estimated for airborne and water releases.

F.1.3 Analysis Methods for Evaluation of Radiation Exposure

F.1.3.1 General. An evaluation of normal operations and hypothetical accidents at the existing and proposed sites was performed to assess the possible radiation exposure to individuals due to the release of radioactive materials. The analyses are based on the same operations carried out at the different potential locations and the same accidents at any of the sites evaluated. With this approach, it is possible to compare the incremental effect of the proposed alternative actions or the different impacts of the postulated accidents at the different sites. These locations include four naval shipyards (Portsmouth, Norfolk, Puget Sound, and Pearl Harbor), five Department of Energy facilities (INEL, Savannah River, Hanford, Nevada Test Site, and Oak Ridge), and the Kesselring Site.

F.1.3.2 Exposures to be Calculated. Radiation exposure to the following different individuals and the general population is calculated for normal operation of the spent fuel facility and for accident conditions:

- Worker (Worker). An individual located 100 meters (330 feet) from the radioactive material release point. (The impact of accidents on close-in workers is not calculated numerically but is discussed qualitatively for each accident in Section F.1.4.3 of this attachment.)

- Maximally exposed collocated worker (MCW). At DOE locations, a theoretical individual located at whichever is the greater of 0.4 mile from the facility area boundary or 75% of the distance to the nearest independent facility area. The MCW is not evaluated if the site boundary is closer than the MCW location. Thus, at shipyard locations and the Kesselring Site, the MCW is not specifically evaluated.

- Maximally exposed off-site individual (MOI). A theoretical individual living at the DOE site or shipyard boundary receiving the maximum exposure. At the Savannah River Site, two separate MOI locations were evaluated depending upon whether the spent fuel facility is constructed on the Savannah River Site or is located at the existing Barnwell Nuclear Fuel Plant (hereafter referred to as the Barnwell Plant) which is adjacent to the Savannah River Site. At Hanford, two separate MOI locations were also evaluated depending upon whether a new facility is constructed in the 200 Area or modifications are made to the Fuels and Materials Examination Facility (FMEF) which is located in the 400 Area.

- Nearest public access individual (NPA). At larger DOE sites, highways used by the public may cross the federal reservation which includes the facility where naval spent nuclear fuel operations could be conducted. Consequently, these analyses included evaluation of the exposure to a theoretical motorist who might be stranded on such a highway at the time of an accident. Based on experience from emergency exercises, emergency response teams would be able to evacuate such an individual within 2 hours, so this was the exposure time used in the calculations. At naval shipyard locations, no public access highways exist, but military personnel, civilian employees, or their family members, including some who reside on the base, may be located outside the controlled industrial area boundary but inside the confines of the military base. Such personnel might be at their homes, in buildings, or on the roadways of the base at the time of an accident or at any time throughout the year for the evaluation of normal operations. The base residents are used as the NPA individuals at these shipyards for analyses of normal operations. In the event of a severe accident they would be evacuated within 2 hours under military control of the base, so this time was used in accident calculations. No NPA value was calculated for the Kesselring Site and the Nevada Test Site because there are no public roads which cross these sites, there are no residents, and there are no other public accesses.

- Maximally exposed individual at nearby communities is evaluated for accidents.

- General population within a 50-mile radius of the facility.

Exposure is calculated to result from direct radiation from the facility and exposure to radioactive contamination released to the air. Normal releases directly to the water pathway occur only at shipyards which are located directly on bodies of water, and contamination of the water at all sites results from fallout of airborne contamination. The releases to the air might result in exposure through several pathways described as follows:

- External direct exposure from immersion in the airborne radioactive material (air immersion)

- External direct exposure from radioactive material deposited on the ground (ground surface)

- Internal exposure from inhalation of radioactive aerosols and suspended particles (inhalation)

- Internal exposure from ingestion of terrestrial food and animal products (ingestion)
- Exposure from contaminated water (water release).

The radiation exposure is calculated by the computer programs discussed in Section F.1.3.6 in a manner recommended by the International Commission on Radiological Protection (ICRP 1977; ICRP 1979). Weighting factors are used for various body organs to calculate a "committed effective dose equivalent" (CEDE) from radiation inside the body due to inhalation or ingestion. Committed dose equivalents (CDEs) are calculated for organs such as the lungs, stomach, small intestine, upper large intestine, lower large intestine, bone surface red bone marrow, testes, ovaries, muscle, thyroid, bladder, kidneys, liver etc. The CEDE value is the summation of the CDEs to the specific organ weighted by the relative risk to that organ compared to an equivalent whole-body exposure.

The programs also calculate an effective dose equivalent (EDE) for the external exposure pathways (immersion in the radioactive material, exposure to ground contamination) and a 50-year CEDE for the internal exposure pathways . The sum of the EDE from external pathways and the CEDE internal pathways is called the "total effective dose equivalent" (TEDE) in this Environmental Impact Statement (EIS) and is also calculated by the programs. The TEDE reported in the results section is the sum of the TEDE's from air, water, and direct radiation exposures.

The exposure from ingestion of terrestrial food and animal products is calculated on a yearly basis. However, it is expected that continued consumption of contaminated food products by the public would be suspended after a Protective Action Guideline is reached. In 1991, the Environmental Protection Agency recommended protective action guidelines in the range of 1 to 5 rem whole-body exposure. To ensure a consistent analysis basis, no reduction of exposure due to a Protective Action Guideline was accounted for in the analysis. This would result in a conservative approach which may slightly overestimate health effects within an exposed population, but allows for consistent comparisons between alternatives.

Table F.1.3.2-1 identifies selected nearby communities for each site for which hypothetical exposures for a maximally exposed individual were calculated. In all cases, the MOI exposure was greater than maximum exposure at any nearby community. Calculations were performed for these localities to evaluate exposures for areas representative of the range of communities within 50 miles of the sites analyzed. The selection of these communities was not intended to indicate that other localities were not important. Other communities of interest in the vicinity of the sites in addition to those evaluated include a number of communities in Maine and New Hampshire near the Portsmouth Naval Shipyard, including Portsmouth, Durham, Eliot, Greenland, Kittery, New Castle, North Hampton, Ogunquit, Rye, and South Berwick.

Table F.1.3.2-1. Nearby communities for each site.

INEL	Howe, Atomic City, Arco, Blackfoot, Idaho Falls
Savannah River	Snelling, Barnwell, Jackson, Aiken, Allendale, Augusta, Sylvania, Bamberg, Wrens
Hanford	Othello, Richland, Prosser, Pasco, Yakima, Umatilla
Nevada Test Site	Beatty, Pahrump, Las Vegas
Oak Ridge	Oak Ridge, Harriman, Rockwood, Knoxville, Jefferson City
Puget Sound	Seattle, Tacoma, Olympia, Port Angeles
Pearl Harbor	Pearl City, Aiea, Pacific Palisades, Ewa Beach, Honolulu, Ewa, Wahiawa
Norfolk	Newport News, Hampton, Suffolk, Virginia Beach, Williamsburg
Portsmouth	Dover, Exeter, Hampton Beach, Sanford, Nashua, Lowell, Concord, Portland, Boston
Kesselring	Ballston Spa, Saratoga Springs, Amsterdam, Schenectady, Corinth

Table F.1.3.2-2 presents an example of the detailed exposure calculation results which were performed. The table shows the possible exposure pathways and individuals analyzed.

F.1.3.3 Evaluation of Health Effects. Health effects are calculated from the exposure results. The risk factors used for calculations of health effects are taken from Publication 60 of the International Commission on Radiological Protection (ICRP 1991). Table F.1.3.3-1 lists the appropriate factors used in the analysis of both the normal operations and the hypothetical accident scenarios.

Cancer fatalities were used to summarize and compare the results in this Environmental Impact Statement since this effect was viewed to be of the greatest interest to most people. As shown in Table F.1.3.3-1, the number of total health effects (deaths, non-fatal cancers, genetic effects, and other impacts on human health) may be easily obtained by multiplying the latent cancer fatalities by the factor of 1.46, which is the ratio of 7.3/5.0.

The numerical estimates of cancer deaths and other health detriments presented were obtained by the practice of linear extrapolation from the nominal risk estimate for lifetime total cancer mortality at 10 rad. Other methods of extrapolation to the low-dose region could yield higher or lower numerical estimates of cancer deaths. Studies of human populations exposed at low doses are

Table F.1.3.2-2. Summary of exposure calculation results.

Location	Inhalation CEDE (rem)	Air Immersion EDE (rem)	Ground Surface EDE (rem)	Ingestion EDE (rem)	Airborne Release EDE (rem)	Water Release (rem)	Direct Radiation (rem)	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.4×10^{-1}	6.5×10^{-4}	7.9×10^{-1}	N/A	1.3	N/A	8.8×10^{-5}	1.3	5.3×10^{-4}
MCW	4.8×10^{-4}	8.6×10^{-7}	3.4×10^{-4}	N/A	8.2×10^{-4}	1.6×10^{-17}	3.8×10^{-8}	8.2×10^{-4}	4.1×10^{-7}
NPA	1.4×10^{-4}	3.2×10^{-7}	5.2×10^{-5}	N/A	1.9×10^{-4}	1.6×10^{-17}	3.4×10^{-9}	1.9×10^{-4}	9.5×10^{-8}
MOI	6.1×10^{-4}	1.2×10^{-6}	7.8×10^{-4}	3.1×10^{-4}	1.7×10^{-3}	3.0×10^{-5}	9.6×10^{-9}	1.7×10^{-3}	8.6×10^{-7}
Exposure to Maximally Exposed Individual at Nearby Communities (rem)									
Arco (30600m)	5.2×10^{-5}	1.3×10^{-7}	6.4×10^{-5}	3.1×10^{-5}	1.5×10^{-4}	3.0×10^{-5}	3.4×10^{-9}	1.8×10^{-4}	8.8×10^{-8}
Howe (16100m)	9.8×10^{-5}	1.8×10^{-7}	1.2×10^{-4}	5.6×10^{-5}	2.7×10^{-4}	3.0×10^{-5}	3.4×10^{-9}	3.0×10^{-4}	1.5×10^{-7}
Idaho Falls (72400m)	3.1×10^{-6}	5.2×10^{-9}	3.6×10^{-6}	2.0×10^{-6}	8.7×10^{-6}	3.0×10^{-5}	2.1×10^{-10}	3.9×10^{-5}	1.9×10^{-8}
Blackfoot (68100m)	4.8×10^{-6}	3.3×10^{-9}	5.2×10^{-6}	3.4×10^{-6}	1.3×10^{-5}	3.0×10^{-5}	2.1×10^{-10}	4.3×10^{-5}	2.2×10^{-8}
Atomic City (24200m)	2.9×10^{-5}	1.0×10^{-7}	3.6×10^{-5}	1.6×10^{-5}	8.1×10^{-5}	3.0×10^{-5}	3.4×10^{-9}	1.1×10^{-4}	5.6×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)									Fatal Cancers
Population of 115690	1.1×10^{-1}	6.1×10^{-5}	1.5×10^{-1}	4.5×10^{-2}	3.0×10^{-1}	3.8	5.3×10^{-6}	4.1	2.1×10^{-3}

Table F.1.3.3-1. Risk estimators for health effects from ionizing radiation.

Effect	Nuclide	Risk Factor (probability per rem)* Worker	General Population
Fatal cancer (all organs)	All	4.0×10^{-4}	5.0×10^{-4}
Weighted non-fatal cancer**	All	8.0×10^{-5}	1.0×10^{-4}
Weighted genetic effects**	All	8.0×10^{-5}	1.3×10^{-4}
Weighted total effects**	All	5.6×10^{-4}	7.3×10^{-4}

* For high individual exposures (≥ 20 rem), the above risk factors are multiplied by a factor of two. General population exposures were not modified because the large drop in exposure with increasing distances results in average exposure rates well below 20 rem.

** In determining a means of assessing health effects from radiation exposure, the ICRP has developed a weighting method for non-fatal cancers and genetic effects to obtain a total weighted effect, or "health detriment".

inadequate to demonstrate the actual level of risk. There is scientific uncertainty about cancer risk in the low-dose region below the range of epidemiologic observation, and the possibility of no risk cannot be excluded (CIRRPC 1992). In this appendix, the doses have been provided in all cases to allow independent evaluation using any relation between exposure and health effects.

F.1.3.4 Population. Population distributions specific to each site were used for the evaluations. The population distributions were obtained from 1990 United States Census data. The population information was obtained in 16 compass directions and 5 equal radial distances from the likely location of a naval spent nuclear fuel site to a 50-mile total distance.

F.1.3.5 Meteorology. For the navy shipyards, Savannah River, and Kesselring Sites, the meteorological data used in the analyses were obtained from the SCRAM bulletin board system. For the INEL, Hanford, Nevada Test Site, and Oak Ridge, site tower meteorological data were used. The SCRAM bulletin board is operated by the Support Center for Regulatory Air Models within the Environmental Protection Agency, Office of Air Quality Planning and Standards. The SCRAM surface meteorological data files are comprised of data acquired from the National Climatic Data Center. The SCRAM data for 4 or 5 years were used with programs from the bulletin board to develop meteorological data in the STability ARray (STAR) format which is a joint frequency distribution of 6 wind speed intervals, 16 wind directions, and 6 stability categories. The STAR data were reformatted into the format required by the GENII program, described below, for evaluation of normal operations.

The STAR data were also used to calculate the 50% and 95% meteorological conditions for the accident analyses. The 50% condition represents the average meteorological condition. This condition is defined as that for which more severe conditions with respect to accident consequences occur less than 50% of the time. The 95% condition represents the meteorological conditions which could produce the highest calculated exposures. This is defined as that condition which is not exceeded more than 5% of the time or is the worst combination of weather stability class and wind speed. Each of these conditions is evaluated for 16 wind directions.

For each location, the nearest available SCRAM data was used to represent the conditions at the site being evaluated. Table F.1.3.5-1 shows the pertinent data for the meteorological data application.

Table F.1.3.5-1. Meteorological data applicability.

Site	Data From	Data Years
Portsmouth	Portland ME Airport	1985-1989
Norfolk	Norfolk VA Airport	1985-1989
Puget Sound	SEATAC Airport	1985-1989
Pearl Harbor	Honolulu Airport	1985-1989
INEL	NRF Tower	1987-1991
Kesselring	Albany NY Airport	1985-1989
Savannah River	Augusta GA Airport	1984-1987
Hanford	200 Area Tower	1983-1990
Nevada Test Site	Desert Rock Tower	1990
Oak Ridge	Y-12 West Tower	1990

F.1.3.6 Computer Programs. Five computer programs were used to evaluate the radiation exposures to the specified individuals and general population.

F.1.3.6.1 GENII. The code used for the environmental and transport and exposure assessment calculations for normal operations was GENII (Napier et al. 1988). This code was developed at Pacific Northwest Laboratory by Battelle Memorial Institute to incorporate the internal dosimetry models recommended by the International Commission on Radiological Protection in Publication 26 (ICRP 1977) and Publication 30 (ICRP 1979) into environmental pathway analysis models in use at Pacific Northwest Laboratory.

Although GENII can be used to model both acute and chronic releases to the atmosphere, only the chronic option was used in the normal operations evaluation reflecting long-term average exposure to the released radioactive contaminants. For the chronic evaluations, the code also uses meteorological conditions averaged over each sector to reflect exposure to long-term average concentrations. The ingestion calculation used the modeling approach that exposed individuals within 50 miles of the site consumed 30% of milk products and 10% of all products grown locally where the people live.

F.1.3.6.2 RSAC-5. The computer code RSAC-5 was developed by Westinghouse Idaho Nuclear Co, Inc., for the DOE-ID Operations Office and is in the public domain (Wenzel 1993). The code calculates the consequences of the release of radionuclides to the atmosphere. It allows the amount of each fission product nuclide from a nuclear event to be input individually or to be calculated internally by the code. RSAC-5 calculates potential radiation exposures to maximally exposed individuals or population groups via inhalation, ingestion, exposure to radionuclides deposited on the ground surface, immersion in airborne radioactive material, and radiation from a cloud of radioactive material. RSAC-5 meteorological capabilities include Gaussian plume dispersion for Pascal-Gifford conditions. RSAC-5 release scenario modeling allows reduction of nuclides by chemical group or element and calculates decay and buildup during transport through operations, facilities, and the environment. It also models the effect of filters or other cleanup systems. Population exposures are the product of the calculated individual exposure and the number of people in the affected population.

F.1.3.6.3 ORIGEN. ORIGEN (Croff 1980) is a computer code system for calculating the buildup and decay of radioactive materials (fission products, actinides, and activation products). The code input was modeled to describe the naval nuclear fuel system and incorporates cross-section data that are distinct to naval fuels.

F.1.3.6.4 SPAN. SPAN (Wallace 1972) is the computer code which was used to calculate the direct radiation levels. Attenuation from air was included in the calculated radiation levels. To determine the unit person exposure per sector, SPAN was used to integrate the radiation level over the sector. The radiation levels calculated at various distances were used as the source to represent the proper distance falloff in the sector, and a total radiation level for each sector was calculated. This total integrated radiation level for each sector was then divided by the sector volume, resulting in an "average" radiation exposure for any point within the sector.

F.1.3.6.5 WATER RELEASE. WATER RELEASE is an unpublished computer code used to calculate exposures to humans arising from radionuclides which have been introduced into water in the vicinity of the proposed spent nuclear fuel storage and examination facilities. The following discussion provides a brief description of the key points associated with obtaining these estimates. All radionuclides which were considered to be introduced into the water at a site were postulated to be promptly distributed uniformly in the water in the immediate vicinity of the site during the time period in which the nuclides were introduced. There are two processes by which radionuclides might enter the water at each site: via liquid discharge or via airborne discharge. For liquid discharges, a fraction of the released radionuclides might enter the water accessed by humans each year by infiltrating the ground to the groundwater then traveling either to wells or surface water. For airborne discharges, some fraction of the released radionuclides might enter the water by deposition from the air. For both of these processes, the fraction of radionuclides that might enter the water used by humans has been postulated to enter the water immediately, except for NRF and the Nevada Test Site. For NRF and the Nevada Test Site, it has been postulated that 20 years pass before the nuclides might enter the water accessed by humans. This estimate is based upon the fact that water must percolate into the ground and reach groundwater resources. Further, contamination must travel with the water in the aquifer to a point where it can be used by humans, such as a well at Atomic City. An assessment of the infiltration rate of radionuclides beneath ICPP estimates that about 200 years are needed for them to pass into the aquifer (Smith 1994). Also, the water in the aquifer flows at a rate of 5 to 20 feet per day. Therefore, 20 years was used as the time for radionuclides to reach humans at INEL. Similarly, at the Nevada Test Site surface water is not present so water must reach aquifers which are more than 600 feet deep. Hence, 20 years was also used at this site.

Once the radionuclides have been introduced into the water at a site, they were calculated to be transported to locations where they might affect man either directly as via immersion (swimming) or indirectly as via ingestion of food. During this transport period, these radionuclides are subjected to various mechanisms which may reduce their concentration in the water such as radioactive decay, dilution in larger volumes of water, removal by sedimentation, etc. The pathways considered in this analysis by which radionuclides in the water at a site might reach man are immersion, exposure to surface deposits, boating and equipment exposure, and consumption of drinking water, fish, crustacea, molluscs, game animals, vegetables and fruits, root crops, milk and eggs, and domesticated animals. During the period when the radionuclides have left the water environment and are being transported through the pathways to man, they may be subjected to both concentration and removal mechanisms which will further modify their effect upon man. These mechanisms include concentration in the surface deposit, animal, and crop pathways; decay during periods between harvesting a crop and its ingestion by man; and removal of activity due to harvesting, handling, and cleaning of a foodstuff.

For each of the sites at which storage or examination of spent nuclear fuel is being considered, estimates were made for the exposures which the total population affected by releases from the site may receive and for the exposures which a maximally exposed individual may receive from these same releases. The exposures to the population affected at a given site were obtained by calculating the exposures received by an average individual in the vicinity of that site and multiplying that exposure by the number of people that are affected. The exposure to a maximally exposed individual used the maximum exposures and consumption rates which any individual at that site may experience regardless of the probabilities associated with just one individual actually following all the maximum pathways. The specific pathways which are applicable at a given site are dependent upon the site, since the exposure of an average or a maximum individual to each of the pathways is different for each of the sites. For example, exposures associated with the drinking water pathway are not considered for the shipyard sites since all radionuclides basically end up in salt water prior to their becoming available to man at these sites. On the other hand, the radionuclides introduced at the DOE and prototype sites can enter the drinking water pathway after a delay period. An initial delay occurs while the radionuclides seep through the ground soil before entering the aquifer. The delay continues while the radionuclides travel through the drinking water pathway and ultimately yield exposures to man. The total exposure to the population or to a maximally exposed individual at a given site is the resultant sum of the exposure commitments from the individual pathways applicable at that site.

F.1.3.7 Categorization of Accidents.

F.1.3.7.1 Abnormal Events. Abnormal Events are unplanned or improper events which result in little or no consequence. Abnormal events include industrial accidents and accidents during normal operations such as skin contamination with radioactive materials, spills of radioactive liquids, or exposure to direct radiation due to improper placement of shielding. The occurrence of these unplanned events has been anticipated and mitigative procedures are in place which promptly detect and eliminate the events and limit the effects of these events on individuals. As a result, there is little hazard to the general population from these events. Such events are considered to occur in the probability range of 1 to 10^{-3} per year. The probability referred to here is the total probability of occurrence and includes the probability the event occurs (e.g., plane crash) times other probabilities required for the consequences. For accidents included in this range, results are presented for both the 50% meteorological condition (average meteorology) and the 95% meteorological condition.

F.1.3.7.2 Design Basis Accident Range. Accidents which have a probability of occurrence in the range of 10^{-3} to 10^{-6} per year are included in the range called the Design Basis Accident Range. The terminology "design basis accident," which normally refers to facilities to be constructed, also includes the "evaluation" basis accident which applies to existing facilities. For accidents included in this range, results are presented for both the 50% meteorological condition (average meteorology) and the 95% meteorological condition. Risk calculations for accidents in this range utilize the consequences associated with 95% meteorological conditions.

F.1.3.7.3 Beyond Design Basis Accidents. This range includes accidents which are less likely to occur than the design basis accidents but which may have very large or catastrophic consequences. Accidents included in this range typically have a total probability of occurrence in the range of 10^{-6} to 10^{-7} per year. Accidents which are less likely than 10^{-7} per year typically are not discussed since it is expected they do not contribute in any substantial way to the risk. For these beyond design basis accidents, consequences are presented for 50% and 95% meteorological conditions. Risk calculations for accidents in this range utilize the consequences associated with 95% meteorological conditions.

F.1.3.8 Evaluation of Impacted Area

The impacted area surrounding a facility following an accident was determined for each scenario evaluated. The impacted area was defined as that area in which the plume deposited radioactive material to such a degree that an individual standing on the boundary of the fallout area would receive approximately 0.01 mrem/hr of exposure. If this individual spends 24 hours a day at this location, that person would receive about 88 mrem per year from the ground surface shine. This is within the 100 mrem/year limit of 10CFR20.

To best characterize the affected areas for each casualty, a typical 50% meteorology was chosen (Pasquill-Gifford Class D, wind speed 10 mph) and applied to each accident scenario. The RSAC-5 results for ground surface dose were interpolated to determine the distance downwind where the centerline dose had dropped to approximately 88 mrem per year based on 24 hours per day exposure. For the wind class chosen, the plume remains within a singe 22.5-degree sector. The area affected by the plume is determined as the entire sector contaminated to the calculated downwind distance. Table F.1.3.8-1 lists each facility accident analyzed and the contaminated footprint associated with the accident.

F.1.3.8-1. Footprint estimates for facility accidents.

Accident Scenario	Footprint Length (miles)	Footprint Area* (acres)	Sites with Footprint Beyond Facility Boundary
Drained Water Pool	0.29	11	Norfolk, Oak Ridge, Portsmouth
Criticality	0.25	8	Norfolk, Oak Ridge, Portsmouth
Wet Storage Mechanical Damage	<0.06	<0.5	none
Wet Storage Airplane Crash	<0.06	<0.5	none
Dry Storage Mechanical Damage	<0.06	<0.5	none
Dry Storage Airplane Crash	0.91	106	Pearl Harbor, Norfolk, Oak Ridge, Portsmouth
Dry Cell Mechanical Damage	<0.06	<0.5	none
HEPA Filter Fire	<0.06	<0.5	none
Dry Cell Airplane Crash	1.27	207	Oak Ridge

*Based on contamination of a single sector.

Although the plume would be contained within a single sector, the direction of the wind is unknown. Therefore, each site was examined for impacts in all directions around the facility site out to a distance equal to the footprint length. Since the accidents do occur over a short duration of time, the acreage of the sector quoted is still an accurate indication of the total contaminated area. Identification of the potential impacts for each site is contained in Tables F.1.3.8-2 through -11.

Table F.1.3.8-2. Secondary impacts of facility accidents at Puget Sound Naval Shipyard.

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	National Defense	Environmental Contamination	Endangered Species	Land Use	Treaty Rights
Puget Sound Naval Shipyard	1. Dry Storage Plane Crash 2. Drained Water Pool 3. Criticality and all other radiological accidents	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	Naval vessels at the shipyard could be temporarily contaminated during the accident. Cleanup operations would restore these ships to full readiness.	1. A total of approximately 106 acres might require cleanup. Contamination could extend about 0.6 miles beyond the closest site boundary. 2. Contamination might occur up to the nearest shipyard boundary but would be limited to approximately 10 acres total. 3. Contamination would be within the shipyard boundaries. Table F.1.3.8-1 lists the area that could be contaminated.	The facility accident would not result in the extermination of any species. Nor would it effect the long term potential for survival of any species. A listing of endangered species can be found in Section 4.1.1 of this Appendix.	Access to some areas may be temporarily restricted until cleanup is completed. The total area restricted would be no greater than the areas identified under "Environmental Contamination".	No enduring impacts

Table F.1.3.8-3. Secondary impacts of facility accidents at Pearl Harbor Naval Shipyard.

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	National Defense	Environmental Contamination	Endangered Species	Land Use	Treaty Rights
Pearl Harbor Naval Shipyard	1. Dry Storage Plane Crash 2. All other radiological accidents	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	Naval vessels at the shipyard could be temporarily contaminated during the accident. Cleanup operations would restore these ships to full readiness.	1. A total of approximately 106 acres might require cleanup. Contamination could extend about 0.4 miles beyond the closest site boundary. 2. Contamination would be within the shipyard boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.	The facility accident would not result in the extermination of any species. Nor would it effect the long term potential for survival of any species. A listing of endangered species can be found in Section 4.1.4 of this Appendix.	Access to some areas may be temporarily restricted until cleanup is completed. The total area restricted would be no greater than the areas identified under "Environmental Contamination".	No enduring impacts

Table F.1.3.8-4. Secondary impacts of facility accidents at Norfolk Naval Shipyard.

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	National Defense	Environmental Contamination	Endangered Species	Land Use	Treaty Rights
Norfolk Naval Shipyard	1. Dry Storage Plane Crash 2. Drained Water Pool and Criticality 3. All other radiological accidents	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	Naval vessels at the shipyard could be temporarily contaminated during the accident. Cleanup operations would restore these ships to full readiness.	1. A total of approximately 106 acres might require cleanup. Contamination could extend about 0.8 miles beyond the closest site boundary. 2. This accident might contaminate about 10 acres which could extend beyond the nearest site boundary by about 0.1 miles 3. Contamination would be within the shipyard boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.	The facility accident would not result in the extermination of any species. Nor would it effect the long term potential for survival of any species. A listing of endangered species can be found in Section 4.1.2 of this Appendix.	Access to some areas may be temporarily restricted until cleanup is completed. The total area restricted would be no greater than the areas identified under "Environmental Contamination."	No enduring impacts

Table F.1.3.8-5. Secondary impacts of facility accidents at Portsmouth Naval Shipyard.

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	National Defense	Environmental Contamination	Endangered Species	Land Use	Treaty Rights
Portsmouth Naval Shipyard	1. Dry Storage Plane Crash 2. Drained Water Pool 3. Criticality and all other radiological accidents	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	Naval vessels at the shipyard could be temporarily contaminated during the accident. Cleanup operations would restore these ships to full readiness.	1. A total of approximately 106 acres might require cleanup. Contamination could extend about 0.6 miles beyond the closest site boundary. 2. Contamination might occur up to the nearest shipyard boundary but would be limited to approximately 10 acres total. 3. Contamination would be within the shipyard boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.	The facility accident would not result in the extermination of any species. Nor would it effect the long term potential for survival of any species. A listing of endangered species can be found Section 4.1.3 of this Appendix.	Access to some areas may be temporarily restricted until cleanup is completed. The total area restricted would be no greater than the areas identified under "Environmental Consequences".	No enduring impacts

Table F.1.3.8-6. Secondary impacts of facility accidents at Oak Ridge Reservation.

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	National Defense	Environmental Contamination	Endangered Species	Land Use	Treaty Rights
Oak Ridge Reservation	1. Dry Cell Air Plane Crash 2. Dry Storage Plane Crash 3. Drained Water Pool and Criticality 4. All other radiological accidents	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	No impacts	1. A total of approximately 207 acres might require cleanup. Contamination could extend about 1.1 miles beyond the closest site boundary. 2. This accident could contaminate about 106 acres and would extend beyond the nearest site boundary by about 0.7 miles. 3. About 10 acres might become contaminated extending about 0.1 miles offsite. 4.Contamination would remain within the site boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.	The facility accident would not result in the extermination of any species. Nor would it effect the long term potential for survival of any species. A listing of endangered species can be found in Section 4.5 of this Appendix.	Access to some areas may be temporarily restricted until cleanup is completed. The total area restricted would be no greater than the areas identified under "Environmental Consequences".	Some temporary restrictions on access may be required until cleanup is completed. No enduring impacts are expected.

Table F.1.3.8-7. Secondary impacts of facility accidents at Savannah River Site.

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	National Defense	Environmental Contamination	Endangered Species	Land Use	Treaty Rights
Savannah River Site	All Radiological Accidents	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on farming, fishing and other support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	No impacts	Contamination would remain within the site boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.	The facility accident would not result in the extermination of any species. Nor would it effect the long term potential for survival of any species. A listing of endangered species can be found in Section 4.3 of this Appendix.	Access to some areas may be temporarily restricted until cleanup is completed.	Some temporary restrictions on access may be required until cleanup is completed. No enduring impacts are expected.

Table F.1.3.8-8. Secondary impacts of facility accidents at Nevada Test Site.

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	National Defense	Environmental Contamination	Endangered Species	Land Use	Treaty Rights
Nevada Test Site	All Radiological Accidents	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	No impacts	Contamination would remain within the site boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.	The facility accident would not result in the extermination of any species. Nor would it effect the long term potential for survival of any species. A listing of endangered species can be found Section 4.6 of this Appendix.	Access to some areas may be temporarily restricted until cleanup is completed.	Some temporary restrictions on access may be required until cleanup is completed. No enduring impacts are expected.

Table F.1.3.8-9. Secondary impacts of facility accidents at Idaho National Engineering Laboratory.

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	National Defense	Environmental Contamination	Endangered Species	Land Use	Treaty Rights
Idaho National Engineering Laboratory	All Radiological Accidents	Plants and animals on the site and around the site will experience no long tenn impacts.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	No impacts	Contamination would remain within the site boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.	The facility accident would not result in the extennination of any species. Nor would it effect the long tenn potential for survival of any species. A listing of endangered species can be found Section 4.2 of this Appendix.	Access to some areas may be temporarily restricted until cleanup is completed.	Some temporary restrictions on access may be required until cleanup is completed. No enduring impacts are expected.

Table F.1.3.8-10. Secondary impacts of facility accidents at Hanford Site.

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	National Defense	Environmental Contamination	Endangered Species	Land Use	Treaty Rights
Hanford Site	All Radiological Accidents	Plants and animals on the site and around the site will experience no long term impacts.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	No impacts	Contamination would remain within the site boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.	The facility accident would not result in the extermination of any species. Nor would it effect the long term potential for survival of any species. A listing of endangered species can be found Section 4.4 of this Appendix.	Access to some areas may be temporarily restricted until cleanup is completed.	Some temporary restrictions on access may be required until cleanup is completed. No enduring impacts are expected.

Table F.1.3.8-11. Secondary impacts of facility accidents at Kenneth A. Kesselring Site.

Site	Significant Accidents in Decreasing Severity	Biotic Resources	Water Resources	Economic Impacts	National Defense	Environmental Contamination	Endangered Species	Land Use	Treaty Rights
Kenneth A. Kesselring Site	1. Dry Storage Plane Crash 2. Drained Water Pool and all other radiological accidents	Plants and animals on the site and around the site will experience no long tenn impacts.	The water used for drinking and industrial purposes is monitored and use may be temporarily suspended during cleanup operations. Some recreational activities may also be temporarily suspended. No enduring impacts are expected.	A small number of individuals may experience temporary job loss due to temporary restrictions on support activities near the facility during cleanup operations. Some costs would also be incurred for the actual cleanup operation.	No impacts	1. Contamination is expected right up to the nearest site boundary but limited to approximately 106 acres total. 2.Contamination would remain within the shipyard boundaries. Table F.1.3.8-1 lists the areas that could be contaminated.	The facility accident would not result in the extennination of any species. Nor would it effect the long tenn potential for survival of any species. A listing of endangered species can be found Section 4.1.5 of this Appendix.	Access to some areas may be tempoarily restricted until cleanup is completed.	Some temporary restrictions on access may be required until cleanup is completed. No enduring impacts are expected.

F.1.3.9 Emergency Preparedness and Mitigative Measures.

F.1.3.9.1 Emergency Preparedness Emergency plans are in effect at shipyards and prototype sites to ensure that workers and the public would be properly protected in the event of an accident. In addition, emergency plans are in effect for accidents involving the transportation of radioactive materials. These response plans include the activation of emergency response teams provided by the site and a site emergency control center, as well as activation of a command and control network with Naval Reactors Headquarters and supporting laboratories. The long standing emergency planning program that exists within the Naval Nuclear Propulsion Program includes the ability to utilize the comprehensive and extensive emergency response resources of each naval site and provides for coordination with appropriate civil authorities. In addition to the Naval Nuclear Propulsion Program resources, extensive federal emergency response resources are available as needed to support State or local response.

Emergency response measures include provisions for immediate response to any emergency at the shipyard or prototype site, identification of the accident conditions, and communications with civil authorities providing radiological data and recommendations for any appropriate protective actions. In the event of an accident involving radioactive or toxic materials, workers in the vicinity of the accident would promptly evacuate the immediate area. This evacuation can typically be accomplished within minutes of the accident and would reduce the hazard to workers.

Regularly scheduled exercises are conducted periodically at each site in order to test each site's ability to respond to accidents. These exercises include realistic tests of people, equipment, and communications involved in all aspects of the plans, and the plans are regularly reviewed and modified to incorporate experience gained from the exercises. These exercises also periodically include steps to verify the adequacy of interactions with local hospitals and emergency personnel and state officials.

F.1.3.9.2 Mitigative Factors. For members of the general public residing at the site boundary or beyond, no credit is taken for any preventive or mitigative actions that would limit their exposure. These individuals are calculated as being exposed to the entire contaminated plume as it travels downwind from the accident site. Similarly no action is taken to prevent these people from continuing their normal day-to-day routine and ingestion of terrestrial food and animal products continue on a yearly basis. As discussed in Section F.1.3, action would be taken to prevent the public from exceeding a Protective Action Guideline, if needed. No reduction of exposure due to these actions are accounted for in this analysis. The public is assumed to spend approximately 30% of the day within their homes or other buildings and the exposure to ground surface radiation is therefore reduced appropriately on a yearly basis.

Individuals that reside or work on site, or those that may be traversing the site in a vehicle would be evacuated from the affected area within 2 hours. This is based on the availability of security personnel at all locations to oversee the removal of residents, collocated workers, and travelers in a safe and efficient manner. Periodic training and evaluation of the security personnel is conducted to ensure that correct actions are taken during an actual casualty. Therefore, residents, collocated workers, and travelers would be exposed to the entire contaminated plume as it travels downwind for a period not to exceed 2 hours. Similarly, the radiation shine from the deposited radioactive materials would be limited to a 2-hour period. No ingestion of contamination is calculated for these individuals.

Facility workers all undergo training to take quick, decisive action during a casualty. These individuals quickly evacuate the area and move to previously defined "relocation" areas on the facility site. Workers could be exposed to a full 5 minutes of the radioactive plume as they move to the "relocation" centers. Once the immediate threat of the plume has moved off-site and downwind, the workers would be instructed to walk to vehicles waiting to evacuate them from the site. An additional 15 minutes would be required to evacuate the workers from the contaminated area and therefore the workers receive a total of 20 minutes of ground shine. No ingestion of contamination is calculated for these individuals.

The following summary provides the individual exposure times utilized in the accident analyses presented in Section F.1.4.2.

Estimated Time an Individual Might be Exposed

	Worker (100 m)	Collocated Worker (MCW) and Nearest Public Access (NPA)	Individual at Nearest Site Boundary (MOI)
To Plume	5 min.	100% of release time up to 120 min.	100% of release time
To Fallout on Ground Surface	20 min.	120 min.	0.7 yr
To Food	N/A	N/A	1 yr

F.1.3.10 Perspective on Calculations of Cancer Fatalities and Risk

The topics of human health effects caused by radiation and the risks associated with normal operations or postulated accidents associated with spent nuclear fuel management are discussed many times throughout this Environmental Impact Statement. It is important to understand these concepts and how they are used in order to understand the information presented in this document. It is also valuable to have some frame of reference or comparison for understanding how the risks compare to the risks of daily life.

The method used to calculate the risk of any impact is fundamental to all of the evaluations presented and follows standard accepted practices. The first step is to determine the probability that a specific event will occur. For example, the probability that a routine task, such as operating a crane, will be performed sometime during a year of normal operations at a facility would be 1. That means that the action would certainly occur. The probability that an accident might occur is less than 1.0. This is true because accidents occur only occasionally and some of the more severe accidents, such as a catastrophic earthquake, might occur at any location only once in hundreds, thousands, or millions of years.

Once the probability of an event has been determined, the next step is to predict what the consequences of the event being considered might be. One important measure of consequences chosen for this EIS is the number of human fatalities from cancer induced by radiation. This was chosen because this document deals with radioactive materials. The number of cancer fatalities that might be caused by any routine operation or any postulated accident can be calculated using a standard technique based on the amount of radiation exposure that might occur from all conceivable pathways and the number of people who might be affected (refer to Section F.1.3.3).

A couple of examples should serve to illustrate the calculation of risk. In the first, the lifetime risk of dying in a motor vehicle accident can be computed from the likelihood of an individual being in an automobile accident and the consequences or number of fatalities per accident. There were 10,000,000 motor vehicle accidents during 1992 in the United States resulting in about 40,000 deaths (NSC 1993). Thus, the probability of a person being in an automobile accident is 10,000,000 accidents divided by approximately 250,000,000 persons in the United States, or 0.04 per year. The number of fatalities per accident, 0.004 (40,000 deaths divided by 10,000,000 accidents), is less than 1 since many accidents do not cause fatalities. Multiplying the probability of the accident (0.04 per year) by the consequences of the accident (0.004 deaths per accident) by the number of years the person is exposed to the risk (72 years is considered to be an average lifetime) gives the risk for any individual being killed in an automobile accident. From this calculation, the overall risk of someone dying in a motor vehicle accident is about 1 chance in 87 over their lifetime.

A second example illustrates the calculation of risk for another event which occurs daily. Fossil fuels, such as natural gas or coal, contain naturally occurring radioactive material that is released into the air during combustion. This radioactivity in the air finds its way into our bodies through our food and the air we breathe. This radioactivity has been estimated to produce about 0.5 millirem of radiation dose to the average American each year (NCRP 1987). The probability of this happening is essentially 1.0 since these fuels are burned every day all over the country. The number of fatal cancers from exposure to 0.5 millirem per year is calculated by taking 0.5 millirem per year times the 72 years considered to be an average lifetime times the 0.0005 fatal cancers estimated to be caused by each rem (0.5 millirem per year x 72 years x 0.0005 fatal cancers per rem = 0.000018 fatal cancers per individual lifetime). The risk is the probability (1.0) times the consequences (0.000018 cancer fatalities) which equals about 1 chance in 55,000 of death from this cause over a lifetime.

These risks and others from everyday life can be used to gain a perspective on the risks associated with the alternatives in this EIS. As illustrated, the risk of death from cancer from the radioactivity released daily from combustion of fossil fuels is about 1 chance in 55,000 for the average American. As a further comparison, the naturally occurring radioactive materials in agricultural fertilizer contribute about 1 to 2 millirem per year to an average American's exposure to radiation (NCRP 1987). A calculation similar to the one in the preceding paragraph shows that the use of fertilizer to produce food crops in the United States results in a risk of death from cancer between 1 chance in 12,500 and 1 chance in 25,000. Finally, the average American's risk of dying from cancer from all causes is 1 chance in 5 over his or her lifetime. These risks can be compared, for example, to the average individual risk of less than 1 chance in 1 billion for a resident in the vicinity of the INEL developing a fatal cancer due to normal operations at the Expended Core Facility (see the data in Section F.1.4.1).

A frame of reference for the risks from accidents associated with spent nuclear fuel management alternatives can be developed in the same way. For an average resident in the vicinity of the INEL, the individual risk of death from cancer caused by the water leaking from the Expended Core Facility after a large earthquake would be approximately 1 chance in 9 billion. This individual risk was determined by dividing the risk value to the population within 50 miles (1.7×10^{-7} fatalities per year per accident from Table F-3) by the total population of 115,690 and multiplying by an average life span of 72 years. This risk can be compared to the risks of death from other accidental causes to gain a perspective. For example, the risk of death in a motor vehicle accident was calculated earlier to be about 1 chance in 87. Similarly, the risk of death for the average American from fires is approximately 1 chance in 500, and for death from accidental poisoning the risk is about 1 chance in 1000 (Crouch 1982).

F.1.4 Analysis Results

F.1.4.1 Normal Operations. The purpose of this analysis is to determine the hypothetical health effects on workers and the public due to routine handling of naval spent nuclear fuel. Radioactive releases from facilities involved in routine handling of naval spent nuclear fuel are small and less than those of comparable DOE and commercial nuclear facilities. Records of routine releases due to operations at ECF were used as source terms for all locations to estimate what effects these types of releases have on workers and the public. Site-specific meteorological and population data were used at each of the locations analyzed. For normal operations at the Naval Reactors Facility (NRF and Oak Ridge), exposure to the nearest public access (NPA) individual is not estimated due to the short period of time that such an individual would spend on-site while driving on the public access road. At Hanford, the NPA is located at the Washington Public Power Supply System Plant, and at Savannah River at the U.S. Forestry Service Office. The NPA at shipyard locations is defined in Section F.1.3.2.

F.1.4.1.1 Water Pool Examination and Storage Source Terms. The evaluation of normal water pool operations was performed using two different source terms. In one analysis, a source term was utilized which included both the incremental release of radioactive materials due to the alternative spent nuclear fuel storage actions and the release from other ongoing Naval Reactors activities. Identical source terms were used for the evaluation of radiation exposure due to the release of radioactive materials during normal operations of wet storage and spent fuel examinations. The 1991 annual airborne release from the INEL-ECF was used to evaluate these operations. Since the INEL-ECF releases are extremely low, this upper limit approach is not unduly conservative for the wet storage option which is expected to have a lower release. Table F.1.4.1.1-1 shows the 1991 INEL-ECF release rate, the current release rate at Kesselring and NRF (including both INEL-ECF and prototypes), and the release rate representing Naval Reactors operations at naval shipyards. The release rate representing naval shipyards is based on upper bound data from Navy operations contained in Naval Nuclear Propulsion Program (NNPP) Report NT-94-1 (NNPP 1994). With no current Naval Reactors facilities at Savannah River, Hanford, Oak Ridge, or the Nevada Test Site, the current release for each of these sites is zero for this analysis.

Table F.1.4.1.1-1. Airborne releases from current Naval Reactors operations.

Location	Annual Releases (Ci/year)			
INEL-ECF	H-3	9.35×10^{-2}	Y-90	5.5×10^{-6}
	C-14	7.0×10^{-1}	I-131	4.82×10^{-6}
	Sr-90	5.5×10^{-6}	Kr-85	3.0×10^{-1}
NRF	H-3	9.35×10^{-2}	Sr-90	2.45×10^{-5}
	C-14	8.0×10^{-1}	Y-90	2.45×10^{-5}
	Ar-41	2.7×10^{-1}	I-131	6.3×10^{-6}
	Co-60	1.6×10^{-6}	Cs-137	6.3×10^{-6}
	Kr-85	3.0×10^{-1}		
Kesselring	H-3	1.0×10^{-1}	Kr-85	1.0×10^{-3}
	C-14	4.0×10^{-1}	I-131	5.0×10^{-4}
	Ar-41	1.4	Cs-137	5.0×10^{-4}
	Co-60	1.0×10^{-3}		
Savannah River, Hanford, Nevada Test Site, Oak Ridge	none			
Portsmouth, Norfolk Puget Sound, Pearl Harbor	H-3	1.0×10^{-3}	Kr-87	5.0×10^{-2}
	C-14	1.0×10^{-1}	Kr-88	2.0×10^{-2}
	Ar-41	4.1×10^{-1}	Xe131m	5.0×10^{-3}
	Co-60	1.0×10^{-3}	Xe133m	1.0×10^{-2}
	Kr-83m	2.0×10^{-2}	Xe-133	2.1×10^{-1}
	Kr-85m	2.4×10^{-2}	Xe-135	2.5×10^{-1}
	Kr-85	1.0×10^{-3}		

The evaluation of continuing Naval Reactors activities combined with the proposed alternatives for naval spent nuclear fuel is based on the combined airborne release source terms shown in Table F.1.4.1.1-2. This table presents a summation of the INEL-ECF source term and the current Naval Reactors operations source terms from Table F.1.4.1.1-1 for each location. Beginning in 1995, with the shutdown of the S5G prototype, the NRF releases will only result from the INEL-ECF, and this condition is shown in the table.

The other analysis utilized the same source term at all locations. The INEL-ECF source term of Table F.1.4.1.1-1 was used to compare the incremental health effects due to providing water pool storage or examination facilities at each location.

Both analyses also considered the impact on health effects of direct radiation levels from a water pool facility and the deposition of radionuclides onto the ground and into water supplies as discussed in Sections F.1.3.6.4 and F.1.3.6.5.

Table F.1.4.1.1-2. Airborne releases used in the analysis of water pool activities plus ongoing Naval Reactors operations.

Location	Annual Releases (Ci/year)			
NRF, Savannah River, Hanford, Nevada Test Site, Oak Ridge	H-3	9.35×10^{-2}	Y-90	5.5×10^{-6}
	C-14	7.0×10^{-1}	I-131	4.82×10^{-6}
	Sr-90	5.5×10^{-6}	Kr-85	3.0×10^{-1}
Kesselring	H-3	1.935×10^{-1}	Sr-90	5.5×10^{-6}
	C-14	1.1	Y-90	5.5×10^{-6}
	Ar-41	1.4	I-131	5.0×10^{-4}
	Kr-85	3.0×10^{-1}	Cs-137	5.0×10^{-4}
	Co-60	1.0×10^{-3}		
Portsmouth, Norfolk Puget Sound, Pearl Harbor	H-3	9.45×10^{-2}	Kr-88	2.0×10^{-2}
	C-14	8.0×10^{-1}	Sr-90	5.5×10^{-6}
	Ar-41	4.1×10^{-1}	Y-90	5.5×10^{-6}
	Co-60	1.0×10^{-3}	I-131	4.8×10^{-6}
	Kr-83m	2.0×10^{-2}	Xe131m	5.0×10^{-3}
	Kr-85m	2.4×10^{-2}	Xe133m	1.0×10^{-2}
	Kr-85	3.0×10^{-1}	Xe-133	2.1×10^{-1}
	Kr-87	5.0×10^{-2}	Xe-135	2.5×10^{-1}

F.1.4.1.2 Dry Storage Source Terms. Another operation analyzed was the storage of naval spent nuclear fuel in shipping containers or storage casks in a safe array at NRF, the naval shipyards, and Kesselring locations. It is postulated that shielding and physical boundaries are established in accordance with existing regulations to protect facility workers. There are expected to be no routine airborne or water releases from the dry storage activity. The source will consist of an array of filled storage containers. Supplementary shielding would be provided as needed to ensure that there would be no measurable increase in radiation levels at the perimeter of the industrial area and that radiation levels within the industrial area but outside the storage area would not require occupational radiation exposure monitoring for workers. Each location analyzed would have a different number of storage casks. As containers are received over time, shielding will be provided to limit radiation exposure rates as discussed above. Distance falloff for radiation levels was determined using SPAN computer calculations as discussed in Section F.1.3.6.4.

F.1.4.1.3 Dry Cell Facility Source Terms. The normal airborne release source terms utilized for the dry cell facility analyses are identical to the INEL-ECF releases in Table F.1.4.1-1. It is expected that these values bound the actual releases from the proposed facility. A source term different from the water pool analysis was utilized for the direct radiation calculations. This source term is based on the proposed facility design, expected fuel examination capacity, and shielding calculations. Like the airborne releases, source terms for water deposition were identical to those utilized in the water pool analysis.

F.1.4.1.4 Water Pool Storage. This section presents tabulated radiation exposure results for the wet storage option. The following summary provides an indication of the incremental change at each location due to the addition of an ECF-type facility.

Summary of Exposure Calculation Results
For Normal Operations - Water Pool Examination or Storage only
At All Sites

	INEL/NRF	Savannah River	Hanford	Puget Sound	Pearl Harbor
Worker EDE (rem)	7.1×10^{-5}	9.1×10^{-5}	8.9×10^{-5}	9.4×10^{-5}	1.1×10^{-4}
MOI EDE (rem)	2.5×10^{-7}	4.8×10^{-7} 3.8×10^{-6}*	2.4×10^{-7} 4.4×10^{-7}**	8.7×10^{-5}	2.0×10^{-5}
NPA EDE (rem)	N/A	2.1×10^{-8}	1.3×10^{-8}	6.2×10^{-4}	5.2×10^{-4}
Total EDE (person-rem)	1.7×10^{-3}	3.6×10^{-2}	8.0×10^{-3}	1.3×10^{-1}	1.4×10^{-1}
Number of Fatal Cancers	8.5×10^{-7}	1.8×10^{-5}	4.0×10^{-6}	6.5×10^{-5}	7.0×10^{-5}

* MOI (Barnwell Plant)
** MOI (FMEF)

	Norfolk	Portsmouth	Kesselring	Nevada Test Site	Oak Ridge
Worker EDE (rem)	6.9×10^{-5}	7.7×10^{-5}	8.5×10^{-5}	4.6×10^{-5}	1.2×10^{-4}
MOI EDE (rem)	1.1×10^{-4}	4.4×10^{-5}	6.8×10^{-6}	3.4×10^{-7}	1.0×10^{-4}
NPA EDE (rem)	6.8×10^{-5}	3.3×10^{-4}	N/A	N/A	N/A
Total EDE (person-rem)	2.8×10^{-1}	4.5×10^{-2}	8.2×10^{-2}	1.8×10^{-4}	1.0×10^{-1}
Number of Fatal Cancers	1.4×10^{-4}	2.3×10^{-5}	4.1×10^{-5}	9.0×10^{-8}	5.0×10^{-5}

Evaluations of environmental impacts at DOE sites are presented in Volume 1, Appendices A, B, C, and F. The radiological impacts at these sites are quite low in that fatal cancer projections to the population within 50 miles from normal operations are well below 1.0. Further, impacts at naval shipyards and prototype sites are addressed in Appendix D and also are well below 1.0. Hence, the addition of the above small values to those which already exist at a site result in total values whicb are also quite small.

The following summary provides the exposure calculation results for water pool storage or examination plus all ongoing Naval Reactors operations at each site.

Summary of Exposure Calculation Results
For Normal Operations - Water Pool Examination or Storage
plus all ongoing Naval Reactors operations
At all sites

	INEL/NRF	Savannah River	Hanford	Puget Sound	Pearl Harbor
Worker EDE (rem)	7.1×10^{-5}	9.1×10^{-5}	8.9×10^{-5}	1.2×10^{-4}	1.4×10^{-4}
MOI EDE (rem)	2.5×10^{-7}	4.8×10^{-7} 3.8×10^{-6}*	2.4×10^{-7} 4.4×10^{-7}**	1.0×10^{-4}	2.3×10^{-5}
NPA EDE (rem)	N/A	2.1×10^{-8}	1.3×10^{-8}	7.2×10^{-4}	5.8×10^{-4}
Total EDE (person-rem)	1.7×10^{-3}	3.6×10^{-2}	8.0×10^{-3}	1.5×10^{-1}	1.7×10^{-1}
Number of Fatal Cancers	8.5×10^{-7}	1.8×10^{-5}	4.0×10^{-6}	7.6×10^{-5}	8.5×10^{-5}

* MOI (Barnwell Plant)
** MOI (FMEF)

	Norfolk	Portsmouth	Kesselring	Nevada Test Site	Oak Ridge
Worker EDE (rem)	8.4×10^{-5}	9.7×10^{-5}	1.4×10^{-4}	4.6×10^{-5}	1.2×10^{-4}
MOI EDE (rem)	1.2×10^{-4}	5.0×10^{-5}	1.2×10^{-5}	3.4×10^{-7}	1.0×10^{-4}
NPA EDE (rem)	7.4×10^{-5}	3.5×10^{-4}	N/A	N/A	N/A
Total EDE (person-rem)	3.4×10^{-1}	5.5×10^{-2}	1.4×10^{-1}	1.8×10^{-4}	1.0×10^{-1}
Number of Fatal Cancers	1.7×10^{-4}	2.7×10^{-5}	7.2×10^{-5}	9.0×10^{-8}	5.0×10^{-5}

Tables F.1.4.1.4-1 through -10 present the detailed results of using the source terms of Table F.1.4.1-2 to determine the radiation exposures. These tables thus depict the result if an ECF-type examination operation is added to existing, current, continuing Naval Reactors operations at DOE sites and Navy shipyards.

Table F.1.4.1.4-1. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors operations
At INEL

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.1×10^{-5}	2.8×10^{-8}
MCW	4.2×10^{-8}	1.7×10^{-11}
MOI	2.5×10^{-7}	1.3×10^{-10}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115,690	1.7×10^{-3}	8.5×10^{-7}

Table F.1.4.1.4-2. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors operations
At Savannah River

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.1×10^{-5}	3.6×10^{-8}
MCW	1.4×10^{-6}	5.6×10^{-10}
MOI (New ECF)*	4.8×10^{-7}	2.4×10^{-10}
MOI (Barnwell Plant)**	3.8×10^{-6}	1.9×10^{-9}
NPA	2.1×10^{-8}	1.1×10^{-11}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579,541	3.6×10^{-2}	1.8×10^{-5}

* MOI (New ECF) applies if spent fuel facility is constructed on the Savannah River Site.
** MOI (Barnwell Plant) applies if spent fuel facility is constructed at Barnwell Nuclear Fuel Plant.

Table F.1.4.1.4-3. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors operations
At Hanford

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.9×10^{-5}	3.6×10^{-8}
MCW	1.6×10^{-6}	6.4×10^{-10}
MOI (New ECF)*	2.4×10^{-7}	1.2×10^{-10}
MOI (FMEF)**	4.4×10^{-7}	2.2×10^{-10}
NPA	1.3×10^{-8}	6.5×10^{-12}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375,860	8.0×10^{-3}	4.0×10^{-6}

* MOI (New ECF) applies if spent fuel facility is constructed at the 200 area on the Hanford Site.
** MOI (FMEF) applies if spent fuel facility is constructed at the Fuels and Materials Examination Facility.

Table F.1.4.1.4-4. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operations
At Puget Sound

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.2×10^{-4}	4.8×10^{-8}
MOI	1.0×10^{-4}	5.1×10^{-8}
NPA	7.2×10^{-4}	3.6×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2,975,810	1.5×10^{-1}	7.6×10^{-5}

Table F.1.4.1.4-5. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operations
At Pearl Harbor

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4×10^{-4}	5.6×10^{-8}
MOI	2.3×10^{-5}	1.1×10^{-8}
NPA	5.8×10^{-4}	2.9×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817,385	1.7×10^{-1}	8.5×10^{-5}

Table F.1.4.1.4-6. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operations
At Norfolk

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.4×10^{-5}	3.4×10^{-8}
MOI	1.2×10^{-4}	6.1×10^{-8}
NPA	7.4×10^{-5}	3.7×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1,539,002	3.4×10^{-1}	1.7×10^{-4}

Table F.1.4.1.4-7. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operations
At Portsmouth

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.7×10^{-5}	3.9×10^{-8}
MOI	5.0×10^{-5}	2.5×10^{-8}
NPA	3.5×10^{-4}	1.7×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2,432,627	5.5×10^{-2}	2.7×10^{-5}

Table F.1.4.1.4-8. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Storage plus all ongoing Naval Reactors operations
At Kesselring

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4×10^{-4}	5.6×10^{-8}
MOI	1.2×10^{-5}	5.8×10^{-9}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1,148,587	1.4×10^{-1}	7.2×10^{-5}

Table F.1.4.1.4-9. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors operations
At Nevada Test Site

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.6×10^{-5}	1.8×10^{-8}
MCW	3.7×10^{-9}	1.5×10^{-12}
MOI	3.4×10^{-7}	1.7×10^{-10}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13,792	1.8×10^{-4}	9.0×10^{-8}

Table F.1.4.1.4-10. Summary of Exposure Calculation Results.
For Normal Operations - Water Pool Examination plus all ongoing Naval Reactors operations
At Oak Ridge

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.2×10^{-4}	4.8×10^{-8}
MCW	1.3×10^{-7}	5.1×10^{-11}
MOI	1.0×10^{-4}	5.1×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871,531	1.0×10^{-1}	5.0×10^{-5}

F.1.4.1.5 Dry Storage. This section presents tabulated radiation exposure results for tbe dry storage option at INEL, Navy shipyard sites, and tbe Kesselring Site. Dry storage at Hanford, Savannah River, tbe Nevada Test Site, and Oak Ridge is not included in tbis section as it is discussed in EIS Volume 1, Appendices A, C, and F, respectively. The following summary provides an indication of tbe incremental change at each location due to tbe addition of dry storage areas. The healtb effect due to dry storage of spent fuel is largest at the Navy shipyards and is extremely small at all DOE locations.

Summary of Exposure Calculation Results
For Normal Operations - Dry Storage only
At all sites

	INEL	Puget Sound	Pearl Harbor	Norfolk	Portsmoutb	Kesselring
Worker EDE (rem)	1.1×10^{-2}	5.4×10^{-3}	2.1×10^{-3}	5.8×10^{-3}	2.7×10^{-3}	6.1×10^{-4}
MOI EDE (rem)	6.5×10^{-14}	8.9×10^{-5}	1.5×10^{-6}	2.9×10^{-3}	5.6×10^{-5}	5.2×10^{-11}
NPA EDE (rem)	N/A	7.4×10^{-3}	2.3×10^{-2}	2.9×10^{-3}	2.2×10^{-2}	N/A
Total EDE (person-rem)	1.7×10^{-12}	2.4×10^{-3}	1.9×10^{-5}	4.3×10^{-2}	4.6×10^{-4}	8.2×10^{-9}
Number of Fatal Cancers	8.6×10^{-16}	1.2×10^{-6}	9.3×10^{-9}	2.1×10^{-5}	2.3×10^{-7}	4.1×10^{-12}

Tables F.1.4.1.5-1 through -6 present the results if a dry storage area is added to existing, current, continuing Naval Reactors operations at all locations.

Table F.1.4.1.5-1. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At INEL

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.1×10^{-2}	4.4×10^{-6}
MOI	1.1×10^{-10}	5.5×10^{-14}
NPA	6.5×10^{-14}	3.3×10^{-17}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115,690	1.7×10^{-12}	8.6×10^{-16}

Table F.1.4.1.5-2. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Puget Sound

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.4×10^{-3}	2.2×10^{-6}
MOI	1.1×10^{-4}	5.3×10^{-8}
NPA	7.5×10^{-3}	3.8×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2,975,810	3.6×10^{-2}	1.8×10^{-5}

Table F.1.4.1.5-3. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Pearl Harbor

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1×10^{-3}	8.5×10^{-7}
MOI	5.3×10^{-6}	2.7×10^{-9}
NPA	2.3×10^{-2}	1.2×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817,385	3.3×10^{-2}	1.7×10^{-5}

Table F.1.4.1.5-4. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Norfolk

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.8×10^{-3}	2.3×10^{-6}
MOI	2.9×10^{-3}	1.5×10^{-6}
NPA	2.9×10^{-3}	1.5×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1,539,002	9.7×10^{-2}	4.9×10^{-5}

Table F.1.4.1.5-5. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Portsmouth

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.7×10^{-3}	1.1×10^{-6}
MOI	6.3×10^{-5}	3.1×10^{-8}
NPA	2.2×10^{-2}	1.1×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2,432,627	9.2×10^{-3}	4.6×10^{-6}

Table F.1.4.1.5-6. Summary of Exposure Calculation Results.
For Normal Operations - Dry Storage plus all ongoing Naval Reactors operations
At Kesselring

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	6.6×10^{-4}	2.7×10^{-7}
MOI	5.1×10^{-6}	2.6×10^{-9}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1,148,587	5.7×10^{-2}	2.9×10^{-5}

F. 1.4. 1.6 Dry Cell Operations. This section presents tabulated radiation exposure results for tbe dry cell operations option. Since a facility like tbe proposed dry cell would only be constructed for tbe alternatives which include examination of all naval spent fuel, this analysis was only performed for the INEL, Savannah River, Hanford, the Nevada Test Site, and Oak Ridge locations. The following summary provides an indication of tbe incremental change at each location due to tbe addition of a dry cell facility. The calculated healtb effect to the general population is roughly proportional to tbe surrounding population witb Oak Ridge being tbe worst and Nevada Test Site being the best.

Summary of Exposure Calculation Results
For Normal Operations - Dry Cell Operations
At all sites

	INEL/NRF	Savannah River	Hanford	Nevada Test Site	Oak Ridge
Worker EDE (rem)	6.3×10^{-5}	8.3×10^{-5}	8.1×10^{-5}	3.5×10^{-5}	1.1×10^{-4}
MOI EDE (rem)	2.5×10^{-7}	4.8×10^{-7} 3.8×10^{-6}*	2.4×10^{-7} 4.4×10^{-7}**	3.4×10^{-7}	8.9×10^{-5}
NPA EDE (rem)	N/A	2.1×10^{-8}	1.3×10^{-8}	N/A	N/A
Total EDE (person-rem)	1.7×10^{-3}	3.6×10^{-2}	8.0×10^{-3}	1.8×10^{-4}	1.0×10^{-1}
Number of Fatal Cancers	8.5×10^{-7}	1.8×10^{-5}	4.0×10^{-6}	9.0×10^{-8}	5.0×10^{-5}

* MOI (Barnwell Plant)
** MOI (FMEF)

Tables F.1.4.1.6-1 tbrough -5 present the detailed analysis results.

Table F.1.4.1.6-1. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At INEL

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	6.3×10^{-5}	2.5×10^{-8}
MCW	4.2×10^{-8}	1.7×10^{-11}
MOI	2.5×10^{-7}	1.3×10^{-10}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115,690	1.7×10^{-3}	8.5×10^{-7}

Table F.1.4.1.6-2. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At Savannah River

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.3×10^{-5}	3.3×10^{-8}
MCW	1.3×10^{-6}	5.3×10^{-10}
MOI (New ECF)*	4.8×10^{-7}	2.4×10^{-10}
MOI (Barnwell Plant)**	3.8×10^{-6}	1.9×10^{-9}
NPA	2.1×10^{-8}	1.1×10^{-11}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579,541	3.6×10^{-2}	1.8×10^{-5}

* MOI (New ECF) applies if spent fuel facility is constructed on the Savannah River Site.
** MOI (Barnwell Plant) applies if spent fuel facility is constructed at Barnwell Nuclear Fuel Plant.

Table F.1.4.1.6-3. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At Hanford

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.1×10^{-5}	3.2×10^{-8}
MCW	1.5×10^{-6}	6.1×10^{-10}
MOI (New ECF)*	2.4×10^{-7}	1.2×10^{-10}
MOI (FMEF)**	4.4×10^{-7}	2.2×10^{-10}
NPA	1.3×10^{-8}	6.5×10^{-12}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375,800	8.0×10^{-3}	4.0×10^{-6}

* MOI (New ECF) applies if spent fuel facility is constructed at the 200 area on the Hanford Site.
**MOI (FMEF) applies if spent fuel facility is constructed at the Fuels and Materials Examination Facility.

Table F.1.4.1.6-4. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At Nevada Test Site

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.5×10^{-5}	1.5×10^{-8}
MCW	3.7×10^{-9}	1.5×10^{-12}
MOI	3.4×10^{-7}	1.7×10^{-10}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13,792	1.8×10^{-4}	9.0×10^{-8}

Table F.1.4.1.6-5. Summary of Exposure Calculation Results.
For Normal Operations - Dry Cell Operations
At Oak Ridge

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.1×10^{-4}	4.4×10^{-8}
MCW	1.1×10^{-7}	4.6×10^{-11}
MOI	8.9×10^{-5}	4.5×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871,531	1.0×10^{-1}	5.0×10^{-5}

F.1.4.2 Accident Evaluation. The analysis of airborne releases from hypothetical accidents is evaluated with RSAC-5. Unless stated otherwise, the following conditions were used when performing calculations with RSAC-5. In most cases, these conditions are taken directly as defaults from the code.

Meteorological Data

- Wind speed, direction, and Pasquill stability are taken from 50% and 95% meteorology. See Section F.1.3.5 for a discussion of meteorological conditions.

- The release is calculated as occurring at ground level (0 m).

- Mixing layer height is 400 meters (1320 feet). Airborne materials freely diffuse in the atmosphere near ground level in what is known as the mixing depth. A stable layer exists above the mixing depth which restricts vertical diffusion.

- Wet deposition is zero (no rain occurs to accelerate deposition and reduce the area affected).

- Dry deposition of the cloud is modeled. During movement of the radioactive plume, a fraction of the plume is deposited on the ground due to gravitational forces and becomes available for exposure by ground surface radiation and ingestion.

- The quantity of deposited radioactive material is proportional to the material size and speed. The following dry deposition velocities (m/s) were used:
  solids = 0.001 halogens = 0.01 noble gases = 0.0
  cesium = 0.001 ruthenium = 0.001.

- If radioactive releases occur through a stack, then additional plume dispersion can be accounted for by calculating a jet plume rise. In this analysis, jet plume rise is ignored.

- When released gases have a heat content, the plume can disperse more quickly. In this calculation, buoyant plume effects are ignored.

Inhalation Data

- Breathing rate is 3.33×10^{-4} cubic meters per second (cu m/s) for worker, MCW, and NPA; 2.66×10^{-4} cu m/s for people at site boundary and beyond.

- Particle size is 1.0 micron.

- The internal exposure period is 50 years for individual organs and tissues which have radionuclides committed.

- Exposure to the entire plume for the general public. The worker, MCW, and NPA are exposed as discussed in Section F.1.3.9.

- Inhalation exposure factors based on ICRP 30.

Ground Surface Exposure

- Exposed to contaminated soil for 1 year for the general public. See Section F.1.3.9 for additional details.

- Building shielding factor is 0.7 which exposes the individual to contaminated soil for 16 hours a day.

Ingestion Data

- Ingestion numbers will be reduced by a factor of 10 to account for only 10% of the food consumed being grown locally (such as in a person's garden).

- The following changes from RSAC-5 defaults were used:

  Annual Dietary Consumption Rates:

  177 Kg/yr Stored Vegetables (produce)
  18.3 Kg/yr Fresh Vegetables (leafy)
  94 Kg/yr Meat
  112 L/yr Milk.

F.1.4.2.1 Water Pool Storage. In the analysis of a spent fuel storage pool, a number of possible disturbances and minor accidents have been postulated. A prerequisite for a large release of radioactive material to the environment under more severe accident conditions is the damage of the cladding of a fairly large amount of stored fuel, with an accompanying release of gaseous and airborne particles of radioactive material from the fuel. Several conceivable mechanisms which might lead to this situation are the possibility that the fuel overheats so that the fuel cladding loses its integrity or there is a massive mechanical impact on the stored fuel.

The only way for the fuel to overheat would be to lose enough pool water such that cooling of the stored fuel ceases and the fuel temperature increases to fission product release temperatures due to decay heat. The pool water could be lost by leakage at a rate in excess of the makeup system capability. Unless a catastrophic event like an earthquake causes severe damage to the structure of the water pool, loss of water from the pool structure would be a slow phenomenon with only gradually increasing severity for which corrective measures can be taken in due time. Additionally, a thermal analysis was conducted to demonstrate that fuel overheating is not possible in the event of a drained water pool.

The circumstances in which an event could lead to severe mechanical loading of the fuel have been identified as:

- accidents during handling of heavy items, such as a lifting device failure
- external events (earthquake, tornado, flood, aircraft crash, etc.) which could cause structural failure.

Prevention of inadvertent, uncontrolled nuclear chain reactions is generally assured by the design of the racks for the fuel, primarily by diminishing the chances for a chain reaction by spacing the fuel element bundles far enough apart to eliminate the possibility. Special attention is given to the risk of accidental criticality which might be experienced in fuel transport and handling operations. Uncontrolled nuclear reaction is prevented during fuel handling by applying the principle of transferring one fuel element, module, or container at a time. In addition, fuel handling rules are developed to ensure that criticality cannot occur. The double accident criterion is applied to ensure that criticality would not occur following two severe, concurrent, unrelated accidents. Thus, three fuel handling accidents are required to reach an uncontrolled nuclear chain reaction.

F.1.4.2.1.1 Drained Water Pool.

F.1.4.2.1.1.1 Description of Conditions. In this hypothetical accident scenario, a catastrophic event, like an earthquake, causes severe damage to the structure of the water pool, resulting in a complete loss of pool water. A thermal analysis of spent fuel in a water pool was conducted to demonstrate that clad failure or fuel melting is not possible in the event of an accidentally drained water pool. Air circulation through the fuel racks and fuel units was shown to be sufficient to prevent clad failure in the unlikely event of complete loss of pool water. However, the loss of water could result in increased direct radiation and a release of corrosion products.

F.1.4.2.1.1.2 Source Term. Conditions used in developing the source term are as follows:

- 300 naval fuel units would be in the water pool.
- The thermal analysis demonstrates that no fission product release would occur during the accident.
- The amount of corrosion products on the fuel units is based on best estimate values.
- The release to the environment would occur at a constant rate over a 15-minute period.
- One percent of the original corrosion products from the fuel units might be released to the atmosphere due to thermal air currents. Additionally, 10% of the corrosion products could be released to the environment with the pool water.
- The following amounts of corrosion product nuclides might be released to the atmosphere. As noted above, the release to the water environment is 10 times these values. This listing includes nuclides that result in at least 99% of the exposure.
- No filtration by High Efficiency Particulate Air (HEPA) filters is assumed.

Nuclide	Curies
Co-60	3.6
Fe-55	6.6
Co-58	1.3
Mn-54	2.2×10^{-1}
Fe-59	1.9×10^{-2}

F.1.4.2.1.1.3 Results. The following table summarizes the public health risk to the general population that might result from the hypothetical drained water pool accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. The results are presented for the design basis accident with 50% and 95% meteorology. For INEL, the evaluation basis earthquake results in a 0.24 g peak ground acceleration at the ECF (Rizzo 1994). This is based on the event being initiated at the Howe earthquake epicenter and involving a surface rupture length of 34 kilometers. Using the medium response spectra, which is appropriate for a risk oriented analysis, the analyses of the structures at the INEL-ECF indicate that damage sufficient to cause the pool to drain would not occur if the pool is filled, but that, if several sections of the water pool were empty, a crack could develop in the area between the wall and floor of some of the older sections of the water pool. However, the INEL-ECF water pools are nearly always filled. Sections of the pool are only drained if maintenance work is necessary within the pools. Taking into account the probability of the initiating seismic event (1×10^{-4} per year to 4×10^{-4} per year) and the probability the earthquake will occur with a section of the pool drained, the total probability of occurrence of an event leading to draining of the pool is estimated to be in the range of 10^{-5} to 10^{-6} per year. A value of 10^{-5} was used to develop the risk results in the table.

A beyond design basis seismic event was also considered. For INEL, this beyond design basis earthquake is based on a scenario that results in a peak ground acceleration at the INEL-ECF of 0.40 g (Rizzo 1994). Analysis of this event has shown that some cracks could develop. The probability of this beyond design basis event is estimated to be in the range of 10^{-6} to 10^{-7} per year based on the probability of the initiating seismic event (2×10^{-5} to 6×10^{-5}), and the probability of failure of the mitigative actions that would be taken to prevent the pool from draining. A value of 10^{-6} was selected to calculate risk for this beyond design basis event. Any cracks developed as a result of either a design basis or a beyond design basis seismic event are expected to be small and mitigative actions could be taken to stop the pool from draining. Analysis has shown that air cooling is sufficient to maintain fuel integrity if the pool was drained. No overheating of fuel would occur; hence, no fission products would be released even if the pool were completely drained. The consequences calculated stem from the release of radioactive corrosion products within the pool water and would be the same for the design basis and beyond design basis seismic events. Since the consequences are the same, the following table uses the accident probability for the design basis seismic event since that results in the larger risk.

For locations other than INEL, water pools might need to be constructed. For these locations, it was expected that the design approaches would be similar to or better than were used in the construction of the INEL-ECF. Therefore, a probability value of 10^{-5} per year was also used at these locations for the total probability that a design basis seismic event would lead to draining of a water pool. Consequences were based on site specific population data and meteorology.

Drained Water Pool Summary			
Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
INEL	1.7×10^{-2}	1.7×10^{-2}	1.7×10^{-7}
Savannah River	1.6×10^{-2}	1.1×10^{-1}	1.1×10^{-6}
Hanford	6.3×10^{-3}	4.7×10^{-2}	4.7×10^{-7}
Puget Sound	1.4	5.1×10^{-1}	5.1×10^{-6}
Pearl Harbor	7.9×10^{-1}	1.1	1.1×10^{-5}
Norfolk	3.0	6.0×10^{-1}	6.0×10^{-6}
Portsmouth	1.6	3.4×10^{-1}	3.4×10^{-6}
Kesselring	2.9×10^{-1}	2.5×10^{-1}	2.5×10^{-6}
Nevada Test Site	3.3×10^{-2}	1.9×10^{-3}	1.9×10^{-8}
Oak Ridge	5.2	1.8×10^{-1}	1.8×10^{-6}

The risk for this hypothetical accident is generally more severe at Navy shipyards than at the DOE sites. At all sites, this accident results in the highest risk of the wet storage accidents evaluated.

For the hypothetical drained water pool scenario, the radioactive plume might result in contamination of the ground to a downwind distance of 0.29 mile. This would yield a total area impacted by the accident of approximately 11 acres. The calculated downwind distance would be contained within the boundaries of all sites under evaluation with the exception of Oak Ridge and Norfolk.

Table F.1.4.2.1.1-1. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At INEL

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.5×10^{-1}	3.0×10^{-4}
MCW	6.9×10^{-4}	2.7×10^{-7}
NPA	3.9×10^{-4}	2.0×10^{-7}
MOI	2.8×10^{-3}	1.4×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	6.7	3.3×10^{-3}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3×10^{-4}
MCW	7.6×10^{-3}	3.0×10^{-6}
NPA	2.3×10^{-3}	1.2×10^{-6}
MOI	1.7×10^{-2}	8.5×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	3.5×10^{1}	1.7×10^{-2}

Table F.1.4.2.1.1-2. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Savannah River

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.4×10^{-1}	1.3×10^{-4}
MCW	2.0×10^{-2}	7.9×10^{-6}
NPA	2.5×10^{-4}	1.3×10^{-7}
MOI (New ECF)	3.5×10^{-3}	1.8×10^{-6}
MOI (Barnwell)	1.3×10^{-2}	6.3×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	2.4×10^{1}	1.2×10^{-2}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3×10^{-4}
MCW	2.5×10^{-1}	1.0×10^{-4}
NPA	4.3×10^{-3}	2.1×10^{-6}
MOI (New ECF)	1.6×10^{-2}	8.0×10^{-6}
MOI (Barnwell)	1.4×10^{-1}	7.2×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	2.2×10^{2}	1.1×10^{-1}

Table F.1.4.2.1.1-3. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Hanford

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.4×10^{-1}	1.3×10^{-4}
MCW	2.6×10^{-2}	1.0×10^{-5}
NPA	3.0×10^{-4}	1.5×10^{-7}
MOI (New ECF)	8.3×10^{-4}	4.2×10^{-7}
MOI (FMEF)	1.7×10^{-3}	8.6×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	4.8	2.4×10^{-3}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3×10^{-4}
MCW	1.6×10^{-1}	6.6×10^{-5}
NPA	4.8×10^{-3}	2.4×10^{-6}
MOI (New ECF)	6.3×10^{-3}	3.2×10^{-6}
MOI (FMEF)	2.2×10^{-2}	1.1×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	9.4×10^{1}	4.7×10^{-2}

Table F.1.4.2.1.1-4. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Puget Sound

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.8×10^{-1}	7.3×10^{-5}
MCW	N/A	N/A
NPA	2.2×10^{-1}	1.1×10^{-4}
MOI	1.2×10^{-1}	6.0×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	1.7×10^{2}	8.2×10^{-2}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3×10^{-4}
MCW	N/A	N/A
NPA	2.6	1.3×10^{-3}
MOI	1.4	7.2×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	1.0×10^{3}	5.1×10^{-1}

Table F.1.4.2.1.1-5. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Pearl Harbor

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.5×10^{-1}	3.0×10^{-4}
MCW	N/A	N/A
NPA	1.9×10^{-1}	9.7×10^{-5}
MOI	2.0×10^{-1}	9.8×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	8.0×10^{2}	4.0×10^{-1}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3×10^{-4}
MCW	N/A	N/A
NPA	6.3	3.1×10^{-3}
MOI	7.9×10^{-1}	3.9×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	2.2×10^{3}	1.1

Table F.1.4.2.1.1-6. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Norfolk

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.8×10^{-1}	7.4×10^{-5}
MCW	N/A	N/A
NPA	4.6×10^{-2}	2.3×10^{-5}
MOI	2.8×10^{-1}	1.4×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.5×10^{2}	7.7×10^{-2}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3×10^{-4}
MCW	N/A	N/A
NPA	5.3×10^{-1}	2.7×10^{-4}
MOI	3.0	1.5×10^{-3}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.2×10^{3}	6.0×10^{-1}

Table F.1.4.2.1.1-7. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Portsmouth

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.8×10^{-1}	7.3×10^{-5}
MCW	N/A	N/A
NPA	4.4×10^{-2}	2.2×10^{-5}
MOI	1.3×10^{-1}	6.4×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	6.5×10^{1}	3.2×10^{-2}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3×10^{-4}
MCW	N/A	N/A
NPA	9.8×10^{-1}	4.9×10^{-4}
MOI	1.6	7.9×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	6.7×10^{2}	3.4×10^{-1}

Table F.1.4.2.1.1-8. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Kesselring

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.8×10^{-1}	7.4×10^{-5}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	2.0×10^{-2}	1.0×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	7.1×10^{1}	3.6×10^{-2}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3×10^{-4}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	2.9×10^{-1}	1.5×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	5.0×10^{2}	2.5×10^{-1}

Table F.1.4.2.1.1-9. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Nevada Test Site

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.2×10^{-1}	4.8×10^{-5}
MCW	9.3×10^{-5}	3.7×10^{-8}
NPA	N/A	N/A
MOI	1.5×10^{-3}	7.5×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	3.2×10^{-1}	1.6×10^{-4}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3×10^{-4}
MCW	5.4×10^{-3}	2.2×10^{-6}
NPA	N/A	N/A
MOI	3.3×10^{-2}	1.7×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	3.7	1.9×10^{-3}

Table F.1.4.2.1.1-10. Summary of Exposure Calculation Results.
For Wet Storage - Drained Water Pool
At Oak Ridge

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.5×10^{-1}	3.0×10^{-4}
MCW	2.0×10^{-2}	7.9×10^{-6}
NPA	2.6×10^{-1}	1.3×10^{-4}
MOI	8.2×10^{-1}	4.1×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	7.1×10^{1}	3.6×10^{-2}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1	8.3×10^{-4}
MCW	1.2×10^{-1}	4.8×10^{-5}
NPA	1.6	8.2×10^{-4}
MOI	5.2	2.6×10^{-3}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	3.5×10^{2}	1.8×10^{-1}

F.1.4.2.1.2 Accidental Criticality.

F.1.4.2.1.2.1 Description of Conditions. In this hypothetical accident scenario, an accidental uncontrolled chain reaction producing 1 x 10^{19} fissions is postulated. The criticality occurs in the water pool which is not emptied by the event and does not subsequently empty. Release of fission products includes those specified in Regulatory Guide 3.34 (NUREG 1979b) from the criticality, plus fission products remaining in the fuel as a result of the original use. Removal of fission products by the pool water is included.

F.1.4.2.1.2.2 Source Term. Conditions used in developing the source term are as follows:

- The fraction of the fission products released to the building is 100% of the noble gases, 25% of the halogens, 0.1% of the ruthenium (Elder et al. 1986), and 0.05% of the cesium and remaining solids.

- The original inventory of fission products from two naval fuel units are available for release in addition to those created by the criticality event.

- A High Efficiency Particulate Air (HEPA) filter removes 99.9% of the solid fission products from the plume.

- The release to the environment occurs at a constant rate over a 15-minute period. This is conservative as compared to the 8-hour release allowed in Regulatory Guide 3.34.

- The following amounts of radionuclides are released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

Nuclide	Curies	Nuclide	Curies
Te-133	3.4×10^{3}	I-132	1.7×10^{0}
I-134	3.5×10^{2}	Sr-90	1.94×10^{-2}
I-135	1.2×10^{2}	Y-91m	4.3×10^{-8}
Cs-138	1.6×10^{-4}	Rb-88	1.7×10^{-5}
Rb-89	6.05×10^{-4}	Y-91	1.1×10^{-2}
Pu-238	3.7×10^{-4}	Cs-139	7.3×10^{-3}
Br-84	2.3×10^{2}	Ba-142	4.8×10^{-3}
I-133	2.4×10^{0}	Y-93	1.3×10^{-6}
Sr-91	5.4×10^{-6}	Ba-137m	1.9×10^{-2}
Sr-92	2.4×10^{-4}	Ru-106	7.6×10^{-3}
Ba-139	6.9×10^{-6}	Zr-95	1.4×10^{-2}
Ba-141	8.8×10^{-4}	Sr-89	7.01×10^{-3}
I-129	5.1×10^{-3}	Eu-154	1.3×10^{-3}
I-131	3.2×10^{-1}		
H-3	1.42×10^{2}		
Cs-134	1.5×10^{-2}		
Ba-140	2.5×10^{-5}		
I-136	1.1×10^{4}		
Cs-137	2.0×10^{-2}		
Ce-144	4.5×10^{-2}		
Nb-95	2.7×10^{-2}		
Rb-90	2.2×10^{-2}		

F.1.4.2.1.2.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical criticality accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. An accidental criticality during spent nuclear fuel handling operations is extremely unlikely. There are no known events of this type which have occurred during handling of fuel modules either in or out of water. Due to the need for a neutron moderator, extremely large quantities of naval fuels would be required to achieve criticality in a dry state. Fuel handling procedures in water in conjunction with required physical barriers ensure that a double accident criterion is met. This criterion specifies that the fuel will not attain a critical condition even if any two unlikely and unrelated accidents occur at the same time. The DOE criticality control requirement is a double contingency criterion which specifies that a second unlikely and unrelated accident would be required for a critical condition to result. To satisfy the NNPP double accident criterion, naval fuel handling operations are conducted in the following manner:

- No more than one module is to be handled in one area at a time.

- If two modules are capable of achieving a critical condition, separation must be maintained by a positive barrier between them which is locked in place.

- If three modules are required to achieve criticality, a physical barrier which does not need to be locked is required to be placed between them.

- If four or more modules are needed to achieve criticality, no barriers are required, but modules are to remain separated.

Based on the above requirements, at least three distinct errors are needed to achieve accidental criticality. For example, bringing two or more modules in close proximity is always prohibited. Failure to maintain separation constitutes an error. Secondly, failure to recognize and use physical barriers when required also constitutes an error. A human error rate of 10^{-3} per operation (Swain and Guttman 1983) is taken as the probability of error for trained personnel. Further, because all fuel handling operations must be checked by an independent verifier, an additional factor of 10^{-1} may be taken for a probability of 10^{-4} for each independent error. For naval fuel handling, an error in which two modules are brought together is a violation of a fundamental requirement. Compliance with this requirement alone ensures that a subcritical state is maintained. Therefore, the bringing of two or more modules together error is considered separate and independent of all other errors. Because a second error must occur to cause accidental criticality, an additional reduction in the probability is warranted. For example, failure to recognize the need to install a barrier when required is such an error. Because this mistake is independent of the first error and has been checked, a second value of 10^{-4} is appropriate for a total value of 10^{8} per year. This probability is taken as the likelihood of a criticality for movement of a single module. Based on an estimated 1,000 fuel handling operations a year, a value of 10^{-5} per year has been used in the risk assessment of accidental criticality.

Accidental Criticality Summary			
Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
INEL	9.2×10^{-3}	6.4×10^{-3}	6.4×10^{-8}
Savannah River	9.4×10^{-3}	4.5×10^{-2}	4.5×10^{-7}
Hanford	2.8×10^{-3}	1.6×10^{-2}	1.6×10^{-7}
Puget Sound	1.3	2.8×10^{-1}	2.8×10^{-6}
Pearl Harbor	6.7×10^{-1}	6.0×10^{-1}	6.0×10^{-6}
Norfolk	2.7	3.5×10^{-1}	3.5×10^{-6}
Portsmouth	1.4	1.5×10^{-1}	1.5×10^{-6}
Kesselring	2.3×10^{-1}	1.1×10^{-1}	1.1×10^{-6}
Nevada Test Site	2.0×10^{-2}	7.0×10^{-4}	7.0×10^{-9}
Oak Ridge	4.7	8.8×10^{-2}	8.8×10^{-7}

The risk for this hypothetical accident is more severe at Navy shipyards than at the DOE sites. At all sites, this accident results in the second highest risk of the wet storage accidents evaluated.

For the hypothetical criticality accident scenario, the radioactive plume might cause contamination of the ground to a downwind distance of 0.25 mile. This would yield a total area impacted by the accident of approximately 8 acres. The calculated downwind distance would be contained within the boundaries of all sites under evaluation with the exception of Oak Ridge and Norfolk.

Table F.1.4.2.1.2-1. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At INEL

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.0	1.2×10^{-3}
MCW	1.3×10^{-3}	5.1×10^{-7}
NPA	5.9×10^{-4}	2.9×10^{-7}
MOI	2.0×10^{-3}	1.0×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	5.5	2.8×10^{-3}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2×10^{-3}
MCW	1.3×10^{-2}	5.0×10^{-6}
NPA	2.8×10^{-3}	1.4×10^{-6}
MOI	9.2×10^{-3}	4.6×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	1.3×10^{1}	6.4×10^{-3}

Table F.1.4.2.1.2-2. Summary of Exposure Calculation Results. For Wet Storage - Accidental Criticality At Savannah River

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.3	5.3×10^{-4}
MCW	6.8×10^{-2}	2.7×10^{-5}
NPA	7.4×10^{-4}	3.7×10^{-7}
MOI (New (ECF)	3.3×10^{-3}	1.6×10^{-6}
MOI (Barnwell)	1.2×10^{-2}	5.9×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	2.2×10^{1}	1.1×10^{-2}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2×10^{-3}
MCW	7.9×10^{-1}	3.1×10^{-4}
NPA	6.4×10^{-3}	3.2×10^{-6}
MOI (New ECF)	9.4×10^{-3}	4.7×10^{-6}
MOI (Barnwell)	1.1×10^{-1}	5.3×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	8.9×10^{1}	4.5×10^{-2}

Table F.1.4.2.1.2-3. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Hanford

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.3	5.3×10^{-4}
MCW	8.9×10^{-2}	3.5×10^{-5}
NPA	6.6×10^{-4}	3.3×10^{-7}
MOI (New (ECF)	4.7×10^{-4}	2.4×10^{-7}
MOI (FMEF)	1.3×10^{-3}	6.7×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	2.2	1.1×10^{-3}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2×10^{-3}
MCW	4.9×10^{-1}	2.0×10^{-4}
NPA	6.9×10^{-3}	3.5×10^{-6}
MOI (New ECF)	2.8×10^{-3}	1.4×10^{-6}
MOI (FMEF)	1.2×10^{-2}	6.1×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	3.1×10^{1}	1.6×10^{-2}

Table F.1.4.2.1.2-4. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Puget Sound

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2×10^{-1}	2.9×10^{-4}
MCW	N/A	N/A
NPA	7.7×10^{-1}	3.8×10^{-4}
MOI	1.1×10^{-1}	5.6×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	2.3×10^{2}	1.1×10^{-1}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2×10^{-3}
MCW	N/A	N/A
NPA	8.8	4.4×10^{-3}
MOI	1.3	6.3×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	5.6×10^{2}	2.8×10^{-1}

Table F.1.4.2.1.2-5. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Pearl Harbor

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.0	1.2×10^{-3}
MCW	N/A	N/A
NPA	7.0×10^{-1}	3.5×10^{-4}
MOI	1.8×10^{-1}	8.9×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	5.6×10^{2}	2.8×10^{-1}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2×10^{-3}
MCW	N/A	N/A
NPA	2.2×10^{1}	2.2×10^{-2}
MOI	6.7×10^{-1}	3.4×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	1.2×10^{3}	6.0×10^{-1}

Table F.1.4.2.1.2-6. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Norfolk

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.4×10^{-1}	2.9×10^{-4}
MCW	N/A	N/A
NPA	1.6×10^{-1}	8.2×10^{-5}
MOI	2.7×10^{-1}	1.3×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.6×10^{2}	8.1×10^{-2}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2×10^{-3}
MCW	N/A	N/A
NPA	1.8	8.8×10^{-4}
MOI	2.7	1.4×10^{-3}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	7.0×10^{2}	3.5×10^{-1}

Table F.1.4.2.1.2-7. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Portsmouth

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2×10^{-1}	2.9×10^{-4}
MCW	N/A	N/A
NPA	1.5×10^{-1}	7.7×10^{-5}
MOI	1.2×10^{-1}	5.9×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	7.9×10^{1}	4.0×10^{-2}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2×10^{-3}
MCW	N/A	N/A
NPA	3.3	1.6×10^{-3}
MOI	1.4	7.0×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	2.9×10^{2}	1.5×10^{-1}

Table F.1.4.2.1.2-8. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Kesselring

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.4×10^{-1}	2.9×10^{-4}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	1.9×10^{-2}	9.7×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	5.6×10^{1}	2.8×10^{-2}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2×10^{-3}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	2.3×10^{-1}	1.2×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	2.2×10^{2}	1.1×10^{-1}

Table F.1.4.2.1.2-9. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Nevada Test Site

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.8×10^{-1}	1.9×10^{-4}
MCW	2.1×10^{-4}	8.0×10^{-8}
NPA	N/A	N/A
MOI	1.5×10^{-3}	7.3×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	4.3×10^{-1}	2.2×10^{-4}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2×10^{-3}
MCW	8.1×10^{-3}	3.3×10^{-6}
NPA	N/A	N/A
MOI	2.0×10^{-2}	9.9×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	1.4	7.0×10^{-4}

Table F.1.4.2.1.2-10. Summary of Exposure Calculation Results.
For Wet Storage - Accidental Criticality
At Oak Ridge

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.0	1.2×10^{-3}
MCW	6.6×10^{-2}	2.6×10^{-5}
NPA	9.1×10^{-1}	4.6×10^{-4}
MOI	7.6×10^{-1}	3.8×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	7.4×10^{1}	3.7×10^{-2}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.0	3.2×10^{-3}
MCW	3.6×10^{-1}	1.4×10^{-4}
NPA	5.6	2.8×10^{-3}
MOI	4.7	2.4×10^{-3}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	1.8×10^{2}	8.8×10^{-2}

F.1.4.2.1.3 Mechanical Damage from Operator Error, Crane Failure, or Similar Accidents

F.1.4.2.1.3.1 Description of Conditions. Accidental mechanical damage to spent fuel was evaluated. The hypothetical accident included damage to one fuel unit, allowing fission products within the elements to escape through the clad failures. All gas and some volatile and solid nuclides were calculated to be released to the pool. The release fractions are consistent with severe accident analyses and Regulatory Guide 1.4. Due to the presence of pool water, no solids would be released into the air inside the facility.

F.1.4.2.1.3.2 Source Term. Conditions used in developing the source term are as follows:

- One fuel unit is damaged because only one fuel unit would be handled at a time and the storage facility design prevents damage to stored units from such events.
- One percent of the fuel is damaged and those fission products are available for release.
- All (100%) of the noble gases are released to the environment.
- Approximately 25% of the halogens are released to the pool and 90% of these fission products are absorbed in the water as they rise through the pool water. Therefore, 2.5% of the halogens are released to the air inside the facility.
- Due to the gaseous nature of the released fission products, installed HEPA filters would not remove them once they are released to the air in the building.
- The release to the environment occurs at a constant rate over a 15-minute period.
- There is no particulate fission product release to the atmosphere due to the presence of pool water.

- The following amounts of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

Nuclides	Curies
H-3	1.42
I-129	2.52×10^{-6}
I-131	5.37×10^{-5}

F.1.4.2.1.3.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical mechanical damage accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. The probability of the occurrence of fuel damage is small based on the conservative fuel handling rules. At the INEL-ECF, it is recognized that the drop of a heavy container into a storage rack could crush the rack and the stored fuel and so heavy casks are never moved over the storage rack area. The heavy containers are brought only into an empty receiving area to discharge a single fuel unit. The spent fuel is removed from the receiving area before the next fuel unit is brought into the receiving area. Therefore, two errors must occur before damaged fuel is possible. The first is that fuel is improperly left in the discharge station while the heavy cask is moved over the discharge station. The second is that the cask must accidentally fall from the overhead crane or the crane must fail. The probability of failure associated with crane failure has been taken as 10^{-2} per year. Further, the crane failure must also occur in the right location and the drop must be high enough that sufficient energy is available to damage both the discharge station structurals and the fuel inside. An additional factor of 10^{-2} has been taken for this event, giving the total probability of 10^{-4} for the drop of the cask in the right location. Allowing a fuel unit to remain in the stand requires an operator error because fuel handling procedures call for the fuel unit to be removed from the stand and taken to an underwater storage location away from the receiving area. In addition, because independent overchecking is required for all fuel movement, an error by a verifier is also required. Therefore, based on operator error rates (Swain and Guttman 1983), the likelihood of this error is taken as 10^{-4} per year. Hence, the combined probability of cask drop on a fuel unit is taken as 10^{-8} per year per fuel movement. Then, taking an estimated rate of 1,000 fuel movements per year, the overall probability is taken as 10^{-5} events per year.

Wet Storage Mechanical Damage Summary			
Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
INEL	2.6×10^{-6}	5.3×10^{-6}	5.3×10^{-11}
Savannah River	2.2×10^{-6}	2.0×10^{-5}	2.0×10^{-10}
Hanford	9.8×10^{-7}	8.6×10^{-6}	8.6×10^{-11}
Puget Sound	1.7×10^{-4}	7.2×10^{-5}	7.2×10^{-10}
Pearl Harbor	9.3×10^{-5}	1.5×10^{-4}	1.5×10^{-9}
Norfolk	3.5×10^{-4}	8.0×10^{-5}	8.0×10^{-10}
Portsmouth	1.9×10^{-4}	5.6×10^{-5}	5.6×10^{-10}
Kesselring	3.6×10^{-5}	6.0×10^{-5}	6.0×10^{-10}
Nevada Test Site	4.6×10^{-6}	5.6×10^{-7}	5.6×10^{-12}
Oak Ridge	5.9×10^{-4}	3.4×10^{-5}	3.4×10^{-10}

The risk for this hypothetical accident is generally more severe at Navy shipyards than at the DOE sites. At all sites, this accident results in the lowest or next to the lowest risk of the wet storage accidents evaluated.

For the hypothetical wet storage mechanical damage accident scenario, the radioactive plume might cause contamination of the ground to a downwind distance of less than 0.06 mile. This would yield a total area impacted by the accident of less than 0.5 acre. The calculated downwind distance would be contained within the boundaries of all sites under evaluation.

Table F.1.4.2.1.3-1. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At INEL

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.9×10^{-4}	7.6×10^{-8}
MCW	2.5×10^{-7}	9.6×10^{-11}
NPA	1.5×10^{-7}	7.4×10^{-11}
MOI	5.7×10^{-7}	2.9×10^{-10}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	5.0×10^{-3}	2.5×10^{-6}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2×10^{-4}	2.1×10^{-7}
MCW	2.4×10^{-6}	9.6×10^{-10}
NPA	8.3×10^{-7}	4.2×10^{-10}
MOI	2.6×10^{-6}	1.3×10^{-9}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	1.1×10^{-2}	5.3×10^{-6}

Table F.1.4.2.1.3-2. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Savannah River

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.4×10^{-5}	3.4×10^{-8}
MCW	5.2×10^{-6}	2.1×10^{-9}
NPA	9.1×10^{-8}	4.5×10^{-11}
MOI (New ECF)	3.9×10^{-7}	1.9×10^{-10}
MOI (Barnwell)	1.5×10^{-6}	7.4×10^{-10}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	7.1×10^{-3}	3.5×10^{-6}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2×10^{-4}	2.1×10^{-7}
MCW	6.7×10^{-5}	2.6×10^{-8}
NPA	1.4×10^{-6}	7.2×10^{-10}
MOI (New ECF)	2.2×10^{-6}	1.1×10^{-9}
MOI (Barnwell)	1.8×10^{-5}	9.0×10^{-9}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	4.1×10^{-2}	2.0×10^{-5}

Table F.1.4.2.1.3-3. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Hanford

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.4×10^{-5}	3.4×10^{-8}
MCW	7.1×10^{-6}	2.9×10^{-9}
NPA	1.0×10^{-7}	5.1×10^{-11}
MOI (New (ECF)	1.3×10^{-7}	6.5×10^{-11}
MOI (FMEF)	2.4×10^{-7}	1.2×10^{-10}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	9.4×10^{-4}	4.7×10^{-7}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2×10^{-4}	2.1×10^{-7}
MCW	4.4×10^{-5}	1.8×10^{-8}
NPA	1.6×10^{-6}	7.9×10^{-10}
MOI (New ECF)	9.8×10^{-7}	4.9×10^{-10}
MOI (FMEF)	3.1×10^{-6}	1.5×10^{-9}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	1.7×10^{-2}	8.6×10^{-6}

Table F.1.4.2.1.3-4. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Puget Sound

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.6×10^{-5}	1.8×10^{-8}
MCW	N/A	N/A
NPA	5.5×10^{-5}	2.7×10^{-8}
MOI	1.3×10^{-5}	6.7×10^{-9}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	6.0×10^{-3}	3.0×10^{-6}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2×10^{-4}	2.1×10^{-7}
MCW	N/A	N/A
NPA	6.5×10^{-4}	3.2×10^{-7}
MOI	1.7×10^{-4}	8.4×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	1.5×10^{-1}	7.2×10^{-5}

Table F.1.4.2.1.3-5. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Pearl Harbor

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.9×10^{-4}	7.6×10^{-8}
MCW	N/A	N/A
NPA	4.9×10^{-5}	2.4×10^{-8}
MOI	2.3×10^{-5}	1.2×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	1.1×10^{-1}	5.6×10^{-5}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2×10^{-4}	2.1×10^{-7}
MCW	N/A	N/A
NPA	1.6×10^{-3}	7.9×10^{-7}
MOI	9.3×10^{-5}	4.6×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	3.1×10^{-1}	1.5×10^{-4}

Table F.1.4.2.1.3-6. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Norfolk

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.6×10^{-5}	1.9×10^{-8}
MCW	N/A	N/A
NPA	1.2×10^{-5}	6.0×10^{-9}
MOI	3.2×10^{-5}	1.6×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.4×10^{-2}	7.0×10^{-6}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2×10^{-4}	2.1×10^{-7}
MCW	N/A	N/A
NPA	1.4×10^{-4}	7.0×10^{-8}
MOI	3.5×10^{-4}	1.7×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.6×10^{-1}	8.0×10^{-5}

Table F.1.4.2.1.3-7. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Portsmouth

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.6×10^{-5}	1.8×10^{-8}
MCW	N/A	N/A
NPA	1.1×10^{-5}	5.6×10^{-9}
MOI	1.5×10^{-5}	7.4×10^{-9}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	3.8×10^{-3}	1.9×10^{-6}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2×10^{-4}	2.1×10^{-7}
MCW	N/A	N/A
NPA	2.5×10^{-4}	1.3×10^{-7}
MOI	1.9×10^{-4}	9.3×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	1.1×10^{-1}	5.6×10^{-5}

Table F.1.4.2.1.3-8. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Kesselring

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.6×10^{-5}	1.9×10^{-8}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	3.2×10^{-6}	1.6×10^{-9}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	4.7×10^{-2}	2.3×10^{-5}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2×10^{-4}	2.1×10^{-7}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	3.6×10^{-5}	1.8×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	1.2×10^{-1}	6.0×10^{-5}

Table F.1.4.2.1.3-9. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Nevada Test Site

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.0×10^{-5}	1.2×10^{-8}
MCW	3.0×10^{-8}	1.5×10^{-11}
NPA	N/A	N/A
MOI	3.8×10^{-7}	1.9×10^{-10}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	4.5×10^{-4}	2.3×10^{-7}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2×10^{-4}	2.1×10^{-7}
MCW	1.8×10^{-6}	7.1×10^{-10}
NPA	N/A	N/A
MOI	4.6×10^{-6}	2.3×10^{-9}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	1.1×10^{-3}	5.6×10^{-7}

Table F.1.4.2.1.3-10. Summary of Exposure Calculation Results.
For Wet Storage - Mechanical Damage
At Oak Ridge

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.9×10^{-4}	7.6×10^{-8}
MCW	5.4×10^{-6}	2.2×10^{-9}
NPA	6.6×10^{-5}	3.3×10^{-8}
MOI	9.3×10^{-5}	4.7×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	2.0×10^{-2}	1.0×10^{-5}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.2×10^{-4}	2.1×10^{-7}
MCW	3.3×10^{-5}	1.3×10^{-8}
NPA	4.2×10^{-4}	2.1×10^{-7}
MOI	5.9×10^{-4}	3.0×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	6.7×10^{-2}	3.4×10^{-5}

F.1.4.2.1.4 Airplane Crash.

F.1.4.2.1.4.1 Description of Conditions. Impact into water pools by aircraft with resulting damage to the naval fuel units stored inside the pool was evaluated. Based on the probability of occurrence, as discussed in Section F.3, specific analyses were only performed for Savannah River, the Nevada Test Site, Oak Ridge, Pearl Harbor, Norfolk, and Kesselring locations. At other locations, the likelihood of occurrence is less than 10^{-7} per year. The hypothetical accident included damage to all fuel units stored at the water pool. Fission products and corrosion products are released from the fuel units into the water pool; however, the pool water is not released to the environment. An airplane crash into a water pool would not produce enough force to cause the pool to leak because the walls of the water pool are constructed of thick, reinforced concrete with earth surrounding them, making them very strong. In addition, it was judged unlikely that an airplane would impact the water pool at an angle steep enough to expose the floor of the pool or the walls of the pool below the water level to the direct impact. The presence of pool water results in only a release of gaseous fission products to the atmosphere.

F.1.4.2.1.4.2 Source Term. Conditions used in developing the source term are as follows:

- One percent of the fission products from each of the fuel units stored inside the pool is available for release.
- Of the available fission products, 100% of the noble gases and 25% of the halogens are released to the pool water. Due to the presence of pool water, a reduction of the halogen release by a factor of 10 prior to release to the atmosphere occurs.
- No solid fission products or corrosion products are released to the environment due to the continued presence of pool water.
- The release to the environment occurs at a constant rate over a 15-minute period.
- 300 naval fuel units would be in the water pool.
- No filtration by HEPA filters is assumed.

- The following amounts of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

Nuclide	Curies
I-129	7.59×10^{-4}
I-131	1.61×10^{-2}
H-3	4.28×10^{2}

F.1.4.2.1.4.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical airplane crash accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence.

Water Pool Airplane Crash Summary				
Site	Probability of accident per year	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
Savannah River	2×10^{-6}	6.4×10^{-4}	6.1×10^{-3}	1.2×10^{-8}
Pearl Harbor	2×10^{-5}	2.8×10^{-2}	4.6×10^{-2}	9.2×10^{-7}
Norfolk	4×10^{-7}	1.1×10^{-1}	2.4×10^{-2}	9.6×10^{-9}
Kesselring	2×10^{-7}	1.1×10^{-2}	1.8×10^{-2}	3.6×10^{-9}
Nevada Test Site	4×10^{-7}	1.3×10^{-3}	1.7×10^{-4}	6.8×10^{-11}
Oak Ridge	1×10^{-6}	1.8×10^{-1}	1.0×10^{-2}	1.0×10^{-8}

The risk for this hypothetical accident is most severe at Pearl Harbor. For the sites with crash probabilities less than 10^{-7} per year, consequences were not calculated since it is expected that they would not substantially contribute to the risk.

For the hypothetical airplane crash into a wet storage facility accident scenario, the radioactive plume might result in contamination of the ground to a downwind distance of less than 0.06 mile. This would yield a total area impacted by the accident of less than 0.5 acre. The calculated downwind distance would be contained within the boundaries of all sites that are at risk for this accident.

Table F.1.4.2.1.4-1. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Savannah River

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.5×10^{-2}	1.0×10^{-5}
MCW	1.6×10^{-3}	6.3×10^{-7}
NPA	2.8×10^{-5}	1.4×10^{-8}
MOI	1.1×10^{-4}	5.5×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	2.2	1.1×10^{-3}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6×10^{-1}	6.3×10^{-5}
MCW	2.0×10^{-2}	8.0×10^{-6}
NPA	4.3×10^{-4}	2.2×10^{-7}
MOI	6.4×10^{-4}	3.2×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	1.2×10^{1}	6.1×10^{-3}

Table F.1.4.2.1.4-2. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Pearl Harbor

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.7×10^{-2}	2.3×10^{-5}
MCW	N/A	N/A
NPA	1.5×10^{-2}	7.3×10^{-6}
MOI	6.9×10^{-3}	3.5×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	3.3×10^{1}	1.7×10^{-2}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6×10^{-1}	6.3×10^{-5}
MCW	N/A	N/A
NPA	4.7×10^{-1}	2.4×10^{-4}
MOI	2.8×10^{-2}	1.4×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	9.2×10^{1}	4.6×10^{-2}

Table F.1.4.2.1.4-3. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Norfolk

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4×10^{-2}	5.6×10^{-6}
MCW	N/A	N/A
NPA	3.6×10^{-3}	1.8×10^{-6}
MOI	9.6×10^{-3}	4.8×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	4.2	2.1×10^{-3}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6×10^{-1}	6.3×10^{-5}
MCW	N/A	N/A
NPA	4.2×10^{-2}	2.1×10^{-5}
MOI	1.1×10^{-1}	5.3×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	4.8×10^{1}	2.4×10^{-2}

Table F.1.4.2.1.4-4. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Kesselring

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4×10^{-2}	5.6×10^{-6}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	9.5×10^{-4}	4.8×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	1.4×10^{1}	7.1×10^{-3}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6×10^{-1}	6.3×10^{-5}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	1.1×10^{-2}	5.4×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	3.6×10^{1}	1.8×10^{-2}

Table F.1.4.2.1.4-5. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Nevada Test Site

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.0×10^{-3}	3.6×10^{-6}
MCW	9.1×10^{-6}	3.7×10^{-9}
NPA	N/A	N/A
MOI	5.5×10^{-5}	2.8×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	1.3×10^{-1}	6.5×10^{-5}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6×10^{-1}	6.4×10^{-5}
MCW	5.3×10^{-4}	2.2×10^{-7}
NPA	N/A	N/A
MOI	1.3×10^{-3}	6.5×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	3.3×10^{-1}	1.7×10^{-4}

Table F.1.4.2.1.4-6. Summary of Exposure Calculation Results.
For Wet Storage - Airplane Crash
At Oak Ridge

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.7×10^{-2}	2.3×10^{-5}
MCW	1.6×10^{-3}	6.5×10^{-7}
NPA	2.0×10^{-2}	9.9×10^{-6}
MOI	2.8×10^{-2}	1.4×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	6.0	3.0×10^{-3}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6×10^{-1}	6.3×10^{-5}
MCW	9.9×10^{-3}	3.9×10^{-6}
NPA	1.3×10^{-1}	6.3×10^{-5}
MOI	1.8×10^{-1}	8.9×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	2.0×10^{1}	1.0×10^{-2}

F.1.4.2.1.5 HEPA Filter Fire.

F.1.4.2.1.5.1 Description of Conditions. In this hypothetical accident scenario, a fire in the ECF High Efficiency Particulate Air (HEPA) filter banks is postulated. This accident could be initiated by the ignition of a flammable mixture released upstream of the system or by an external, unrelated fire that spreads to this system. Although the risks associated with this accident are relatively minor, it was analyzed to bound the higher probability, lower consequence type accident category. The airborne release fractions associated with this accident were conservatively chosen so that a HEPA filter failure by crushing or impact was also bounded.

F.1.4.2.1.5.2 Source Term. Conditions used in developing the source term are as follows:

- The original inventory of fission products in the filters is based on the total estimated unabated ECF releases over a 5-year period.

- One percent of the radionuclide inventory present on the filters becomes airborne during the fire. Release fractions for HEPA filters are small because the filters are constructed of material containing glass fibers which would melt during a fire and trap particles in the medium. Measurements from experiments show that one one-hundredth of 1% of the material in HEPA filters could be released during a fire, but 1% has been used in these analyses to allow for uncertainties in the final results of an individual fire.

- The release to the environment occurs at a constant rate over a 15-minute period.

- There is no increase in direct radiation due to this accident.

- The following amounts of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

- No filtration by HEPA filters is assumed.

Nuclide	Curies	Nuclide	Curies
Cs-137	1.46×10^{-3}	Co-60	2.09×10^{-3}
Cs-134	2.04×10^{-4}	Sr-90	8.90×10^{-4}
Ba-137M	6.26×10^{-6}	Y-90	8.90×10^{-4}
Fe-55	2.32×10^{-3}	Eu-154	9.80×10^{-5}
Ni-63	2.98×10^{-3}		

F.1.4.2.1.5.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical HEPA filter fire accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. The probability of a fire in a HEPA filter is estimated based on the probability of other fires spreading to the HEPA filter system. As discussed in section F.2.4.2, a probability of 5×10^{-3} is assigned to chemical fires. The probability of HEPA fires is considered less than a chemical fire since chemicals would not be stored in the immediate vicinity of the HEPA filter system. Additionally, HEPA filters are not inherently volatile or explosive. It is estimated that the probability for an existing chemical fire to spread to the HEPA filters is less than 0.1. This results in a probability of less than 5×10^{-4} for a HEPA filter fire. A value of 5×10^{-4} was used to develop the risk results in the table.

HEPA Filter Fire Summary			
Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
INEL	2.5×10^{-5}	5.3×10^{-5}	2.7×10^{-8}
Savannah River	2.1×10^{-5}	1.3×10^{-4}	6.5×10^{-8}
Hanford	7.0×10^{-6}	5.3×10^{-5}	2.7×10^{-8}
Puget Sound	1.6×10^{-3}	6.4×10^{-4}	3.2×10^{-7}
Pearl Harbor	8.7×10^{-4}	1.2×10^{-3}	6.0×10^{-7}
Norfolk	3.3×10^{-3}	6.9×10^{-4}	3.5×10^{-7}
Portsmouth	1.7×10^{-3}	3.9×10^{-4}	2.0×10^{-7}
Kesselring	3.5×10^{-4}	3.3×10^{-4}	1.7×10^{-7}
Nevada Test Site	4.3×10^{-5}	5.7×10^{-6}	2.9×10^{-9}
Oak Ridge	5.7×10^{-3}	2.2×10^{-4}	1.1×10^{-7}

The risk for this hypothetical accident is generally more severe at the Navy shipyards than at the DOE sites.

For the hypothetical HEPA filter fire accident scenario, the radioactive plume might cause contamination of the ground to a downwind distance of less than 0.06 mile. This would yield a total area impacted by the accident of less than 0.5 acre. The calculated downwind distance would be contained within the boundaries of all sites under evaluation.

Table F.1.4.2.1.5-1. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At INEL

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.7×10^{-4}	3.5×10^{-7}
MCW	7.9×10^{-7}	3.2×10^{-10}
NPA	4.5×10^{-7}	2.2×10^{-10}
MOI	9.9×10^{-6}	5.0×10^{-9}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	7.6×10^{-2}	3.8×10^{-5}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4×10^{-3}	9.6×10^{-7}
MCW	8.8×10^{-6}	3.5×10^{-9}
NPA	2.7×10^{-6}	1.4×10^{-9}
MOI	2.5×10^{-5}	1.3×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	1.1×10^{-1}	5.3×10^{-5}

Table F.1.4.2.1.5-2. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Savannah River

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.9×10^{-4}	1.5×10^{-7}
MCW	2.3×10^{-5}	8.8×10^{-9}
NPA	2.9×10^{-7}	1.4×10^{-10}
MOI (New ECF)	7.2×10^{-6}	3.6×10^{-9}
MOI (Barnwell)	1.7×10^{-5}	8.6×10^{-9}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	4.1×10^{-2}	2.0×10^{-5}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4×10^{-3}	9.6×10^{-7}
MCW	2.9×10^{-4}	1.1×10^{-7}
NPA	4.9×10^{-6}	2.5×10^{-9}
MOI (New ECF)	2.1×10^{-5}	1.0×10^{-8}
MOI (Barnwell)	1.6×10^{-4}	8.1×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	2.5×10^{-1}	1.3×10^{-4}

Table F.1.4.2.1.5-3. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Hanford

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.9×10^{-4}	1.5×10^{-7}
MCW	3.0×10^{-5}	1.2×10^{-8}
NPA	3.5×10^{-7}	1.8×10^{-10}
MOI (New ECF)	9.6×10^{-7}	4.8×10^{-10}
MOI (FMEF)	1.9×10^{-6}	9.7×10^{-10}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	6.7×10^{-3}	3.4×10^{-6}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4×10^{-3}	9.6×10^{-7}
MCW	1.9×10^{-4}	7.5×10^{-8}
NPA	5.5×10^{-6}	2.7×10^{-9}
MOI (New ECF)	7.0×10^{-6}	3.5×10^{-9}
MOI (FMEF)	2.4×10^{-5}	1.2×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	1.1×10^{-1}	5.3×10^{-5}

Table F.1.4.2.1.5-4. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Puget Sound

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1×10^{-4}	8.4×10^{-8}
MCW	N/A	N/A
NPA	2.5×10^{-4}	1.2×10^{-7}
MOI	1.4×10^{-4}	6.8×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	3.4×10^{-1}	1.7×10^{-4}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4×10^{-3}	9.6×10^{-7}
MCW	N/A	N/A
NPA	2.9×10^{-3}	1.5×10^{-6}
MOI	1.6×10^{-3}	8.0×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	1.3	6.4×10^{-4}

Table F.1.4.2.1.5-5. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Pearl Harbor

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.7×10^{-4}	3.5×10^{-7}
MCW	N/A	N/A
NPA	2.2×10^{-4}	1.1×10^{-7}
MOI	2.2×10^{-4}	1.1×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	9.0×10^{-1}	4.5×10^{-4}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4×10^{-3}	9.6×10^{-7}
MCW	N/A	N/A
NPA	7.2×10^{-3}	3.6×10^{-6}
MOI	8.7×10^{-4}	4.3×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	2.4	1.2×10^{-3}

Table F.1.4.2.1.5-6. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Norfolk

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1×10^{-4}	8.5×10^{-8}
MCW	N/A	N/A
NPA	5.3×10^{-5}	2.7×10^{-8}
MOI	3.2×10^{-4}	1.6×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	2.3×10^{-1}	1.2×10^{-4}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4×10^{-3}	9.6×10^{-7}
MCW	N/A	N/A
NPA	6.2×10^{-4}	3.1×10^{-7}
MOI	3.3×10^{-3}	1.7×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	1.4	6.9×10^{-4}

Table F.1.4.2.1.5-7. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Portsmouth

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1×10^{-4}	8.4×10^{-8}
MCW	N/A	N/A
NPA	5.0×10^{-5}	2.5×10^{-8}
MOI	1.4×10^{-4}	7.2×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	1.2×10^{-1}	6.0×10^{-5}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4×10^{-3}	9.6×10^{-7}
MCW	N/A	N/A
NPA	1.1×10^{-3}	5.6×10^{-7}
MOI	1.7×10^{-3}	8.7×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	7.9×10^{-1}	3.9×10^{-4}

Table F.1.4.2.1.5-8. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Kesselring

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.1×10^{-4}	8.5×10^{-8}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	5.5×10^{-5}	2.7×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	2.0×10^{-1}	9.8×10^{-5}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4×10^{-3}	9.6×10^{-7}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	3.5×10^{-4}	1.8×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	6.7×10^{-1}	3.3×10^{-4}

Table F.1.4.2.1.5-9. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Nevada Test Site

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.4×10^{-4}	5.5×10^{-8}
MCW	1.1×10^{-7}	4.2×10^{-11}
NPA	N/A	N/A
MOI	8.5×10^{-6}	4.2×10^{-9}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	7.6×10^{-3}	3.8×10^{-6}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4×10^{-3}	9.6×10^{-7}
MCW	6.2×10^{-6}	2.5×10^{-9}
NPA	N/A	N/A
MOI	4.3×10^{-5}	2.2×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	1.1×10^{-2}	5.7×10^{-6}

Table F.1.4.2.1.5-10. Summary of Exposure Calculation Results.
For Wet Storage - HEPA Filter Fire
At Oak Ridge

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.7×10^{-4}	3.5×10^{-7}
MCW	2.3×10^{-5}	8.8×10^{-9}
NPA	3.0×10^{-4}	1.5×10^{-7}
MOI	9.0×10^{-4}	4.5×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	1.2×10^{-1}	6.0×10^{-5}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.4×10^{-3}	9.6×10^{-7}
MCW	1.4×10^{-4}	5.6×10^{-8}
NPA	1.9×10^{-3}	9.4×10^{-7}
MOI	5.7×10^{-3}	2.9×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	4.3×10^{-1}	2.2×10^{-4}

F.1.4.2.1.6 Minor Water Pool Leakage.

F.1.4.2.1.6.1 Description of Conditions. In this hypothetical accident scenario, a minor leak develops in the water pool resulting in a gradual discharge to the environment. There is no danger of uncovering any spent nuclear fuel in the water pool, since the leak is so small that it is undetected and water level is maintained in the water pool. Since a strict accounting of water added to and removed from the water pool is maintained, the magnitude of this leak would be less than 4,400 gallons per year. The 4,400 gallons per year value is the maximum amount of water which might leak out of the water pool before periodic review of the water balance would detect a leak.

F.1.4.2.1.6.2 Source Term. There is no airborne release above normal levels in this hypothetical accident scenario. The radionuclide inventory in the leaking water is based on radioactivity analysis of ECF water pool water. The isotopes that were analyzed for but not detected could exist at the minimum detection limit.

Nuclide	Sample Results (μCi/mL)	10CFR20 Effluent Limit (μCi/mL)	Annual Releases (Ci/year)
H-3	2.0×10^{-4}	1.0×10^{-3}	3.3×10^{-3}
Mn-54	2.5×10^{-8}	3.0×10^{-5}	4.1×10^{-7}
Fe-55	1.0×10^{-8} *	1.0×10^{-4}	1.6×10^{-7} *
Co-58	7.0×10^{-8}	2.0×10^{-5}	1.1×10^{-6}
Co-60	1.6×10^{-5}	3.0×10^{-6}	2.6×10^{-5}
Ni-63	2.3×10^{-7}	1.0×10^{-4}	3.8×10^{-6}
Sr-90	4.0×10^{-9}	5.0×10^{-7}	6.5×10^{-8}
Y-90	4.0×10^{-9}	7.0×10^{-6}	6.5×10^{-8}
I-129	4.0×10^{-7} *	2.0×10^{-7}	6.5×10^{-6} *
Cs-137	4.2×10^{-8}	1.0×10^{-6}	6.9×10^{-7}

* These radionuclides were not detected in the ECF water. The numbers quoted reflect the detection limit of the analysis.

It should be noted that the sample results for the water pool indicate that the nuclide levels are all below the Code of Federal Regulations limits for liquid effluent in 10CFR20 with the exception of Co-60. The level of I-129 used in the calculations was based on the minimum detection limit of the sample. This level exceeds the effluent limit; however, I-129 was not actually detected in the water sample. Since Sr-90 has comparable water solubility to I-129 and exists in spent nuclear fuel at about a factor of 1.0 x 10^6 higher than I-129, it is inferred from the detected level of Sr-90 that the actual level of I-129 is well below the 10CFR20 effluent limit.

F.1.4.2.1.6.3 Results. The following table summarizes the public health risk to the general population that might result from the hypothetical minor water pool leak at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. The probability of a leak developing is 10^{-1} per year.

Minor Water Pool Leakage Summary			
Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
INEL	2.5 x 10^{-9}	1.3 x 10^{-8}	1.3 x 10^{-9}
Savannah River	7.9 x 10^{-10}	1.3 x 10^{-9}	1.3 x 10^{-10}
Hanford	9.9 x 10^{-12}	1.7 x 10^{-10}	1.7 x 10^{-11}
Puget Sound	3.2 x 10^{-10}	4.2 x 10^{-9}	4.2 x 10^{-10}
Pearl Harbor	1.3 x 10^{-10}	4.6 x 10^{-10}	4.6 x 10^{-11}
Norfolk	2.7 x 10^{-10}	1.8 x 10^{-9}	1.8 x 10^{-10}
Portsmouth	1.3 x 10^{-10}	1.4 x 10^{-9}	1.4 x 10^{-10}
Kesselring	6.0 x 10^{-9}	8.5 x 10^{-9}	8.5 x 10^{-10}
Nevada Test Site	2.5 x 10^{-9}	1.4 x 10^{-9}	1.4 x 10^{-10}
Oak Ridge	1.5 x 10^{-9}	3.9 x 10^{-9}	3.9 x 10^{-10}

At all sites except the Nevada Test Site, this accident results in the lowest or next to lowest risk of the wet storage accidents evaluated.

Table F.1.4.2.1.6-1. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At INEL

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	1.6×10^{-13}	6.4×10^{-17}
NPA	1.6×10^{-13}	8.0×10^{-17}
MOI	2.5×10^{-9}	1.3×10^{-12}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	2.6×10^{-5}	1.3×10^{-8}

Table F.1.4.2.1.6-2. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Savannah River

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	4.8×10^{-13}	1.9×10^{-16}
NPA	4.8×10^{-13}	2.4×10^{-16}
MOI	7.9×10^{-10}	4.0×10^{-13}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	2.5×10^{-6}	1.3×10^{-9}

Table F.1.4.2.1.6-3. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Hanford

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	8.3×10^{-15}	3.3×10^{-18}
NPA	8.3×10^{-15}	4.2×10^{-18}
MOI	9.9×10^{-12}	5.0×10^{-15}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	3.3×10^{-7}	1.7×10^{-10}

Table F.1.4.2.1.6-4. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Puget Sound

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	1.2×10^{-11}	6.0×10^{-15}
MOI	3.2×10^{-10}	1.6×10^{-13}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	8.4×10^{-6}	4.2×10^{-9}

Table F.1.4.2.1.6-5. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Pearl Harbor

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	4.8×10^{-12}	2.4×10^{-15}
MOI	1.3×10^{-10}	6.5×10^{-14}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	9.2×10^{-7}	4.6×10^{-10}

Table F.1.4.2.1.6-6. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Norfolk

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	9.9×10^{-12}	5.0×10^{-15}
MOI	2.7×10^{-10}	1.4×10^{-13}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	3.6×10^{-6}	1.8×10^{-9}

Table F.1.4.2.1.6-7. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Portsmouth

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	4.8×10^{-12}	2.4×10^{-15}
MOI	1.3×10^{-10}	6.5×10^{-14}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	2.7×10^{-6}	1.4×10^{-9}

Table F.1.4.2.1.6-8. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Kesselring

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	N/A	N/A
NPA	N/A	N/A
MOI	6.0×10^{-9}	3.0×10^{-12}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	1.7×10^{-5}	8.5×10^{-9}

Table F.1.4.2.1.6-9. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Nevada Test Site

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	1.6×10^{-13}	6.4×10^{-17}
NPA	1.6×10^{-13}	8.0×10^{-17}
MOI	2.5×10^{-9}	1.3×10^{-12}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	2.7×10^{-6}	1.4×10^{-9}

Table F.1.4.2.1.6-10. Summary of Exposure Calculation Results.
For Wet Storage - Minor Water Pool Leakage
At Oak Ridge

Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	N/A	N/A
MCW	9.4×10^{-13}	3.8×10^{-16}
NPA	9.4×10^{-13}	4.7×10^{-16}
MOI	1.5×10^{-9}	7.5×10^{-13}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	7.7×10^{-6}	3.9×10^{-9}

F.1.4.2.2 Dry Storage.

F.1.4.2.2.1 Wind-driven Missile Impact into Storage Casks with Mechanical Damage.

F.1.4.2.2.1.1 Description of Conditions. In this hypothetical accident, no fuel damage would result from any impact because of the strength of the containers used. Dry storage containers could experience a major wind storm or tornado which could propel a large object into a storage container causing the container seal to be breached. However, container analysis for this situation shows that the container is strong enough to prevent crushing of the spent nuclear fuel and release of fission products.

Winds produced by tornados are higher than hurricane winds and thus the impacting missile would be travelling with higher velocity and would have higher kinetic energy. Even at this higher velocity, analysis has shown that the missile would not penetrate the container. The probability of penetration at the lower velocity of a hurricane (212 miles per hour) would be even smaller than the probability of penetration for a missile propelled by the winds of a tornado (travelling at 360 mph). While hurricanes can have high winds, hurricane winds normally cannot generate the very large, very fast missiles analyzed for tornados. While hurricanes may occur more frequently than tornados, the overall risk from a hurricane is lower because the container would not be penetrated.

The analysis of wind damage using missiles propelled by the winds of tornados is the same as is done for design of nuclear power plants. Hurricanes very infrequently have winds that could generate such missiles, so the analyses provided for tornados provide an upper limit for the effects of hurricanes. Examination of damage caused by recent severe hurricanes shows that robust structures can withstand hurricanes.

F.1.4.2.2.1.2 Source Term. Conditions used in developing the source term are as follows:

- The source term is based on best estimate spent nuclear fuel corrosion products.

- One percent of the original corrosion products associated with the fuel could be released from the cask to the atmosphere. This is based on experimental measurements of the fraction of corrosion products loosened from naval spent nuclear fuel by shock and vibration and the fact that a wind-driven missile would not penetrate the container or damage the fuel inside. Only loose corrosion products would be available for release from the container, and any release from the container would have to occur via a convoluted path through the damaged seal.

- The release to the environment occurs at a constant rate over a 15-minute period.
- There is no increase in direct radiation due to this accident.
- The following amounts of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

Nuclide	Curies
Co-60	9.58×10^{-2}
Fe-55	1.76×10^{-1}
Co-58	3.54×10^{-2}
Mn-54	5.98×10^{-3}
Fe-59	5.11×10^{-4}

F.1.4.2.2.1.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical wind-driven missile accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. The probability of container damage is small due to the very strong container design. The dry storage containers are expected to be designed as well as shipping containers so that they would not be penetrated by environmentally caused missiles and the fuel would not be affected. However, an analysis was performed for a case in which the impact of a tornado missile might topple a container on a railcar and cause unseating of the container seal and thus release radioactive material in the form of corrosion products.

The probability of the occurrence of a tornado was obtained using the data in document WASH-1300 (AEC 1974). The maximum likelihood of a tornado occurrence at all storage locations being evaluated in the continental United States is 10^{-3} per year. The probability of a missile generated by the tornado striking a container and causing the damage analyzed has been estimated to be less than 10^{-2}. Thus, the total probability of a wind-driven missile damaging a container is less than 10^{-5}, and a probability of 10^{-5} per year was used in the risk assessment.

Dry Storage Mechanical Damage Summary			
Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
INEL	4.6×10^{-4}	4.9×10^{-4}	4.9×10^{-9}
Savannah River	4.9×10^{-4}	3.0×10^{-3}	3.0×10^{-8}
Hanford	1.7×10^{-4}	1.3×10^{-3}	1.3×10^{-8}
Puget Sound	3.9×10^{-2}	1.7×10^{-2}	1.7×10^{-7}
Pearl Harbor	2.1×10^{-2}	3.0×10^{-2}	3.0×10^{-7}
Norfolk	8.1×10^{-2}	1.8×10^{-2}	1.8×10^{-7}
Portsmouth	4.2×10^{-2}	1.0×10^{-2}	1.0×10^{-7}
Kesselring	8.1×10^{-3}	7.4×10^{-3}	7.4×10^{-8}
Nevada Test Site	8.8×10^{-4}	5.3×10^{-5}	5.3×10^{-10}
Oak Ridge	1.4×10^{-1}	5.1×10^{-3}	5.1×10^{-8}

The risk for this hypothetical accident is generally more severe at Navy shipyards than at the DOE sites. This accident results in the lowest risk of the two dry storage accidents evaluated.

For the hypothetical wind-driven missile accident scenario, the radioactive plume might cause contamination of the ground to a downwind distance of less than 0.06 mile. This would yield a total area impacted by the accident of less than 0.5 acre. The calculated downwind distance would be contained within the boundaries of all sites under evaluation.

Table F.1.4.2.2.1-1. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At INEL

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.0×10^{-2}	8.0×10^{-6}
MCW	1.8×10^{-5}	9.2×10^{-9}
NPA	1.0×10^{-5}	5.2×10^{-9}
MOI	8.0×10^{-5}	4.0×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	2.3×10^{-1}	1.2×10^{-4}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6×10^{-2}	2.2×10^{-5}
MCW	2.0×10^{-4}	1.0×10^{-7}
NPA	6.3×10^{-5}	3.1×10^{-8}
MOI	4.6×10^{-4}	2.3×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	9.8×10^{-1}	4.9×10^{-4}

Table F.1.4.2.2.1-2. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Savannah River

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.9×10^{-3}	3.6×10^{-6}
MCW	5.3×10^{-4}	2.1×10^{-7}
NPA	6.7×10^{-6}	3.4×10^{-9}
MOI (New ECF)	1.6×10^{-4}	8.1×10^{-8}
MOI (Barnwell)	4.0×10^{-4}	2.0×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	9.4×10^{-1}	4.7×10^{-4}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6×10^{-2}	2.2×10^{-5}
MCW	6.7×10^{-3}	2.6×10^{-6}
NPA	1.1×10^{-4}	5.7×10^{-8}
MOI (New ECF)	4.9×10^{-4}	2.5×10^{-7}
MOI (Barnwell)	3.9×10^{-3}	2.0×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	6.1	3.0×10^{-3}

Table F.1.4.2.2.1-3. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Hanford

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.9×10^{-3}	3.6×10^{-6}
MCW	7.0×10^{-4}	2.8×10^{-7}
NPA	8.1×10^{-6}	4.1×10^{-9}
MOI (New ECF)	2.3×10^{-5}	1.1×10^{-8}
MOI (FMEF)	4.6×10^{-5}	2.3×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	1.4×10^{-1}	7.0×10^{-5}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6×10^{-2}	2.2×10^{-5}
MCW	4.4×10^{-3}	1.8×10^{-6}
NPA	1.3×10^{-4}	6.3×10^{-8}
MOI (New ECF)	1.7×10^{-4}	8.4×10^{-8}
MOI (FMEF)	5.9×10^{-4}	2.9×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	2.5	1.3×10^{-3}

Table F.1.4.2.2.1-4. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Puget Sound

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.9×10^{-3}	1.9×10^{-6}
MCW	N/A	N/A
NPA	5.7×10^{-3}	2.9×10^{-6}
MOI	3.5×10^{-3}	1.7×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	1.2×10^{1}	5.8×10^{-3}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6×10^{-2}	2.2×10^{-5}
MCW	N/A	N/A
NPA	6.8×10^{-2}	3.4×10^{-5}
MOI	3.9×10^{-2}	1.9×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2975810	3.4×10^{1}	1.7×10^{-2}

Table F.1.4.2.2.1-5. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Pearl Harbor

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.0×10^{-2}	8.0×10^{-6}
MCW	N/A	N/A
NPA	5.2×10^{-3}	2.6×10^{-6}
MOI	5.3×10^{-3}	2.7×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	2.2×10^{1}	1.1×10^{-2}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6×10^{-2}	2.2×10^{-5}
MCW	N/A	N/A
NPA	1.7×10^{-1}	8.4×10^{-5}
MOI	2.1×10^{-2}	1.1×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	5.9×10^{1}	3.0×10^{-2}

Table F.1.4.2.2.1-6. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Norfolk

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.9×10^{-3}	2.0×10^{-6}
MCW	N/A	N/A
NPA	1.2×10^{-3}	6.2×10^{-7}
MOI	7.8×10^{-3}	3.9×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	7.4	3.7×10^{-3}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6×10^{-2}	2.2×10^{-5}
MCW	N/A	N/A
NPA	1.4×10^{-2}	7.1×10^{-6}
MOI	8.1×10^{-2}	4.0×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	3.5×10^{1}	1.8×10^{-2}

Table F.1.4.2.2.1-7. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Portsmouth

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.9×10^{-3}	1.9×10^{-6}
MCW	N/A	N/A
NPA	1.2×10^{-3}	5.8×10^{-7}
MOI	3.5×10^{-3}	1.8×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	4.2	2.1×10^{-3}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6×10^{-2}	2.2×10^{-5}
MCW	N/A	N/A
NPA	2.6×10^{-2}	1.3×10^{-5}
MOI	4.2×10^{-2}	2.1×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	2.0×10^{1}	1.0×10^{-2}

Table F.1.4.2.2.1-8. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Kesselring

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	4.9×10^{-3}	2.0×10^{-6}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	8.8×10^{-4}	4.4×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	3.3	1.7×10^{-3}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6×10^{-2}	2.2×10^{-5}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	8.1×10^{-3}	4.0×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	1.5×10^{1}	7.4×10^{-3}

Table F.1.4.2.2.1-9. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Nevada Test Site

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.2×10^{-3}	1.3×10^{-6}
MCW	2.5×10^{-6}	9.6×10^{-10}
NPA	N/A	N/A
MOI	4.5×10^{-5}	2.2×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	1.5×10^{-2}	7.3×10^{-6}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6×10^{-2}	2.2×10^{-5}
MCW	1.4×10^{-4}	5.8×10^{-8}
NPA	N/A	N/A
MOI	8.8×10^{-4}	4.4×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	1.1×10^{-1}	5.3×10^{-5}

Table F.1.4.2.2.1-10. Summary of Exposure Calculation Results.
For Dry Storage - Mechanical Damage
At Oak Ridge

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.0×10^{-2}	8.0×10^{-6}
MCW	5.3×10^{-4}	2.1×10^{-7}
NPA	6.9×10^{-3}	3.4×10^{-6}
MOI	2.2×10^{-2}	1.1×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	2.8	1.4×10^{-3}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.6×10^{-2}	2.2×10^{-5}
MCW	3.2×10^{-3}	1.3×10^{-6}
NPA	4.4×10^{-2}	2.2×10^{-5}
MOI	1.4×10^{-1}	6.9×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	1.0×10^{1}	5.1×10^{-3}

F.1.4.2.2.2 Airplane Crash.

F.1.4.2.2.2.1 Description of Conditions. A hypothetical aircraft accident scenario was developed for the dry storage option. Based on the probability of occurrence, as discussed in Section F.3, specific analyses were only performed for Savannah River, Oak Ridge, Pearl Harbor, Norfolk, Portsmouth, and Kesselring locations. At other locations, the likelihood of occurrence is less than 10^{-7} per year. The accident is postulated to cause damage to a single storage cask. This is based on the fact that containers used to store naval spent nuclear fuel would be very rugged so that only the rotor shaft from one of an airliner's jet engines would be strong enough and possess enough energy to have a chance of penetrating a container. From analyses of existing container designs, the rotor of a large jet engine, including those from the largest aircraft such as a Boeing 777, Russian Antonov An-225, or a Lockheed C-5, would not penetrate a container during an airliner crash, but, for the purposes of evaluation, calculations were performed for one container damaged to the extent that fission products and corrosion products might be released. Due to the severity of the shock, the cask seal might be breached resulting in damage to the fuel. The severe mechanical shock results in the release of corrosion products to the environment. The release of fission products also occurs due to the impact and resultant fire. The fission product release factors are based on overheating testing performed on the naval fuel systems.

F.1.4.2.2.2.2 Source Term. Conditions used in developing the source term are as follows:

- One percent of all of the fuel units stored inside the cask are damaged either by the impact or the resultant fire and those fission products are available for release.
- Of the available fission products, 100% of the noble gases, 3% of the halogens, 1.1% of the cesium, and 0.1% of the remaining solids are released to the environment.
- The release to the environment occurs at a constant rate over a 15-minute period.
- Ten percent of the original corrosion products from the fuel units are released from the cask to the atmosphere.

- The following amount of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

Nuclide	Curies
Cs-134	2.57×10^{1}
Cs-137	3.56×10^{1}
Pu-238	5.90×10^{-2}
Ba-137M	3.07
Sr-90	3.12
Ce-144	7.17
Nb-95	4.37
Y-90	3.12
Ru-106	6.11×10^{-1}

F.1.4.2.2.2.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical airplane crash accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence.

Dry Storage Airplane Crash Summary				
Site	Probability of accident per year	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
Savannah River	3×10^{-7}	4.7×10^{-1}	2.8	8.4×10^{-7}
Pearl Harbor	1×10^{-5}	19	26	2.6×10^{-4}
Norfolk	1×10^{-6}	72	16	1.6×10^{-5}
Portsmouth	1×10^{-7}	38	9.0	9.0×10^{-7}
Kesselring	1×10^{-7}	7.7	7.5	7.5×10^{-7}
Oak Ridge	3×10^{-7}	120	4.7	1.4×10^{-6}

The risk for this hypothetical accident is most severe at Pearl Harbor and Norfolk. It is also the highest risk for any hypothetical accident evaluated at Pearl Harbor and Norfolk. For the sites with crash probabilities less than 10^{-7} per year, consequences were not calculated since it is expected that they would not substantially contribute to the risk.

For the hypothetical airplane crash into a dry storage cask accident scenario, the radioactive plume might cause contamination of the ground to a downwind distance of approximately 0.9 mile. This would yield a total area impacted by the accident of about 106 acres. The calculated downwind distance would be contained within the boundaries of the Savannah River and Kesselring sites. The contaminated plume would extend beyond the boundaries of Oak Ridge and the shipyards that are at risk for this accident.

Table F.1.4.2.2.2-1. Summary of Exposure Calculation Results.
Dry Storage - Airplane Crash
At Savannah River

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.5×10^{1}	5.9×10^{-3}
MCW	8.7×10^{-1}	3.5×10^{-4}
NPA	1.1×10^{-2}	5.5×10^{-6}
MOI	1.8×10^{-1}	8.8×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	9.6×10^{2}	4.8×10^{-1}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.2×10^{1}	7.4×10^{-2}
MCW	1.1×10^{1}	4.4×10^{-3}
NPA	1.9×10^{-1}	9.5×10^{-5}
MOI	4.7×10^{-1}	2.3×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	5.5×10^{3}	2.8

Table F.1.4.2.2.2-2. Summary of Exposure Calculation Results.
Dry Storage - Airplane Crash
At Pearl Harbor

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.3×10^{1}	2.7×10^{-2}
MCW	N/A	N/A
NPA	8.6	4.3×10^{-3}
MOI	4.7	2.3×10^{-3}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	2.0×10^{4}	9.8

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.2×10^{1}	7.4×10^{-2}
MCW	N/A	N/A
NPA	2.8×10^{2}	2.8×10^{-1}
MOI	1.9×10^{1}	9.3×10^{-3}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 817385	5.2×10^{4}	2.6×10^{1}

Table F.1.4.2.2.2-3. Summary of Exposure Calculation Results.
Dry Storage - Airplane Crash
At Norfolk

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.2	3.3×10^{-3}
MCW	N/A	N/A
NPA	2.0	1.0×10^{-3}
MOI	6.9	3.4×10^{-3}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	6.5×10^{3}	3.2

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.2×10^{1}	7.4×10^{-2}
MCW	N/A	N/A
NPA	2.4×10^{1}	2.4×10^{-2}
MOI	7.2×10^{1}	7.2×10^{-2}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1539002	3.1×10^{4}	1.6×10^{1}

Table F.1.4.2.2.2-4. Summary of Exposure Calculation Results.
Dry Storage - Airplane Crash
At Portsmouth

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.1	3.2×10^{-3}
MCW	N/A	N/A
NPA	1.9	9.6×10^{-4}
MOI	3.1	1.6×10^{-3}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	3.7×10^{3}	1.9

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.2×10^{1}	7.4×10^{-2}
MCW	N/A	N/A
NPA	4.3×10^{1}	4.3×10^{-2}
MOI	3.8×10^{1}	3.8×10^{-2}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 2432627	1.8×10^{4}	9.0

Table F.1.4.2.2.2-5. Summary of Exposure Calculation Results.
Dry Storage - Airplane Crash
At Kesselring

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	8.2	3.3×10^{-3}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	1.3	6.6×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	4.8×10^{3}	2.4

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.2×10^{1}	7.4×10^{-2}
MCW	N/A	N/A
NPA	N/A	N/A
MOI	7.7	3.8×10^{-3}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 1148587	1.5×10^{4}	7.5

Table F.1.4.2.2.2-6. Summary of Exposure Calculation Results.
Dry Storage - Airplane Crash
At Oak Ridge

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.3×10^{1}	2.7×10^{-2}
MCW	8.7×10^{-1}	3.5×10^{-4}
NPA	1.1×10^{1}	5.7×10^{-3}
MOI	1.9×10^{1}	9.7×10^{-3}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	2.9×10^{3}	1.4

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.2×10^{1}	7.4×10^{-2}
MCW	5.3	2.2×10^{-3}
NPA	7.2×10^{1}	7.2×10^{-2}
MOI	1.2×10^{2}	1.2×10^{-1}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	9.5×10^{3}	4.7

F.1.4.2.3 Dry Cell Operations.

F.1.4.2.3.1 Inadvertent Cutting into Fuel Region or Mechanical Damage.

F.1.4.2.3.1.1 Description of Conditions. Mechanical damage due to handling during examination, such as accidentally cutting into the fuel region of an element, was assessed. This hypothetical accident results from inadvertent cutting across the fuel region when cropping off the Zircaloy ends of a fuel unit. All noble gas isotopes within the vicinity of the cut might be released to the facility building and escape to the environment. The majority of the volatile and solid nuclides are likely to be retained in the fuel or the facility exhaust filters. The resulting airborne release to the environment was evaluated. The possible exposure to the workers, individuals living on the site boundary, and the general population was evaluated.

F.1.4.2.3.1.2 Source Term. Conditions used in developing the source term are as follows:

- One percent of the fission products in the fuel element being handled are close enough to the cut site to be available for release.
- All (100%) of the noble gases available for release are released to the atmosphere.
- Twenty-five percent of the halogens available for release are released.
- One percent of the particulate fission products could be released and 99.9% of these are removed by normally installed HEPA filters.
- Cs and Ru would behave like particulate fission products.
- The release to the environment occurs at a constant rate over a 15-minute period.
- There is no increase in direct radiation due to this accident.

- The following amounts of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

Nuclide	Curies
Pu-238	7.2×10^{-5}
Cs-134	2.9×10^{-3}
Cs-137	4×10^{-3}
I-129	2.5×10^{-5}
Sr-90	3.9×10^{-3}
Ce-144	9.0×10^{-3}
Nb-95	5.4×10^{-3}
I-131	5.4×10^{-4}
H-3	1.42
Y-90	3.9×10^{-3}
Ba-137m	3.8×10^{-3}
Ru-106	7.6×10^{-4}
Zr-95	2.9×10^{-3}
Y-91	2.3×10^{-3}
Eu-154	2.7×10^{-4}

F.1.4.2.3.1.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical mechanical damage accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. The probability of damage to fuel during handling is small. The work on fuel at the INEL-ECF includes removal of the non-fueled portions at each end of the fuel unit. This is done in a sawing operation. To cut into the fuel, there must be operator error in positioning the spent fuel in the cutting apparatus and error in selecting the saw cut positioning gage. The combined operator and independent checker error probability for cutting of the fuel has been evaluated to be less than 10^{-7} per cut (Swain and Guttman 1983). Using a conservative number of 10^{3} saw cut operations per year results in a fuel cutting probability of less than 10^{-4} per year which has been used in the risk evaluation.

Dry Cell Mechanical Damage Summary			
Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
INEL	2.2×10^{-4}	3.5×10^{-4}	3.5×10^{-8}
Savannah River	2.4×10^{-4}	1.4×10^{-3}	1.4×10^{-7}
Hanford	7.1×10^{-5}	5.3×10^{-4}	5.3×10^{-8}
Nevada Test Site	4.0×10^{-4}	3.7×10^{-5}	3.7×10^{-9}
Oak Ridge	5.8×10^{-2}	2.5×10^{-3}	2.5×10^{-7}

The risk for this hypothetical accident is roughly proportional to the surrounding population with Oak Ridge being the worst and the Nevada Test Site being the best.

For the hypothetical dry cell mechanical damage accident scenario, the radioactive plume might result in contamination of the ground to a downwind distance of less than 0.06 mile. This would yield a total area impacted by the accident of less than 0.5 acre. The calculated downwind distance would be contained within the boundaries of all DOE sites under evaluation.

Table F.1.4.2.3.1-1. Summary of Exposure Calculation Results.
For Dry Cell Operations - Mechanical Damage
At INEL

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.7×10^{-2}	1.5×10^{-5}
MCW	3.4×10^{-5}	1.4×10^{-8}
NPA	1.9×10^{-5}	9.5×10^{-9}
MOI	6.2×10^{-5}	3.1×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	3.9×10^{-1}	1.9×10^{-4}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.0×10^{-1}	4.1×10^{-5}
MCW	3.7×10^{-4}	1.5×10^{-7}
NPA	1.1×10^{-4}	5.7×10^{-8}
MOI	2.2×10^{-4}	1.1×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115690	7.0×10^{-1}	3.5×10^{-4}

Table F.1.4.2.3.1-2. Summary of Exposure Calculation Results.
For Dry Cell Operations - Mechanical Damage
At Savannah River

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6×10^{-2}	6.6×10^{-6}
MCW	9.6×10^{-4}	3.8×10^{-7}
NPA	1.2×10^{-5}	6.1×10^{-9}
MOI (New ECF)	1.0×10^{-4}	5.1×10^{-8}
MOI (Barnwell)	2.0×10^{-4}	1.0×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	6.2×10^{-1}	3.1×10^{-4}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.0×10^{-1}	4.1×10^{-5}
MCW	1.2×10^{-2}	4.9×10^{-6}
NPA	2.1×10^{-4}	1.0×10^{-7}
MOI (New ECF)	2.4×10^{-4}	1.2×10^{-7}
MOI (Barnwell)	1.7×10^{-3}	8.4×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	2.8	1.4×10^{-3}

Table F.1.4.2.3.1-3. Summary of Exposure Calculation Results.
For Dry Cell Operations - Mechanical Damage
At Hanford

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6×10^{-2}	6.6×10^{-6}
MCW	1.3×10^{-3}	5.1×10^{-7}
NPA	1.5×10^{-5}	7.4×10^{-9}
MOI (New ECF)	9.8×10^{-6}	4.9×10^{-9}
MOI (FMEF)	2.0×10^{-5}	9.9×10^{-9}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	6.2×10^{-2}	3.1×10^{-5}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.0×10^{-1}	4.1×10^{-5}
MCW	8.0×10^{-3}	3.2×10^{-6}
NPA	2.3×10^{-4}	1.2×10^{-7}
MOI (New ECF)	7.1×10^{-5}	3.6×10^{-8}
MOI (FMEF)	2.5×10^{-4}	1.2×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375860	1.07	5.3×10^{-4}

Table F.1.4.2.3.1-4. Summary of Exposure Calculation Results.
For Dry Cell Operations - Mechanical Damage
At Nevada Test Site

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.8×10^{-3}	2.3×10^{-6}
MCW	4.5×10^{-6}	1.8×10^{-9}
NPA	N/A	N/A
MOI	4.7×10^{-5}	2.3×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	3.6×10^{-2}	1.8×10^{-5}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.0×10^{-1}	4.1×10^{-5}
MCW	2.6×10^{-4}	1.0×10^{-7}
NPA	N/A	N/A
MOI	4.0×10^{-4}	2.0×10^{-7}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	7.4×10^{-2}	3.7×10^{-5}

Table F.1.4.2.3.1-5. Summary of Exposure Calculation Results.
For Dry Cell Operations - Mechanical Damage
At Oak Ridge

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	3.7×10^{-2}	1.5×10^{-5}
MCW	9.6×10^{-4}	3.8×10^{-7}
NPA	1.3×10^{-2}	6.3×10^{-6}
MOI	9.3×10^{-3}	4.6×10^{-6}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	1.9	9.5×10^{-4}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.0×10^{-1}	4.1×10^{-5}
MCW	5.9×10^{-3}	2.4×10^{-6}
NPA	8.0×10^{-2}	4.0×10^{-5}
MOI	5.8×10^{-2}	2.9×10^{-5}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	5.1	2.5×10^{-3}

F.1.4.2.3.2 Partial Loss of Shielding Due to Earthquake.

F.1.4.2.3.2.1 Description of Conditions. A hypothetical earthquake causes the proposed Dry Cell Facility to lose some portion of its concrete shielding. Direct radiation exposure to the on-site work force and the general public has been calculated.

F.1.4.2.3.2.2 Source Term. The conditions used to calculate the dry cell direct radiation levels are as follows:

- For calculational purposes, a total of 50% of the high-density concrete dry cell shielding might be removed due to the earthquake. More realistic damage from an earthquake would result in cracks or small openings in the shielding. This bounds anticipated damage to the facility.

- Building containment and ventilation systems remain in operation. Therefore, there is no airborne release to the environment. Calculations have already been performed in Section F.1.4.2.1.1 for a drained water pool hypothetical accident which bound any anticipated airborne releases from the dry cell facility should the building containment and ventilation systems fail.

F.1.4.2.3.2.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical loss of shielding accident at each location. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence. As discussed in Section F.1.4.2.1.1.3, the probability of this hypothetical accident is estimated to be 10^{-5} per year.

Dry Cell Partial Loss of Shielding Summary			
Site	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
INEL	9.3×10^{-17}	3.0×10^{-19}	3.0×10^{-24}
Savannah River	6.7×10^{-15}	3.0×10^{-16}	3.0×10^{-21}
Hanford	3.3×10^{-23}	4.9×10^{-24}	4.9×10^{-29}
Nevada Test Site	6.3×10^{-11}	3.7×10^{-37}	3.7×10^{-42}
Oak Ridge	1.2×10^{-2}	7.5×10^{-6}	7.5×10^{-11}

At all sites, the risks associated with this accident are the lowest of any accident evaluated.

Table F.1.4.2.3.2-1. Summary of Exposure Calculation Results.
For Dry Cell Operations - Partial Loss of Shielding
At INEL

Receptor Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2×10^{-5}	2.9×10^{-8}
MCW	7.5×10^{-13}	3.0×10^{-16}
MOI	9.3×10^{-17}	4.7×10^{-20}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 115,690	5.9×10^{-16}	3.0×10^{-19}

Table F.1.4.2.3.2-2. Summary of Exposure Calculation Results.
For Dry Cell Operations - Partial Loss of Shielding
At Savannah River

Receptor Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2×10^{-5}	2.9×10^{-8}
MCW	2.7×10^{-6}	1.1×10^{-9}
MOI (New ECF)	6.7×10^{-15}	3.4×10^{-18}
MOI (Barnwell Plant)	2.4×10^{-6}	1.2×10^{-9}
NPA	7.9×10^{-17}	4.0×10^{-20}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579,541	5.9×10^{-13}	3.0×10^{-16}

Table F.1.4.2.3.2-3. Summary of Exposure Calculation Results.
For Dry Cell Operations - Partial Loss of Shielding
At Hanford

Receptor Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2×10^{-5}	2.9×10^{-8}
MCW	2.7×10^{-6}	1.1×10^{-9}
MOI (New ECF)	3.3×10^{-23}	1.7×10^{-26}
MOI (FMEF)	6.7×10^{-15}	3.4×10^{-18}
NPA	3.9×10^{-25}	2.0×10^{-28}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 375,860	9.7×10^{-21}	4.9×10^{-24}

Table F.1.4.2.3.2-4. Summary of Exposure Calculation Results.
For Dry Cell Operations - Partial Loss of Shielding
At Nevada Test Site

Receptor Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2×10^{-5}	2.9×10^{-8}
MCW	7.1×10^{-15}	2.8×10^{-18}
MOI	6.3×10^{-11}	3.2×10^{-14}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 12,159	8.7×10^{-33}	4.4×10^{-36}

Table F.1.4.2.3.2-5. Summary of Exposure Calculation Results. For Dry Cell Operations - Partial Loss of Shielding At Oak Ridge

Receptor Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	7.2×10^{-5}	2.9×10^{-8}
MCW	5.5×10^{-7}	2.2×10^{-10}
MOI	1.2×10^{-2}	6.0×10^{-6}
NPA	1.4×10^{-4}	7.0×10^{-8}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871,531	1.5×10^{-2}	7.5×10^{-6}

F.1.4.2.3.3 Airplane Crash Into Dry Cell Facility.

F.1.4.2.3.3.1 Description of Conditions. A hypothetical aircraft accident scenario was developed for dry cell operations. Based on the probability of occurrence, as discussed in Section F.3, specific analysis was only performed for Savannah River, the Nevada Test Site, and Oak Ridge. The accident was postulated to cause major damage to the building, resulting in the loss of containment and filtered exhaust systems. The fuel units inside the dry cell could also be damaged due to mechanical impacts and potential fire. The fission products which might be released are based on factors derived from overheating testing performed on the naval fuel systems. The mechanical impact also could result in the release of corrosion products to the environment.

F.1.4.2.3.3.2 Source Term. The development of the radioactive source term for this scenario is based on the following:

- One percent of the fuel units stored inside of the dry cell might be damaged by either the impact or resultant fire and those fission products would be available for release.

- Of the fission products available for release, 100% of the noble gases, 3% of the halogens, 1.1% of the cesium, and 0.1% of the remaining solids could be released to the environment.

- The release to the environment would occur at a constant rate over a 15-minute period.

- 10% of the available corrosion products could be released to the environment.

- A portion of the concrete shielding is destroyed; however, the resultant rubble provides a minimum of 6 inches of concrete shielding.

- The following amount of radionuclides could be released to the environment. This listing includes nuclides that result in at least 99% of the possible exposure.

Nuclide	Curies
Cs-134	4.5×10^{1}
Cs-137	6.23×10^{1}
Pu-238	1.03×10^{-1}
BA-137M	5.37
Sr-90	5.46
Ce-144	1.25×10^{1}
Nb-95	7.65
Y-90	5.46
Ru-106	1.07

F.1.4.2.3.3.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical airplane crash into the dry cell at the Savannah River Site. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence.

Site	Probability of accident per year	Maximally exposed off-site individual (MOI) (rem)	No. of fatal cancers if accident occurs	Risk per year
Savannah River	2×10^{-6}	8.2×10^{-1}	4.8	9.6×10^{-6}
Nevada Test Site	4×10^{-7}	1.6	1.8×10^{-1}	7.2×10^{-8}
Oak Ridge	1×10^{-6}	350	8.4	8.4×10^{-6}

This accident results in the highest risk for any hypothetical accident evaluated at Savannah River, the Nevada Test Site, and Oak Ridge.

For the hypothetical airplane crash into a dry cell accident scenario, the radioactive plume might cause contamination of the ground to a downwind distance of approximately 1.3 miles. This would yield a total area impacted by the accident of about 207 acres. The calculated downwind distance would be contained within the boundaries of Savannah River and the Nevada Test Site, but not Oak Ridge.

Table F.1.4.2.3.3-1. Summary of Exposure Calculation Results.
For Dry Cell Operations - Airplane Crash
At Savannah River

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	2.6×10^{1}	2.1×10^{-2}
MCW	1.6	6.2×10^{-4}
NPA	1.9×10^{-2}	9.6×10^{-6}
MOI	3.1×10^{-1}	1.5×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	1.6×10^{3}	8.1×10^{-1}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6×10^{2}	1.3×10^{-1}
MCW	1.9×10^{1}	7.8×10^{-3}
NPA	3.3×10^{-1}	1.7×10^{-4}
MOI	8.2×10^{-1}	4.1×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 579541	9.6×10^{3}	4.8

Table F.1.4.2.3.3-2. Summary of Exposure Calculation Results.
For Dry Cell Operations - Airplane Crash
At Nevada Test Site

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	9.2	3.7×10^{-3}
MCW	7.1×10^{-3}	2.9×10^{-6}
NPA	N/A	N/A
MOI	2.5×10^{-1}	1.3×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	2.1×10^{2}	1.1×10^{-1}

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6×10^{2}	1.3×10^{-1}
MCW	4.2×10^{-1}	1.7×10^{-4}
NPA	N/A	N/A
MOI	1.6	8.0×10^{-4}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 13792	3.5×10^{2}	1.8×10^{-1}

Table F.1.4.2.3.3-3. Summary of Exposure Calculation Results.
For Dry Cell Operations - Airplane Crash
At Oak Ridge

50% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	5.8×10^{1}	4.7×10^{-2}
MCW	1.5	6.2×10^{-4}
NPA	2.2×10^{1}	2.2×10^{-2}
MOI	1.7×10^{2}	1.7×10^{-1}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	5.2×10^{3}	2.6

95% METEOROLOGY		
Location	Total EDE (rem)	Likelihood of Fatal Cancer
Worker	1.6×10^{2}	1.3×10^{-1}
MCW	9.3	4.7×10^{-3}
NPA	1.3×10^{2}	1.3×10^{-1}
MOI	3.5×10^{2}	3.5×10^{-1}
Exposure to Population within 50-mile Radius (person-rem)		Number of Fatal Cancers
Population of 871531	1.7×10^{4}	8.4

F.1.4.3 Impact of Accidents on Close-in Workers. An evaluation has been made of the impact to close-in workers involved in naval spent nuclear fuel management that might occur due to the various radiological accidents postulated in spent fuel handling. This evaluation focused on the radiological consequences of the accident. Clearly, a limited number of fatalities may occur which are related to spent fuel handling only in a secondary manner; i.e., the worker who happened to be in the facility may be killed due to a plane crash, seismic event, crane failure, etc. These secondary effects are not discussed in the following. Rather, only radiological consequences are considered.

F.1.4.3.1 Wet Storage.

F.1.4.3.1.1 Drained Water Pool Due to Seismic Event. No fatalities to workers close to the scene of the accident would be expected due to radiological consequences. This is because drainage of the large amount of water in a water pool is expected to take several days which provides ample time for workers to leave the facility.

F.1.4.3.1.2 Accidental Criticality in a Water Pool Due to Human Error. It is likely no fatalities would occur. At most, two or three workers may receive some appreciable radiation exposure. This is because the criticality would occur under approximately 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.

F.1.4.3.1.3 Mechanical Damage to Fuel in a Water Pool Due to Operator Error or Crane Failure. No fatalities to workers would be expected from radiological consequences. This is because the release of the source term is underwater. Attenuation by the water would occur for most products, but release of noble gases would cause a direct radiation exposure to workers in the area. Upon releases from the surface of the water pool, radiation alarms would sound requiring evacuation of nearby workers. Timely evacuation would prevent substantial radiation exposure.

F.1.4.3.1.4 Airplane Crash into Water Pool Storage. No fatalities to workers would be expected from radiological consequences. This is because any release of radioactive products would be underwater and radiation alarms would sound requiring evacuation of nearby workers. Timely evacuation would prevent substantial radiation exposure.

F.1.4.3.2 Dry Storage.

F.1.4.3.2.1 Wind-driven Missile Impact on Storage Casks. It is likely there would be no fatalities to workers from radiological consequences. This is because there usually would be no nearby workers except for brief periods when a container is being placed in the dry storage array. Since a wind-driven missile is not expected to penetrate a dry storage container, direct radiation exposures even to nearby workers would not be expected. The container seal could be breached and some airborne products released. At most, two or three nearby workers may receive some radiation exposure from inhalation of airborne radioactivity.

F.1.4.3.2.2 Airplane Crash into Dry Storage. It is not likely that any fatalities would occur to nearby workers due to the radiological consequences of this accident. As in Section F.1.4.3.2.1 above, workers are usually not in the dry storage array except when a container is being placed into the array. At most, two or three nearby workers might receive significant radiation exposure from inhalation of airborne radioactivity since the container seal may be 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.

F.1.4.3.3 Dry Cell Operations.

F.1.4.3.3.1 Inadvertent Cutting into Fuel or Mechanical Damage. No fatalities to workers would be expected from the radiological consequences of this accident. This is because the ventilation systems' exhaust from a dry cell is directed to the outside of the building in which a dry cell is constructed and away from nearby workers.

F.1.4.3.3.2 Partial Loss of Shielding of a Dry Cell. It is likely that no fatalities would occur among nearby workers from the radiological consequences of this accident. This is because there is still substantial shielding of radiation from material inside the cell even with the assumed 50-percent loss of the high-density concrete. However, one or two nearby workers may receive some exposure from radiation streaming through a crack in the dry cell if this is the mode of failure. Workers are trained to evacuate quickly when radiation alarms sound.

F.1.4.3.4 Other Accidents.

F.1.4.3.4.1 HEPA Filter Fire. No fatalities would be expected among nearby workers from the radiological consequences of a fire in a HEPA filter. This is because HEPA filters are not located in an area where workers are likely to be working. In addition, the release of radioactivity involved in a HEPA filter fire is not large.

F.1.4.3.4.2 Small Leaks from Water Pools. No fatalities are expected among nearby workers from the radiological consequences of a small leak from a water pool. The leak would be expected to be into the ground through the water pathway. Drinking water supplies would not be immediately impacted. In addition, the typical concentration of radioactivity in the water is low.

F.1.4.4 Evaluation of Shipboard Fire Involving Shipping Containers.

F.1.4.4.1 Description of Conditions. In this hypothetical accident scenario, a fire onboard a ship that is transporting naval spent nuclear fuel in shipping containers from Pearl Harbor to Puget Sound is postulated. This accident could be initiated by a collision with another ship. The collision and subsequent fire are postulated to occur in Puget Sound in the center of the shipping lane at a distance of approximately 2 miles from Seattle. The consequences of a similar accident at Pearl Harbor would be less because of the smaller population and the fact that Pearl Harbor is a restricted area and is very close to the sea on the south side, limiting the number of people who might be exposed. This section addresses the radiological consequences of this postulated accident scenario. The toxic chemical consequences related to the burning fuel oil are presented in Section F.2.4.2.2.

During shipment, the containers are well protected from direct mechanical damage should a ship collision occur. The rugged nature of the shipping container and the naval reactor's fuel system is demonstrated by the analysis of airplane crashes which showed that a jet engine rotor would not penetrate the container or rupture the fuel. A severe fire is necessary to potentially cause failure of the container seals and overheat the spent fuel sufficiently to release fission products. Collisions of this severity are extremely unlikely. During the hypothetical accident, the fire would need to burn intensely in the hold for several hours to cause release of fission products or corrosion products to the environment.

F.1.4.4.2 Source Term. Conditions used in developing the source term are as follows:

- Ten percent of all fuel unit cladding inside of two shipping containers is ruptured and the contained fission products are available to be released from the fuel units.

- Of the available fission products, 100% of the noble gases, 3% of the halogens, 1.1% of the cesium, and 0.1% of the remaining solid fission products are assumed to be released to the container.

- Ten percent of all fission products released to the container are released to the environment and the remainder are adherent on the fuel and cask surfaces.

- Ten percent of the original corrosion products from the fuel units are released from the cask to the environment.

- The following amount of radionuclides could be released to the environment. This listing includes nuclides from one container that result in at least 99% of the possible exposure.

Nuclide	Curies
Cs-134	2.57×10^{1}
Cs-137	3.56×10^{1}
Pu-238	5.90×10^{-2}
Ba-137M	3.07
Sr-90	3.12
Ce-144	7.17
Nb-95	4.37
Y-90	3.12
Ru-106	6.11×10^{-1}

F.1.4.4.3 Results. The following table summarizes the public health risk to the general population that would result from the hypothetical shipboard fire accident. The number of fatal cancers would be expected to occur over a 50-year period. "Risk" is defined as the number of fatal cancers times the probability of occurrence.

The probability of occurrence of this hypothetical shipping accident is 6.7×10^{-8} per year or less, and was obtained as follows. The probability of a single port entry accident is 1.6×10^{-4} (DOE 1994). The probability of a fire, given the occurrence of an accident, is 8×10^{-4} (DOE 1994). Combining these two probabilities with the port entry frequency of 21 naval spent nuclear fuel shipments spread over 40 years results in a probability of 6.7×10^{-8} per year. Due to the rugged nature of the naval fuel and likely effectiveness of fire fighting over a several hour period, the probability of fission product release to the environment would be even less.

DOE guidance (DOE 1993b) provides that the consequence of an accident which has a probability of occurrence of less than 1×10^{-7} per year need not be calculated. However, in view of interest in this accident expressed in several public comments, the following table is provided listing hoth the consequence and the risk.

Shipboard Fire Involving Shipping Containers				
In Puget Sound Shipping Lane	50% Meteorology		95% Meteorology	
Maximally Exposed Off-site Individual (MOI)	Total EDE (Rem)	Likelihood of Fatal Cancer	Total EDE (Rem)	Likelihood of Fatal Cancer
	9.3×10^{-1}	4.7×10^{-4}	1.8	9.2×10^{-4}
General Population within 50-mile Radius	Exposure (Person-Rem)	Number of Fatal Cancers	Exposure (Person-Rem)	Number of Fatal Cancers
	2.27×10^{4}	11.4	1.03×10^{5}	51.5
Risk per year	7.6×10^{-7}		3.5×10^{-6}	

The risk for this hypothetical accident is slightly lower than that for the most severe facility accident analyzed at Puget Sound.

For the hypothetical shipboard fire accident, the radioactive plume might cause contamination to a downwind distance of less than 1 mile. However, since this area is entirely over water, the contamination would be quickly diluted by tidal flow and turbulence.

F.1.5 Analysis of Uncertainties

The analyses of the impacts of normal operations and hypothetical accidents associated with management of naval spent nuclear fuel presented in this Environmental Impact Statement (EIS) are based on conservative calculations. This is necessary because virtually all of the events analyzed have never occurred and most of the impacts of routine operations are so small that they cannot be measured. The use of calculations introduces the possibility that the actual impacts may differ from those calculated due to various kinds of uncertainties, such as differences between actual behavior and the theoretical models or equations and the variability of the values of factors used in the calculations. In order to portray the effects of such variability and uncertainty, the analyses performed for this appendix have been divided into four components: the probability that an event, such as an accident, could occur; the amount of radioactive material or radiation that might be released by the event; the calculation of the potential for exposure to human beings from the release; and the conversion of the radiation exposure to detrimental health effects. Each of these components is discussed separately in the following sections for both routine operations and accidents.

Each of these components has been analyzed for both routine operations and accidents. The discussion in the following sections focuses on accident analyses, but it should be understood that the analysis of uncertainties for routine operations is the same, with a few exceptions. First, routine operations are certain to occur, so the "probability" of such events is effectively 1.0. Second, the source terms used for the analyses of routine operations are based on monitoring of current operations at Naval Nuclear Propulsion Program facilities such as the Expended Core Facility at INEL. Consequently, the estimates of the amount of radiation or radioactivity involved are expected to be close to those which might actually occur under the alternatives evaluated in this EIS. It is possible that there would be some variations among facilities and that future efforts to keep exposures to workers as low as reasonably achievable might reduce the source terms further, but the values used in the analyses in this EIS are expected to be little different from those actually encountered. The effects of routine operations and accidents have been calculated using similar analytical methods and models for determination of radionuclide movement in the environment, pathways to humans, and conversion of exposure to health effects. Therefore, the discussion of uncertainties in Sections F.1.5.3 and F.1.5.4 applies to the results of analyses of routine operations, as well as to postulated accidents.

F.1.5.1 Probabilities of Events. The probability that an accident might occur has been determined for a number of events which might reasonably be postulated. These probabilities are used in this appendix to calculate the risk, defined as the product of the probability times the consequences, for each postulated accident.

The best methods available have been used to estimate the probabilities for the events selected for analysis. For example, a methodology developed by Sandia Laboratories (Sandia 1983) was used to compute the probability that an aircraft might crash into naval spent nuclear fuel facilities. This method uses actual aircraft crash statistics obtained from the Federal Aviation Administration and was developed by Sandia to reproduce the observed frequencies as closely as possible. Probabilities for seismic events were derived from published studies of the frequencies of seismic activity and represent the best available estimates, but these probabilities are subject to some uncertainty due to the relatively few events which have occurred at the sites evaluated under the alternatives in this EIS.

The probabilities of a range of accidents which might be caused by human error have also been included. Such events include accidental criticality caused by handling errors, dropping of fuel modules, improper operation of cranes, and incorrectly performing machining procedures. For human error, a probability of one error in one thousand operations (a frequency of 10^{-3} events per year) is used for operations performed by a single trained operator following a written procedure. If the procedure requires verification of the action by a second trained operator, this frequency is lowered to 10^{-4}. These probabilities are derived from the methodology used by the Nuclear Regulatory Commission for assessment of human reliability (Swain 1983).

In many instances, the probabilities assigned to the events reflect the likelihood that a particular event, such as an earthquake or an aircraft crash, might occur. However, for the purpose of the analyses, the resulting accident was assumed to have quite severe consequences. The probability of such severe consequences is smaller than the probability that the initiating event might occur, with consequences as severe as used in the analyses possibly occurring only one time in 10 or 100 occurrences of the initiating event. The probabilities for most of the analyses in this appendix used only the probability of the initiating event and did not include the further reduction in the probability of the postulated severe consequences resulting from the severity used. This was done, in part, because the severe consequences assumed, and in some cases the initiating events themselves, occur very infrequently, or have never occurred, so little data on their frequency is available.

For example, one accident analyzed is the impact on a spent fuel container of a missile produced by a tornado or other high winds. The sequence of events analyzed included breaching the container seal in order to release radioactive material. In reality, the missile would have to be large enough and traveling at high enough speed to cause the postulated damage. Similarly, it would have to contact the container at the correct location and at the correct angle in order to damage the seal. The probability assigned to this accident is 10^{-5} per year, the probability that a wind-driven missile might strike a container, and does not include any factor to account for other elements in the sequence required to actually damage the seal. Therefore, the probability of the consequences calculated for this accident would be much smaller than the probability of 10^{-5} per year used in the analysis.

A second example is provided by the analysis of aircraft impact on shipping containers used for storage of naval spent nuclear fuel. In this accident analysis, the impact was assumed to cause a shipping container to be penetrated if the container were contacted by the aircraft. However, naval spent nuclear fuel shipping containers are of very rugged design, and structural analysis of the container showed that a naval shipping container is very unlikely to be penetrated by an aircraft crash, even by the hardest parts of the airplane. Consequently, the probability that the naval spent nuclear fuel could be damaged and that fission products might be released is much, much less than the crash probability alone, which is the probability assigned to these consequences in this appendix.

A third example is seen in the ship fire accident. In this analysis, it is assumed that if a ship carrying naval spent nuclear fuel shipping containers were involved in a very severe collision and a fire occurred, the fire would include the cargo hold where the naval spent nuclear fuel containers are carried, the fire would not be extinguished by the redundant systems provided, and it would burn long enough at sufficient intensity to damage the shipping container and the spent nuclear fuel inside and cause release of radioactive materials from the containment provided. Given that a severe collision occurred, the probability that all of the necessary conditions would occur and a fire of the required intensity and duration would occur in the cargo hold is clearly far less than the probability of the collision.

As can be see from these examples, the actual probability of the consequences resulting from the analyses are smaller than the values presented in this appendix, at least in part because these probabilities do not include an additional factor to reflect the accident severity used in the analyses. As a result, the risks stated in this appendix for most accidents are believed to be at least 10 to 100 times larger than what would actually occur. However, the same probabilities have been used in the evaluation of all of the alternatives considered and all of the risks are small, so the approach used is adequate for the purposes of this EIS.

F.1.5.2 Release of Radioactive Material or Radiation (Source Term). Since the source terms used in the accident analyses are typically for accidents which have never occurred, there is greater room for uncertainty. All of the accidents analyzed in this EIS are intended to be accidents which produce consequences which are unlikely to be exceeded by any reasonably foreseeable accident. As a result, the accidents themselves and the sequences of events during the accidents have been chosen to maximize the source term. For example, systems such as high efficiency particulate filters have been considered to be inoperative in all cases where the accident might have an opportunity to disable them.

The source terms for the hypothetical accident analyses are dependent upon a number of factors. For there to be an accidental release of radioactivity to the environment, there must be damage to the storage facility or containment structure. Furthermore, naval spent nuclear fuel must be damaged as well in order for there to be any release of fission products since all fission products are fully contained within naval nuclear fuel. The amount of damage to the external containment or the fuel is dependent upon the severity and the nature of the accident. In the accidents analyzed, there are assumptions concerning the containment or the extent of damage to the fuel units which were made to provide a conservative, bounding evaluation whose results would not be exceeded by reasonably postulated accidents of a similar type.

One example of this is the evaluation of the dry storage container impacted by a wind-driven missile. Damage to the container by the missile is not expected to occur, but for the analysis in this EIS, the seal is assumed to be damaged by the missile impact and corrosion products within the container are assumed to be released through the damaged seal. The uncertainty on the resultant release is one-sided since the probability of a release larger than in the calculation (resulting in a higher calculated dose) is essentially zero while the possibility of a release of less radioactive material is large (for example, no release if the container seal is not broken). The range of variation, or the uncertainty interval, in the source term for this accident is between +0% and -100%.

Another example is the plane crash into a dry processing facility for naval spent nuclear fuel. The dry processing facility includes a thick concrete shielded cell in which a few naval spent nuclear fuel units are processed at a time. The massive concrete shield is provided to protect operating personnel from radiation but it has the secondary benefit of protecting the fuel units being processed from missiles caused by natural or man-made phenomena. In the unlikely event that an airplane crashed into the facility, it is expected that no damage to the spent fuel would result. Even so, for evaluation of this accident in this EIS, it is assumed that 1% of the fuel in the dry cell could be damaged and that sufficient jet fuel could enter the dry cell to cause a fire which could cause the release of fission products from the damaged fuel and destroy the filtration system. Again, the uncertainty range is one-sided since no damage to fuel is expected, causing the variability or uncertainty to range from +0% to -100%.

All of the source terms used for the evaluation of the accidents were developed in a similar fashion. Thus, the expected outcome for all of the accidents is that a lower release to the environment is expected than is used in the analysis, representing a range of variation of +0% to -100%.

F.1.5.3 Exposure to Humans. Exposure to the individuals and the general population is evaluated by integrated computer programs. The methods used model the movement of airborne, ground, and water contamination resulting from the postulated release using five types of pathways to the population. These pathways include exposure directly to the radiation from the material in the plume, direct exposure to radiation from contaminated soil or water, inhalation of air containing gases or particles, and ingestion of contaminated water or food. The analyses in this appendix used parameter values which were the best available estimates or, when best estimate values were not available, are conservative.

The Gaussian plume model used in these analyses to represent airborne movement of radioactive material is the standard used in virtually all evaluations of environmental effects. Comparison of distributions calculated using the Gaussian plume model with test data has shown that the results may differ by as much as a factor of 5 in some circumstances. In order to ensure that exposures would be as high as could occur under any set of conditions, in most of the analyses a ground level release was used and no reduction in the airborne concentrations was included for either turbulence caused by buildings or the effect of wind meander which occurs naturally at the low wind speeds accompanying the worst case meteorological conditions.

One intentional choice of parameters to ensure that the results would be conservative is the use of the worst case meteorological conditions in the tabulations of the risks and consequences for all alternatives provided in Chapters 3 and 5. The results for both the most likely meteorological conditions and for the worst case are provided in detailed tables in this attachment and show that the worst case meteorological conditions produce exposure estimates which are 2 to 10 times higher than those for the most likely conditions (depending upon local meteorological conditions). Overall, the net effect is that the Gaussian plume model might introduce an uncertainty of a factor of 5 or less in either direction, but the use of the worst case meteorological conditions would essentially offset any underestimation of effects.

The direct radiation from the cloud is calculated using a conservative representation of the plume as a finite cloud, and, as a result, little uncertainty is introduced in this part of the analysis. Direct radiation from contamination which results from particles from the plume deposited on the ground surface depends upon the deposition parameters which are input as best-estimate values. Faster deposition would result in more material on the ground and increased exposure to those closer to the accident location but less material on the ground and decreased exposure for those farther from the accident site. Any effects of uncertainty in this parameter would depend upon the population distribution around the postulated accident scene.

The possible exposure to direct radiation from material in surface water and associated sediments as a result of accidental release directly to the water or fallout from an airborne release was estimated for people involved in activities such as professional fishing, maritime operations, swimming, and boating. The calculations took no credit for dilution by river currents or tidal movement and the concentrations in the air were not reduced by the amount of material deposited in the water. Due to the conservative concentrations used in the calculations and an assumption that every member of the population in the area would be exposed to direct radiation from surface waters, exposure from this pathway is very likely overestimated.

The inhalation pathway evaluation is based on average breathing rates and uptake consistent with the recommendations by the ICRP (ICRP 1977 and ICRP 1979). Obviously, higher values for these parameters would increase the estimated exposures and lower values would decrease the estimates. There appears to be little controversy concerning these parameters and the same parameters are used for evaluation of all of the alternatives in this appendix.

The ingestion pathway includes meat, seafood, dairy and crop products, and drinking water. Best-estimate parameters are used to evaluate the contamination levels in food and water when ready for consumption. Consumption rates for individuals are based on observed eating habits. The analysis also includes the assumption that a conservative 10% of the entire diet of the affected population consists of contaminated products. The uncertainties associated with these pathways can obviously affect the estimated impacts, but the range of variation is not large and the same values for a given site were used for evaluation of all alternatives.

The drinking water contribution to the ingestion pathway was calculated by assuming that a portion of the radioactive material would become dissolved in the drinking water supply. At sites where fresh surface water provides drinking water, any contamination of the water was assumed to occur promptly and no decreases due to radioactive decay were used. At sites where aquifers are a source of drinking water, consumption of water from the aquifer was delayed for the time required for the contamination to reach the aquifer and then to reach the nearest drinking water source. As an example, for a postulated leak from the Expended Core Facility, it was assumed that 20 years would pass before water carrying the radioactive material would reach a well drawing from the aquifer and that 1 percent of material released would enter the aquifer each year. Maximum exposed individuals were conservatively assumed to drink only water from the contaminated source and to drink 2 liters of water per day. For the population in general, a conservative fraction of the population was assumed to drink 1 liter of water per day from affected sources. The concentrations in these calculations are considered to be higher than expected because no reduction of the concentration by dilution was included and the fraction of the population exposed to the affected drinking water is conservatively high.

At sites where irrigation is used, contamination of food crops, livestock, and local game was analyzed. The same concentration of radioactive material as in drinking water was used in the irrigation water. Affected crops, livestock, and game were assumed to receive all water from the contaminated water source and applicable biological accumulation factors were used. Human consumption rates for the crops, livestock, and game were used to calculate the exposure from this source. The uncertainty from this source is associated with the concentration of contaminants in the irrigation water, the amount of such foods consumed, and the fraction of the population which ingests the affected food.

The population used to determine the effects of postulated accidents in this appendix is the entire population within the 22.5-degree sector at each distance within 50 miles downwind of the accident. The spread of the plume for the worst case meteorology does not cover the entire sector. The result is that there is a conservatism of more than a factor of 2 in the application of the calculations to the evaluation of the dose to the population. The population data used were obtained from the 1990 U. S. census, so population growth or decreases in a region could introduce small changes, but the same population distributions were used for a specific site for evaluation of all alternatives.

Considering all of the factors which might have an appreciable effect on the results of the analyses, any tendency of the Gaussian plume model to underestimate concentrations would be offset by the use of other parameters which are known to be conservative. Examples of such conservative factors include the general use of the meteorological conditions which would produce the most severe effects and the use of the entire population of a 22.5-degree sector. Consequently, this portion of the analyses would appear to contribute little in the way of uncertainty which could cause the results to be greater than presented in this appendix.

F.1.5.4 Conversion of Exposure to Health Effects. The conversion of amounts of radiation or radioactive material transmitted to an individual or to population groups requires the calculation of the exposure or dose received by humans caused by inhaling or ingesting radioactive material or by being in a radiation field. Such calculations are based on a number of factors, including the nature and rate of human metabolic processes, such as respiration or excretion, the type of radiation involved, the sensitivity of various organs, and the age of the individuals involved. The rates of human metabolic processes are well characterized at this time and the energies, half-lives, and similar properties of radioactive material or radiation have been measured extensively and are not subject to great debate. Consequently, these factors introduce little uncertainty into the calculations in this EIS.

However, the number of detrimental health effects which might result from exposure of a large group of people to low levels of radiation has been the subject of debate for many years. The National Academy of Sciences has conducted several investigations of this matter and its full commentary on page 181 of its latest study of the health effects of exposure to low levels of radiation, frequently identified as BEIR V (NAS 1990), states:

> Finally, it must be recognized that derivation of risk estimates for low doses and dose rates through the use of any type of risk model involves assumptions that remain to be validated. At low doses, a model dependent interpolation is involved between the spontaneous incidence and the incidence at the lowest doses for which data are available. Since the committee's preferred risk models are a linear function of dose, little uncertainty should be introduced on

> this account, but departure from linearity cannot be excluded at low doses below the range of observation. Such departures could be in the direction of either an increased or decreased risk. Moreover, epidemiologic data cannot rigorously exclude the existence of a threshold in the millisievert dose range. Thus, the possibility that there may be no risks from exposures comparable to external natural background radiation cannot be ruled out. At such low dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero.

The National Academy of Sciences considers that the uncertainty in the lifetime total excess cancer mortality risk estimates calculated using the linear extrapolation, no threshold models it has designated as preferred, which is consistent with the model used in this EIS, is approximately a factor of 2 in either direction (an interval of 0.5 to 2 times the calculated estimates).

The calculations of health effects performed in this Environmental Impact Statement use the relation recommended by the International Council on Radiation Protection because it is well-documented and kept up to date by the Council. It is also consistent with the preferred model identified by the National Academy of Sciences in the BEIR V report and is widely accepted by the scientific community as representing a method which produces estimates of health effects which will not be exceeded. However, there are some who believe that exposure to low levels of radiation can produce more health effects than would be estimated using the International Council on Radiation Protection relation. On the other hand, a growing number of researchers believe that the International Council on Radiation Protection relation overestimates the number of detrimental health effects produced by low levels of radiation and, in fact, the possibility of no effect cannot be excluded (CIRRPC 1992).

Clearly, using a relation developed by one or the other of these groups would produce a larger or smaller estimate of the number of health effects than the values presented in this EIS, but a factor of 2 change in the small risks calculated for all of the alternatives would still leave them as small risks. All of the results of analyses of normal operations and hypothetical accidents in Appendix D include the calculated exposure in addition to the number of health effects in order to permit independent calculations using any relation between radiation exposure and health effects judged appropriate.

F.1.5.5 Summary of Uncertainties. As discussed in the preceding portions of this section, 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 of actual operations provide clearly realistic source terms, which, when combined with conservative estimates of the effects of radiation, produce estimates of risk which 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 provide more opportunities for uncertainty, primarily because the calculations must be based on sequences of events and models of effects which have not occurred. In this appendix, the goal in selecting the hypothetical accidents analyzed has been to evaluate events which would produce effects which would be as severe or more severe than any other accidents which might reasonably be postulated. 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 which are as realistic as possible. However, in many cases, the very low probability of the accidents postulated has required the use of models or values for input which produce estimates of consequences and risks which are higher than would actually occur because of the desire to provide results which will not be exceeded. In summary, it is judged that the risks presented in this appendix are believed to be at least 10 to 100 times larger than what would actually occur.

The use of conservative analyses is not an important problem or disadvantage in this EIS since all of the alternatives have been evaluated using the same methods and data, allowing a fair comparison of all of the alternatives on the same basis. Furthermore, even using these conservative analytical methods, the risks for all of the alternatives are small, which greatly reduces the significance of any uncertainty analysis parameters.

F.2 TOXIC CHEMICAL ISSUES AT NAVAL SPENT NUCLEAR FUEL EXAMINATION AND STORAGE SITES

The INEL-ECF is a large laboratory facility used to receive, examine, and ship naval nuclear fuel and irradiated test specimen assemblies. In order to accomplish these tasks, some chemicals classified as toxic are involved in a variety of operations and thus a potential exists for releases of toxic chemicals due to human error and failure or malfunctioning of equipment.

This section provides the results of an evaluation of both normal operations and accidents that could result in toxic chemical releases. This section describes how facilities and operations were selected for analysis, discusses the computer codes used in the analysis, presents the weather conditions and atmospheric dispersion, defines the hypothetical accidents which would produce the most severe consequences, and estimates the potential health effects. Each alternate location's specific population and meteorology were used to produce estimated consequences for each operation and accident.

F.2.1 Toxic Chemical Inventory

Some chemicals classified as toxic are routinely used in a variety of operations at the INEL-ECF. Table F.2-1 provides the INEL-ECF Chemical Inventory. This inventory was developed from the Naval Reactors Facility Superfund Amendments and Reauthorization Act (SARA) Section 312 chemical inventory (INEL 1993). Those chemicals specifically stored and used at INEL-ECF as well as those used for facility support (e.g., fuel oil, diesel fuel, sulfuric acid, and sodium hydroxide) were included. Chemicals at INEL-ECF that were (a) in excess of 500 pounds, or (b) in excess of reportable quantities (usually 1 pound) on the EPA Title III List of Lists (EPA 1992a) were evaluated. The chemicals in the EPA Title III List of Lists are the hazardous chemicals defined in:

- SARA Section 302 Extremely Hazardous Substances (CFR 1992a)
- CERCLA Hazardous Substances (CFR 1992b)
- SARA Section 313 Toxic Chemicals (CFR 1992c)
- RCRA Hazardous Wastes (CFR 1992d)
- EPA list of 100 extremely hazardous chemicals (FR 1993).

Table F.2-1. INEL-ECF chemical inventory.

CAS No.	Chemical Name	Weight Total (pounds)	Weight Unit[1] (pounds)
Chemicals Used for Water Pool Operations			
60-00-4	Ethylenediaminetetraacetic Acid (EDTA) (reagent for water analyses)	46.3	1.1
75-71-8	Dichlorodifluoromethane (CFC-12) (refrigerant in coolers for pool water)	30.0	30.0
Chemicals Used for Examination Operations			
60-29-7	Ethyl Ether	5.7	5.7
67-63-0	Isopropyl Alcohol	100.6	6.6
123-31-9	Hydroquinone (photographic film developer)	65.5	3.3
144-55-8	Sodium Bicarbonate	198.0	99.0
302-01-2	Hydrazine	3.7	1.8
7664-41-7	Ammonia[2]	2.8	0.28
7727-37-9	Diatomic Nitrogen	643	125
Chemicals Used for Facility Support			
107-21-1	Ethylene Glycol (anti-freeze and paint additive)	516.1	514.0
115-07-1	Propylene (Propene)	0.01	0.005
1310-73-2	Sodium Hydroxide (boiler water pH control)	43260	43260
7664-93-9	Sulfuric Acid (boiler and cooling tower water pH control)	96427	96427
68476-33-5	Fuel Oil #5	776210	204270
68476-34-6	Diesel Fuel #2	14316	10735
72623-83-7	Hydrotreated Lubricating Oil	882.6	413
Chemical Used for Nuclear Poison			
1332-77-0	Potassium Tetraborate	17000	10

[1] The quantities in this column represent the amount of chemical stored in the largest single container as identified in the INEL-ECF chemical inventory.

[2] The ammonia is present as ammonium hydroxide.

In order to evaluate the alternate locations, the same inventory of chemicals at the INEL-ECF was used at the DOE sites; namely, the Savannah River Site, the Hanford Site, the Nevada Test Site, and the Oak Ridge Reservation. In addition, the Barnwell Nuclear Fuel Plant (hereafter referred to as the Barnwell Plant), which is adjacent to the Savannah River Site, was evaluated along with the DOE sites. Since the shipyards would not be involved with examination operations (except for Puget Sound), of the chemicals listed, only diesel fuel would be available in a substantial quantity, in the form of fuel stored at the shipyards. Although several of the chemicals listed in Table F.2-1 are water treatment chemicals associated with water pool operations and small water pools may be needed at the shipyards for fuel storage and inspection, the shipyard would already have on-hand similar water treatment chemicals for other operations at the shipyard. Therefore, an increase in the quantities or types of chemicals at the shipyards was considered to be very small and thus did not require evaluation. In addition, even though the Kenneth A. Kesselring Site is not a shipyard, this facility would also not be involved with examination operations. Therefore, this facility was evaluated in the same manner as the shipyards.

F.2.2 Computer Modeling to Estimate Toxic Chemical Exposures

Factors such as locations of affected persons, terrain, meteorological conditions, release conditions, and characteristics of the chemical inventory are required as input parameters for calculations to determine human exposure from airborne releases of toxic chemicals. This section describes the computer models used to perform exposure estimates. Specific input parameters used in the analyses are summarized in the appropriate subsection for normal operations and accident conditions. The EPIcode was used to evaluate toxic chemical releases resulting from accidents, and the ISC2 code was used to evaluate releases from normal operations.

F.2.2.1 EPIcode™. The Emergency Prediction Information Computer Code (EPIcode™) is the computer code chosen for estimating airborne concentrations resulting from most releases of toxic chemicals (Homann 1988). Like RSAC, EPIcode uses the well-established Gaussian Plume Model to calculate the airborne toxic chemical concentrations usually at the same downwind locations as RSAC. The EPIcode library contains information on over 600 toxic substances listed by the American Conference of Governmental Industrial Hygienists in the EPIcode Manual. EPIcode also allows user description of substances not included in the library. A step-by-step flow chart of the main EPIcode features (up to the output options) is shown in Figure F.2-1.

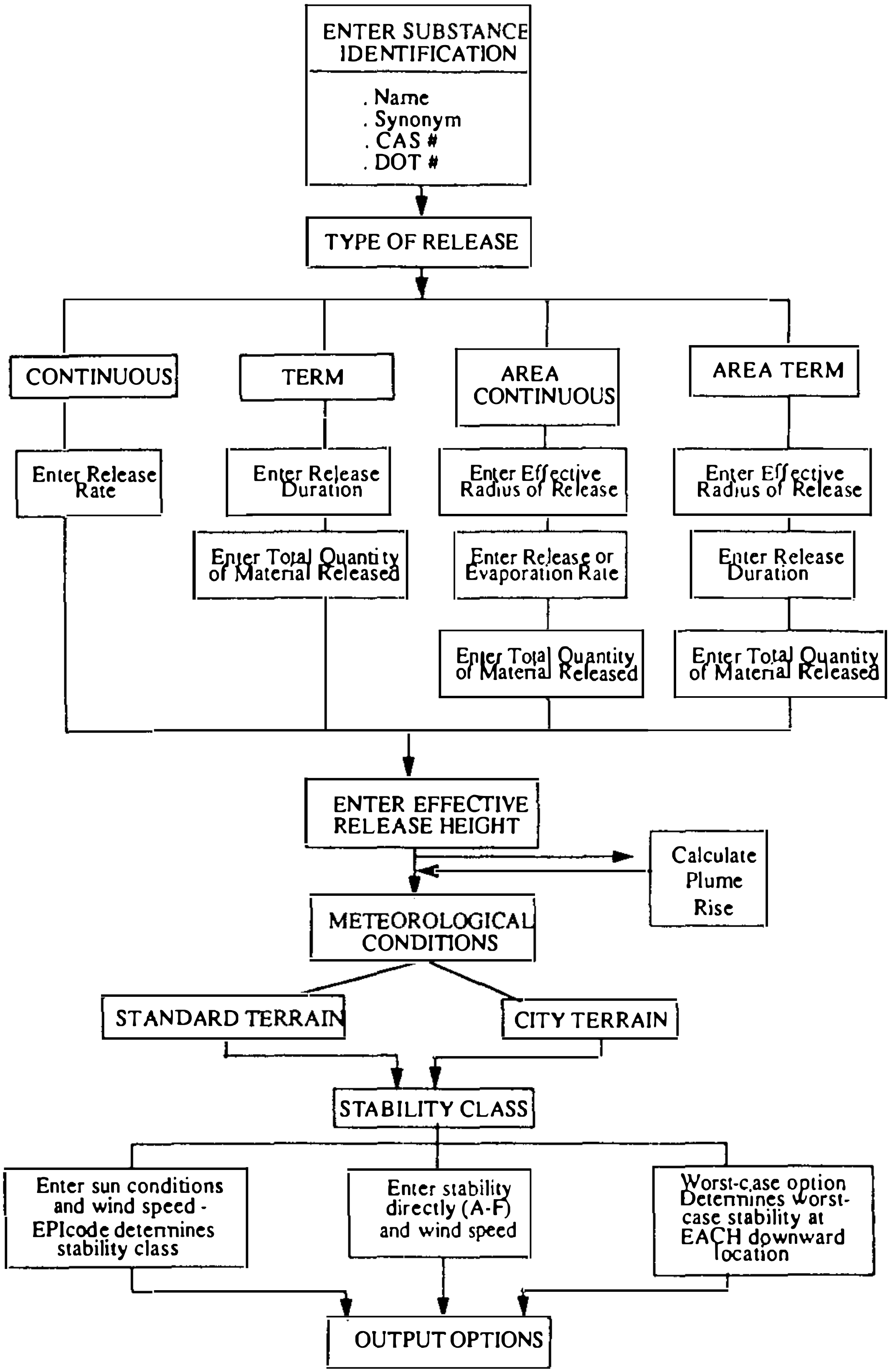

Figure F.2-1. Flow sheet for EPIcode (Homann 1988).

As shown in Figure F.2-1, the continuous release models require specification of the source term as an ambient concentration and a release rate. For releases over a specific time interval (i.e., term releases), the user specifies the release duration and the total quantity of material released.

Area continuous and area term releases are useful in calculating the effects of a release from pools of spilled volatile liquids. The user must enter the radius of the circle encompassing the spill area. Also entered is the temperature of the pool and ambient temperature to establish release rate from a liquid spill. An upwind virtual point source, which results in an initial lateral diffusion equal to the effective radius of the area source, is used to model an area release.

By specifying a release quantity, release duration, and release area, the user effectively proposes a release rate per unit spill area. The release quantity is defined as a source term (Q) or fraction of the material at risk. The concepts and defined terms are the same as for radiological calculations. EPIcode confirms that the volatility of the spilled substance can support such a release rate. If the proposed release rate exceeds the saturation conditions at the release temperature, EPIcode calculates a lower release rate and a corresponding longer release time.

In calculating effective release height, the actual plume height may not be the physical release height, e.g., the stack height. Plume rise can occur because of the velocity of a stack emission and the temperature differential between the stack effluent and the surrounding air. EPIcode calculates both the momentum plume rise and the buoyant plume rise and chooses the greater of the two results. Since this effective increase in release height leads to lower concentrations at the ground level, the physical release heights were used to calculate the concentrations that the general public may be exposed to during accidental releases of toxic substances. This approach will always yield conservative estimates.

In this application, the standard terrain calculation of EPIcode is always used. Downwind concentrations were calculated using both 95% and 50% meteorological conditions (Section F.1.3.5). The elevation of the affected person is always ground level (0 meters) and, as in RSAC-5, the mixing layer height is always 400 meters (1320 feet). The deposition velocities used (Section F.2.4.2.1.3) are somewhat different than those of RSAC-5, but they are still conservatively low.

As described in its user manual (Homann 1988), EPIcode also includes the following steps:

- Treating a release as instantaneous vs. continuous depending upon the plume length at the specific downwind location being considered
- Correcting the concentration for sampling time
- Adjusting the wind speed for release height
- Depleting the plume as a function of downwind distance
- Adjusting the standard deviations of the crosswind and vertical concentrations for brief releases.

As output, EPIcode can generate data plots of mean toxic chemical concentration (during a specified averaging time) as a function of downwind distance. From these graphs and numerical output, the concentrations for the worker at 100 meters (330 feet) (the shortest distance for which EPIcode calculates), for the nearest public access (NPA), for the maximum off-site individual (MOI), and for nearby communities are determined and evaluated for health effects.

EPIcode was selected as the computer code for release analysis of chemicals amenable to Gaussian modeling after comparison with a number of codes, primarily CHARM and ARCHIE. It was judged more applicable for this application than either the CHARM code or the comparable ARCHIE code.

F.2.2.2 ISC2 Code. The Industrial Source Complex (ISC2) model is a widely used, publicly available, and accepted EPA regulatory model which employs straight line (i.e., uniform wind field) Gaussian diffusion to estimate pollutant dispersion (EPA 1992b). ICS2 is an appropriate model for industrial complexes in rural or urban areas with transport distances less than 50 kilometers (30 miles). This model employs a standard meteorological data set requiring single point hourly wind speed, wind direction, ambient air temperature, atmospheric stability, and vertical mixing height values. Also, the ISC2 model is able to account for variations in pollutant concentrations due to the influence of nearby structures.

In addition to the ISC2 model, the MESOPUFF II model was also evaluated. MESOPUFF II is a regional (mesoscale) scale model that takes into account a varying wind field. Past trajectory analyses at the INEL have demonstrated that plumes may undergo many changes in direction due to the varying winds common to the INEL vicinity. The number of changes is partially dependent on release time and transport duration. The plume transport and estimation of pollutant concentration beyond 12 miles (20 kilometers) is best modeled using spatially varying wind data. Although not used as a basis for determining or enforcing compliance with regulations, it is used on a case-by-case basis. The model is also readily available to the public.

Upon review of the ISC2 and MESOPUFF II models, the decision was made to utilize ISC2 for the dispersion analysis of pollutants emitted from stationary sources. ISC2 is able to reasonably and accurately predict downwind pollutant concentrations within 30 miles (50 kilometers) by taking into account multiple point and area emission sources, evaluating hourly meteorological data, and determining the effects of nearby structures.

F.2.3 Health Effects

Toxic constituents dispersed during an accident could induce adverse health effects among exposed individuals. This possible impact is assessed by comparing the airborne concentrations of each substance at specified downwind locations to standard accident exposure guidelines for chemical toxicity.

Where available, Emergency Response Planning Guideline (ERPG) values are used for this comparison. ERPG values are estimates of airborne concentration thresholds above which one can reasonably anticipate observing adverse effects (Rusch 1993). ERPG values are specific for each substance, and are derived for each of three general severity levels:

- Exposure to concentrations greater than ERPG-1 values results in an unacceptable likelihood that one would experience mild transient adverse health effects, or perception of a clearly defined objectionable odor.

- Exposure to concentrations greater than ERPG-2 values results in an unacceptable likelihood that one would experience or develop irreversible or other serious health effects, or symptoms that could impair one's ability to take protective action.

- Exposure to concentrations greater than ERPG-3 values results in an unacceptable likelihood that one would experience or develop life-threatening health effects.

Where ERPG values have not been derived for a toxic substance, other chemical toxicity values are substituted, as follows:

- For ERPG-1, Threshold Limit Value, Time-Weighted Average (TLV-TWA) values (ACGIH 1993) are substituted: The TWA is the time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

- For ERPG-2, Level of Concern values (equal to 0.1 of Immediately Dangerous to Life or Health) are substituted: Level of Concern is defined as the concentration of a hazardous substance in air, above which there may be serious irreversible health effects or death as a result of a single exposure for a relatively short period of time (EPA 1987).

- For ERPG-3, Immediately Dangerous to Life or Health (IDLH) values are substituted: IDLH is defined as the maximum concentration from which a person could escape within 30 minutes without a respirator and without experiencing any effects which would impair the ability to escape or irreversible side effects (NIOSH 1990).

Possible health effects associated with exceeding an ERPG-2 or -3 value are specific for each substance of concern, and must be characterized in that context. When concentrations are found to exceed an ERPG or substitute value, the specific toxicological effects for the chemicals of concern are considered in describing possible health effects associated with exceeding a threshold value.

ERPG values are based upon a 1-hour exposure of a member of the general population. In this EIS, exposures resulting from the release of toxic chemicals during an accident condition were postulated to occur over a period of 1 hour or less to allow for a direct comparison to the ERPG values. This approach provides an additional element of conservatism in the evaluation of accidents with releases that last much less than 1 hour.

In addition to comparing the airborne concentrations of each substance to standard accident exposure guidelines, each substance was evaluated to determine if it has the potential for future carcinogenic health impacts. If a particular substance has this potential, the Integrated Risk Information System (IRIS) (TOXnet 1993) was reviewed and if sufficient toxicological information was available, a future potential likelihood of developing cancer was determined. If sufficient information from IRIS was not available, alternative evaluation methods, including comparison to ambient air quality criteria, were substituted.

The impact of normal operations was also evaluated. This impact was assessed by comparing the airborne concentrations of each substance at specified downwind locations to the National Ambient Air Quality Standards (NAAQS) assigned for each substance. NAAQS consist of national primary and secondary ambient air quality standards (CFR 1991). National primary ambient air quality standards define levels of air quality which the EPA judges are necessary, with an adequate margin of safety, to protect the public health. National secondary ambient air quality standards define levels of air quality which the EPA judges are necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. As a result, the immediate as well as cumulative impact of normal operations was evaluated by comparing the airborne concentrations of each substance to the NAAQS.

F.2.4 Analysis Description and Results

The analysis results for both normal operations and accident conditions are reported for each location analyzed. Detailed estimated concentrations and ERPG levels, expressed in milligrams per cubic meter (mg/m^3), are reported in tabular form for a worker, maximally exposed collocated worker (MCW), maximally exposed off-site individual (MOI), and maximally exposed individual at the nearest public access (NPA). A complete description of these individuals is provided in Section F.1.3.2.

F.2.4.1 Normal Operations.

F.2.4.1.1 Source of Emissions. Emissions resulting from normal operations involving toxic chemicals listed in Table F.2-1 were evaluated. It was determined that the burning of Number 5 fuel oil in the facility's boilers and the burning of Number 2 diesel fuel in the facility's emergency diesel generators represented the largest sources of emissions under normal operations and thus provide the conditions producing the most severe consequences for evaluation. These normal operations result in the release of oxides of nitrogen (90% nitric oxide and 10% nitrogen dioxide), sulfur dioxide, particulates (PM-10), lead, and volatile organic compounds (VOCs). The airborne release of these chemicals was evaluated for effects on the on-site workers, MCW, NPA, and MOI.

The emissions that occur due to normal operations at the INEL-ECF were evaluated using the ISC2 code. These releases were also used at the alternate locations (Hanford, Savannah River, Nevada Test Site, Barnwell Plant, and Oak Ridge) for evaluation purposes. Heating boilers and emergency diesel generators already exist at the alternate shipyard locations and thus selection of these alternate locations would not result in a measurable increase in emissions. Therefore, routine releases from shipyard locations were not considered.

F.2.4.1.2 Conditions and Key Parameters.

- Number 5 fuel oil was burned in facility boilers for space heating.
- Number 2 diesel fuel was burned in facility emergency diesel generators.
- Source term was based on the INEL report on routine yearly releases (NRF 1993) which included:
    - 1.02 tons per year of carbon monoxide released
    - 9.04 tons per year of oxides of nitrogen released
    - 33.7 tons per year of sulfur dioxide
    - 1.54 tons per year of particulates

    - 5.86×10^{-4} tons per year of lead
    - 0.18 tons per year of volatile organic compounds.

- Forty percent of the total boiler and emergency diesel generator use for the Naval Reactors Facility was attributed to the INEL-ECF.
- Three point sources (one representing boilers and two representing emergency diesel generators) were used.
- Stack diameters of 1.07 meters (3.5 feet) for boilers and 0.305 meter (1 foot) for emergency diesel generators were used.
- Stack gas exit velocities of 21.8 meters per second (72 feet per second) for boilers and 44.2 meters per second (145 feet per second) for emergency diesel generators were used.
- Stack gas exit temperatures of 505°K for boilers and 794°K for emergency diesel generators were used.
- Worker concentrations were based on 16 sector polar grids. Other affected locations were defined as discrete points.
- DOE site meteorological data were used for evaluations at the Naval Reactors Facility, Hanford, Nevada Test Site, and Oak Ridge. Meteorological data from the closest National Weather Service Station were used for evaluations at Savannah River and the Barnwell Plant.

F.2.4.1.3 Results. The airborne concentrations, averaged over the duration of each exposure, were calculated by ISC2 for the worker, MCW, NPA, and MOI using normal meteorology. Tables F.2.4.1-1 through -6 list the downwind concentrations at various locations. The airborne concentrations were compared to respective NAAQS values where available. The NAAQS are as follows:

Carbon monoxide. The national primary ambient air quality standards for carbon monoxide are 10 mg/m^3 for an 8-hour average concentration not to be exceeded more than once per year, and 40 mg/m^3 for a 1-hour average concentration not to be exceeded more than once per year.

Sulfur oxides. The national primary ambient air quality standards for sulfur oxides that are measured as sulfur dioxide are 0.08 mg/m^3 as an annual arithmetic mean and 0.365 mg/m^3 as a maximum 24-hour concentration not to be exceeded more than once per year. The national secondary ambient air quality standards are 1.3 mg/m^3 as a maximum 3-hour concentration not to be exceeded more than once per year.

Nitrogen dioxide. The national primary and secondary ambient air quality standard for nitrogen dioxide is 0.1 mg/m^3 as an annual arithmetic mean.

Lead. The national primary and secondary ambient air quality standard for lead and its compounds that are measured as elemental lead is 1.5×10^{-3} mg/m^3 as a maximum arithmetic mean averaged over a calendar quarter.

Particulate matter. The national primary and secondary ambient air quality standard for particulate matter is 0.05 mg/m^3 as an annual arithmetic mean and 0.15 mg/m^3 as a maximum 24-hour concentration.

A comparison of the downwind concentrations provided in Tables F.2.4.1-1 through -6 with the NAAQS identified above indicates that no NAAQS is exceeded for normal operations.

Table F.2.4.1-1. Summary of chemical concentrations for normal operations at the INEL Expended Core Facility.

	CHEMICAL CONCENTRATIONS mg/m^3						
	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead	VOC	PM-10
Worker	4.6×10^{-5}	5.5×10^{-4}	1.9×10^{-4}	2.1×10^{-5}	9.0×10^{-9}	1.9×10^{-5}	2.7×10^{-5}
MCW	3.7×10^{-6}	9.5×10^{-5}	2.6×10^{-5}	2.9×10^{-6}	2.0×10^{-9}	8.5×10^{-7}	4.6×10^{-6}
MOI	7.7×10^{-7}	2.3×10^{-5}	5.8×10^{-6}	6.4×10^{-7}	$<1.0 \times 10^{-9}$	1.6×10^{-7}	1.1×10^{-6}
NPA	7.7×10^{-7}	2.3×10^{-5}	5.8×10^{-6}	6.4×10^{-7}	$<1.0 \times 10^{-9}$	1.6×10^{-7}	1.1×10^{-6}

Table F.2.4.1-2. Summary of chemical concentrations for normal operations at Hanford.

	CHEMICAL CONCENTRATIONS mg/m^3						
	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead	VOC	PM-10
Worker	2.9×10^{-5}	1.5×10^{-4}	1.3×10^{-4}	1.0×10^{-5}	3.0×10^{-9}	1.1×10^{-5}	1.4×10^{-5}
MCW	1.6×10^{-5}	2.1×10^{-4}	9.6×10^{-5}	1.1×10^{-5}	5.0×10^{-9}	4.7×10^{-6}	1.5×10^{-5}
MOI (New ECF)*	1.0×10^{-6}	3.2×10^{-5}	8.0×10^{-6}	8.9×10^{-7}	1.0×10^{-9}	2.0×10^{-7}	1.5×10^{-6}
MOI (FMEF)**	1.4×10^{-6}	4.0×10^{-5}	1.1×10^{-5}	1.2×10^{-6}	1.0×10^{-9}	3.0×10^{-7}	1.9×10^{-6}
NPA	1.3×10^{-6}	4.1×10^{-5}	1.0×10^{-5}	1.1×10^{-6}	1.0×10^{-9}	2.6×10^{-7}	1.9×10^{-6}

*MOI (New ECF) applies if spent fuel facility is constructed at the 200 Area on the Hanford Site.
**MOI (FMEF) applies if spent fuel facility is constructed at the Fuels and Materials Examination Facility.

Table F.2.4.1-3. Summary of chemical concentrations for normal operations at Savannah River.

	CHEMICAL CONCENTRATIONS mg/m^3						
	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead	VOC	PM-10
Worker	1.5×10^{-5}	6.4×10^{-5}	6.4×10^{-5}	7.1×10^{-6}	1.0×10^{-9}	6.2×10^{-6}	5.9×10^{-6}
MCW	9.4×10^{-6}	1.6×10^{-4}	5.7×10^{-5}	6.3×10^{-6}	3.0×10^{-9}	2.8×10^{-6}	8.7×10^{-6}
MOI	1.8×10^{-6}	4.8×10^{-5}	1.3×10^{-5}	1.4×10^{-6}	1.0×10^{-9}	3.8×10^{-7}	2.3×10^{-6}
NPA	8.6×10^{-7}	2.4×10^{-5}	6.3×10^{-6}	7.0×10^{-7}	$<1.0 \times 10^{-9}$	1.9×10^{-7}	1.1×10^{-6}

Table F.2.4.1-4. Summary of chemical concentrations for normal operations at the Nevada Test Site.

	CHEMICAL CONCENTRATIONS mg/m^3						
	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead	VOC	PM-10
Worker	9.0×10^{-5}	3.6×10^{-4}	4.0×10^{-4}	4.5×10^{-5}	7.0×10^{-9}	3.8×10^{-5}	4.1×10^{-5}
MCW	2.5×10^{-7}	7.3×10^{-6}	1.9×10^{-6}	2.1×10^{-7}	$<1.0 \times 10^{-9}$	5.2×10^{-8}	3.5×10^{-7}
MOI	7.9×10^{-7}	2.3×10^{-5}	5.9×10^{-6}	6.6×10^{-7}	$<1.0 \times 10^{-9}$	1.6×10^{-7}	1.1×10^{-6}

Table F.2.4.1-5. Summary of chemical concentrations for normal operations at Oak Ridge.

	CHEMICAL CONCENTRATIONS mg/m^3						
	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead	VOC	PM-10
Worker	6.4×10^{-5}	3.0×10^{-4}	2.8×10^{-4}	3.1×10^{-5}	5.0×10^{-9}	2.6×10^{-5}	2.7×10^{-5}
MCW	1.6×10^{-6}	2.6×10^{-5}	9.6×10^{-6}	1.1×10^{-6}	$<1.0 \times 10^{-9}$	5.0×10^{-7}	1.5×10^{-6}
MOI	1.4×10^{-5}	2.5×10^{-4}	8.8×10^{-5}	9.8×10^{-6}	4.0×10^{-9}	4.3×10^{-6}	1.4×10^{-5}
NPA	1.9×10^{-5}	3.1×10^{-4}	1.1×10^{-4}	1.2×10^{-5}	5.0×10^{-9}	5.6×10^{-6}	1.7×10^{-5}

Table F.2.4.1-6. Summary of chemical concentrations for normal operations at the Barnwell Plant.

	CHEMICAL CONCENTRATIONS mg/m^3						
	Carbon Monoxide	Sulfur Dioxide	Nitric Oxide	Nitrogen Dioxide	Lead	VOC	PM-10
Worker	1.5×10^{-5}	6.5×10^{-5}	6.4×10^{-5}	7.1×10^{-6}	1.0×10^{-9}	6.2×10^{-6}	5.9×10^{-6}
MCW	1.9×10^{-6}	4.7×10^{-5}	1.3×10^{-5}	1.5×10^{-6}	1.0×10^{-9}	4.5×10^{-7}	2.3×10^{-6}
MOI	5.9×10^{-6}	1.4×10^{-4}	4.0×10^{-5}	4.5×10^{-6}	2.0×10^{-9}	1.5×10^{-6}	7.0×10^{-6}
NPA	5.9×10^{-6}	1.4×10^{-4}	4.0×10^{-5}	4.5×10^{-6}	2.0×10^{-9}	1.5×10^{-6}	7.0×10^{-6}

F.2.4.2 Accidents. Spillage of chemicals with a subsequent fire was evaluated for the bounding accident involving toxic chemicals. The toxic chemicals that could be involved in the postulated accident are described in Section F.2.1. As was noted in that section, the extensive listing of chemicals provided in Table F.2-1 would be applicable only at sites involved with fuel examination. The bounding accident evaluated for spent nuclear fuel storage in water pools at shipyard locations was a diesel fuel spill and fire. A diesel fuel fire involving spent nuclear fuel shipping containers aboard a ship at sea in Puget Sound was also evaluated.

Evaluation of the chemical spill with fire accident (excluding diesel fuel) at the alternate sites (INEL-ECF, Hanford, Savannah River, Nevada Test Site, Oak Ridge, and the Barnwell Plant) where naval spent nuclear fuel examinations may be conducted is presented in Section F.2.4.2.1. Evaluation of diesel fuel fires at shipyards and aboard ship in Puget Sound, as well as at INEL-ECF, Hanford, Savannah River, Nevada Test Site, Barnwell Plant, and Oak Ridge, is described in Section F.2.4.2.2.

These accidents incorporate spillage of the entire amount of a given chemical accompanied by a fire. The initiating event might be, for example, an airplane crash or ship collision. Such an accident bounds simpler chemical spills, such as handling accidents involving limited or unit (see Table F.2-1) amounts of a chemical, which were also considered. Consequently, only results for the fire accident are provided. The analyses utilize meteorological (see Section F.1.3.5) and demographic parameters specific to the evaluated location.

The toxic chemicals evaluated in the accident analyses would be used and stored in a number of different areas within the facility. Fuel oils, sulfuric acid, and sodium hydroxide would be expected to be located outside facility buildings in storage tanks. Other chemicals used for facility support and operation would likely be stored in a variety of locations within facility buildings such as tool rooms, laboratories, craft shops, equipment rooms, chemical mixing areas, hot cells, and flammable cabinets. The probability of releasing all or most of these chemicals in a single accident such as an airplane crash would be quite low, less than 10^{-7} per year, as supported in Section F.3.5. However, the probability of releasing an individual or limited number of chemicals is expected to be greater than this level and include a consideration of storage locations, types, sizes, and numbers of containers, and types and frequencies of initiating events. For accidents that could result in a toxic chemical release, a probability of 5×10^{-3} per year (Ganti and Krasner 1984) was considered to be a reasonable upper level. This level was based on the probability that a structurally damaging industrial fire could occur.

F.2.4.2.1 Chemical Spill and Fire.

F.2.4.2.1.1 Accident Description. An accident might occur which caused toxic chemicals to spill, dispersed powdered toxic chemicals, and accelerated the vaporization of the toxic chemicals with a subsequent fire. The airborne release resulting from the involvement of the entire available amount of the toxic chemicals was evaluated with respect to the on-site workers, MCW, NPA, and MOI.

F.2.4.2.1.2 Source Term. The toxic chemicals involved in this hypothetical accident are provided in Table F.2-1. The entire amount of the toxic chemical might be involved due to the catastrophic nature of this accident.

F.2.4.2.1.3 Conditions and Key Parameters.

(1) Gases

- 100% of the gas was released to the atmosphere.
- Release period was 10 minutes.
- Release was a point source.
- Deposition velocity was 0.1 centimeter per second.

(2) Liquids

- 100% of the liquid was released to the atmosphere.
- The liquid was released into a pool of 0.1-inch depth.
- The liquid was at its boiling point.
- The release period was the longer of the calculated evaporation time or 10 minutes.
- Release area was equal to the pool area.
- Deposition velocity was 0.1 centimeter per second.

(3) Solids

- 1% of the solid was dispersed into the atmosphere as PM-10.
- Release period was 10 minutes.

- Release was a point source.
- Deposition velocity was 1.0 centimeter per second.

(4) Specific Chemicals

- CFC-12 could break down at elevated temperatures into hydrochloric acid (10%) and phosgene (1%) with the remaining (89%) released as CFC-12.
- The hypothetical sulfuric acid spill would be contained by a berm resulting in a pool release area of 443.2 square feet.
- The hypothetical spill of sodium hydroxide was in the form of an aqueous solution and was contained by a berm resulting in a pool release area of 374 square feet. A 10-minute period was used for this release, and the sodium hydroxide was dispersed as a particulate.

(5) Meteorology

- Wind speeds and atmospheric stability classifications used for the calculations were based on both 50% and 95% meteorology (Section F.1.3.5) to estimate downwind concentrations. The 95% meteorology included atmospheric stability classes A through F and wind speeds from 1.1 to 30 miles per hour.

(6) General

- Standard rural terrain was used since this most closely resembles the sites being evaluated.
- Release was calculated to occur at ground level.
- No evacuation of downwind populations was included, in order to obtain maximum estimates of effects; therefore, exposures were not reduced to account for this action.
- No credit was taken for building containment or filtration.
- Biological effects of exposure to each chemical were treated separately. This was done to account for a lack of a current methodology to evaluate the effects resulting from simultaneous multiple chemical exposures.

- To determine health impacts, the estimated concentrations were compared against the Emergency Response Planning Guidelines (ERPG) levels 1, 2, and 3 concentration limits or alternates.
- To determine the likelihood of developing cancer from exposure to hydrazine, a slope factor of 1.7 x 10^1 per mg/kg-day obtained from IRIS (TOXnet 1993) was used. In addition, the exposure time was based on the duration of the release, and individual breathing rates and sizes were the same as those used in Section F.1 for radiological accident evaluations using the Radiological Safety Analysis Computer Program (RSAC-5) (Wenzel 1993).

F.2.4.2.1.4 Results. The airborne concentrations, averaged over the duration of each exposure, were calculated using EPIcode for the alternate locations for the worker, MCW, NPA, and MOI for both 50% and 95% meteorology. The airborne concentrations were compared to respective ERPG values where available. However, ERPG values have not been derived for some of the chemicals. The effects of these substances were assessed by comparison with other appropriate values for toxic effects as discussed in Section F.2.3.3.

Tables F.2.4.2-1 through -12 list the downwind concentrations at various locations and corresponding ERPG values (or equivalent if TLV-TWA and IDLH concentrations are available). Hydrochloric acid and phosgene, from decomposition of CFC-12, sulfuric acid, and sodium hydroxide dominate the toxic chemical effects for on-site personnel. Concentrations of these chemicals above ERPG-3 levels might result in life-threatening effects. However, in no case is an ERPG-3 level exceeded for any member of the general public except for Oak Ridge where sulfuric acid concentrations could exceed ERPG-3 levels under both 50% and 95% meteorological conditions and sodium hydroxide concentrations could exceed ERPG-3 levels under 95% meteorological conditions. For the on-site workers, collocated workers, and any member of the general public that could be exposed to toxic chemicals at levels above ERPG-3, it is expected that actual toxic chemical exposures would be much less due to the mitigative measures that would be implemented (Section F.2.4.3).

Additional information on the toxic properties for the chemicals that dominate the toxic effects is provided below.

Hydrochloric acid is a irritant to the respiratory tract, skin, eyes, and mucous membranes. More severe exposures result in pulmonary edema, and often laryngeal spasm. A concentration of 53 mg/m^3 causes irritation of the throat after short exposure. Concentrations of 75-150 mg/m^3 are tolerable for 1 hour; concentrations of 1,500-3,000 mg/m^3 are dangerous, even for brief exposures (TOXnet 1993).

Phosgene, also known as carbonyl chloride, is a highly toxic, corrosive liquid with a low boiling point. It is toxic from intakes by inhalation, ingestion, and dermal absorption. Effects from exposure may include contact burns to the skin and eyes, shortness of breath, chest pain, severe pulmonary edema, and death. At low vapor concentrations, it smells like musty hay. At higher concentrations, it has a sharp and pungent odor. It is a severe irritant to the eyes and respiratory tract and can be fatal if inhaled, even for short durations and at low concentrations. Exposure to 12 mg/cm^3 can result in immediate irritation of the respiratory tract. 80 mg/m^3 may cause lung injuries within 2 minutes; 100 mg/m^3 for as little as 30 minutes is very dangerous; and 360 mg/m^3 is rapidly fatal for exposures of 30 minutes or less (TOXnet 1993).

Sulfuric acid mist can be strongly irritating to the skin, eyes, mucous membranes, and respiratory tract. Odor may be detected at concentrations of 1 mg/m^3; irritating effects may occur at concentrations of 1.1 mg/m^3. Inhalation of concentrations near 3 mg/m^3 may cause constriction of the air passage and choking sensations. At higher concentrations and durations of exposure, inhalation can cause pulmonary edema, emphysema, and permanent changes in pulmonary function (TOXnet 1993).

Sodium hydroxide dust can be irritating to the upper respiratory system. Irritating effects may occur at concentrations of 2 mg/m^3. At higher concentrations and durations of exposure, inhalation can cause extreme irritation of the respiratory tract and permanent changes in pulmonary function (TOXnet 1993).

Table F.2.4.2-1. Summary of chemical concentrations for chemical spill and fire at the INEL Expended Core Facility.

	CHEMICAL CONCENTRATIONS mg/m³ - 50% METEOROLOGY									
	Ethylene Glycol ERPG-1 127 ERPG-2 * ERPG-3 *	Hydrazine ERPG-1 0.13 ERPG-2 10 ERPG-3 100	Isopropyl Alcohol ERPG-1 983 ERPG-2 2950 ERPG-3 29500	Ammonia ERPG-1 18 ERPG-2 140 ERPG-3 700	CFC-12 ERPG-1 4950 ERPG-2 24750 ERPG-3 247500	Hydrochloric Acid ERPG-1 4.5 ERPG-2 30 ERPG-3 150	Phosgene ERPG-1 0.4 ERPG-2 0.8 ERPG-3 4.0	Sulfuric Acid ERPG-1 2 ERPG-2 10 ERPG-3 30	Hydroquinone ERPG-1 2 ERPG-2 * ERPG-3 *	Sodium Hydroxide ERPG-1 2 ERPG-2 25 ERPG-3 250
Worker	3300	49	890	38	400	45	4.5	2300	6.4	2300
MCW	2.3	1.6×10^{-2}	0.45	1.2×10^{-2}	0.12	1.3×10^{-2}	1.3×10^{-3}	1.4	9.3×10^{-4}	0.60
MOI	1.5	1.0×10^{-2}	0.29	7.9×10^{-3}	7.7×10^{-2}	8.5×10^{-3}	8.5×10^{-4}	0.86	5.9×10^{-4}	0.39
NPA	1.6	1.1×10^{-2}	0.30	8.3×10^{-3}	8.1×10^{-2}	9.0×10^{-3}	9.0×10^{-4}	0.91	5.9×10^{-4}	0.39

Table F.2.4.2-2. Summary of chemical concentrations for chemical spill and fire at the INEL Expended Core Facility.

	CHEMICAL CONCENTRATIONS mg/m³ - 95% METEOROLOGY									
	Ethylene Glycol ERPG-1 127 ERPG-2 * ERPG-3 *	Hydrazine ERPG-1 0.13 ERPG-2 10 ERPG-3 100	Isopropyl Alcohol ERPG-1 983 ERPG-2 2950 ERPG-3 29500	Ammonia ERPG-1 18 ERPG-2 140 ERPG-3 700	CFC-12 ERPG-1 4950 ERPG-2 24750 ERPG-3 247500	Hydrochloric Acid ERPG-1 4.5 ERPG-2 30 ERPG-3 150	Phosgene ERPG-1 0.4 ERPG-2 0.8 ERPG-3 4.0	Sulfuric Acid ERPG-1 2 ERPG-2 10 ERPG-3 30	Hydroquinone ERPG-1 2 ERPG-2 * ERPG-3 *	Sodium Hydroxide ERPG-1 2 ERPG-2 25 ERPG-3 250
Worker	4400	58	2200	150	1600	180	18	2800	7.7	2700
MCW	7.6	4.8×10^{-2}	2.6	8.3×10^{-2}	0.80	8.9×10^{-2}	8.9×10^{-3}	3.9	2.2×10^{-3}	1.5
MOI	3.6	2.3×10^{-2}	1.1	3.2×10^{-2}	0.30	3.4×10^{-2}	3.4×10^{-3}	1.9	8.8×10^{-4}	0.58
NPA	3.6	2.3×10^{-2}	1.1	3.2×10^{-2}	0.30	3.4×10^{-2}	3.4×10^{-3}	1.9	8.8×10^{-4}	0.58

*IDLH concentrations are not available; therefore, corresponding ERPG-2 and -3 levels could not be determined.

Table F.2.4.2-3. Summary of chemical concentrations for chemical spill and fire at Savannah River.

	CHEMICAL CONCENTRATIONS mg/m³ - 50% METEOROLOGY									
	Ethylene Glycol ERPG-1 127 ERPG-2 * ERPG-3 *	Hydrazine ERPG-1 0.13 ERPG-2 10 ERPG-3 100	Isopropyl Alcohol ERPG-1 983 ERPG-2 2950 ERPG-3 29500	Ammonia ERPG-1 18 ERPG-2 140 ERPG-3 700	CFC-12 ERPG-1 4950 ERPG-2 24750 ERPG-3 247500	Hydrochloric Acid ERPG-1 4.5 ERPG-2 30 ERPG-3 150	Phosgene ERPG-1 0.4 ERPG-2 0.8 ERPG-3 4.0	Sulfuric Acid ERPG-1 2 ERPG-2 10 ERPG-3 30	Hydroquinone ERPG-1 2 ERPG-2 * ERPG-3 *	Sodium Hydroxide ERPG-1 2 ERPG-2 25 ERPG-3 250
Worker	1500	19	370	14	150	16	1.6	1000	2.9	1200
MCW	32	0.25	6.6	0.19	1.9	0.21	2.1×10^{-2}	20	3.6×10^{-2}	22
MOI	1.3	8.7×10^{-3}	0.24	6.7×10^{-3}	6.4×10^{-2}	7.2×10^{-3}	7.2×10^{-4}	0.88	7.2×10^{-4}	0.47
NPA	1.3	8.7×10^{-3}	0.24	6.7×10^{-3}	6.4×10^{-2}	7.2×10^{-3}	7.2×10^{-4}	0.88	7.2×10^{-4}	0.47

Table F.2.4.2-4. Summary of chemical concentrations for chemical spill and fire at Savannah River.

	CHEMICAL CONCENTRATIONS mg/m³ - 95% METEOROLOGY									
	Ethylene Glycol ERPG-1 127 ERPG-2 * ERPG-3 *	Hydrazine ERPG-1 0.13 ERPG-2 10 ERPG-3 100	Isopropyl Alcohol ERPG-1 983 ERPG-2 2950 ERPG-3 29500	Ammonia ERPG-1 18 ERPG-2 140 ERPG-3 700	CFC-12 ERPG-1 4950 ERPG-2 24750 ERPG-3 247500	Hydrochloric Acid ERPG-1 4.5 ERPG-2 30 ERPG-3 150	Phosgene ERPG-1 0.4 ERPG-2 0.8 ERPG-3 4.0	Sulfuric Acid ERPG-1 2 ERPG-2 10 ERPG-3 30	Hydroquinone ERPG-1 2 ERPG-2 * ERPG-3 *	Sodium Hydroxide ERPG-1 2 ERPG-2 25 ERPG-3 250
Worker	4400	58	2200	150	1600	180	18	2800	7.7	2700
MCW	220	1.6	85	4.0	39	4.3	0.43	120	0.12	72
MOI	4.9	3.0×10^{-2}	1.6	4.7×10^{-2}	0.44	4.9×10^{-2}	4.9×10^{-3}	2.5	1.3×10^{-3}	0.85
NPA	4.9	3.0×10^{-2}	1.6	4.7×10^{-2}	0.44	4.9×10^{-2}	4.9×10^{-3}	2.5	1.3×10^{-3}	0.85

*IDLH concentrations are not available; therefore, corresponding ERPG-2 and -3 levels could not be determined.

Table F.2.4.2-5. Summary of chemical concentrations for chemical spill and fire at Hanford.

	CHEMICAL CONCENTRATIONS mg/m^3 - 50% METEOROLOGY									
	Ethylene Glycol ERPG-1 127 ERPG-2 * ERPG-3 *	Hydrazine ERPG-1 0.13 ERPG-2 10 ERPG-3 100	Isopropyl Alcohol ERPG-1 983 ERPG-2 2950 ERPG-3 29500	Ammonia ERPG-1 18 ERPG-2 140 ERPG-3 700	CFC-12 ERPG-1 4950 ERPG-2 24750 ERPG-3 247500	Hydrochloric Acid ERPG-1 4.5 ERPG-2 30 ERPG-3 150	Phosgene ERPG-1 0.4 ERPG-2 0.8 ERPG-3 4.0	Sulfuric Acid ERPG-1 2 ERPG-2 10 ERPG-3 30	Hydroquinone ERPG-1 2 ERPG-2 * ERPG-3 *	Sodium Hydroxide ERPG-1 2 ERPG-2 25 ERPG-3 250
Worker	1500	19	370	14	150	16	1.6	1000	2.9	1200
MCW	46	0.36	9.6	0.28	2.7	0.30	3.0×10^{-2}	28	4.1×10^{-2}	26
MOI (New ECF)**	0.73	5.1×10^{-3}	8.1×10^{-2}	3.9×10^{-3}	3.8×10^{-2}	4.2×10^{-3}	4.2×10^{-4}	0.44	2.3×10^{-4}	0.16
MOI (FMEF)***	0.97	7.1×10^{-3}	0.19	5.4×10^{-3}	5.2×10^{-2}	5.8×10^{-3}	5.8×10^{-4}	0.96	7.8×10^{-4}	0.51
NPA	1.5	9.9×10^{-3}	0.29	7.9×10^{-3}	7.6×10^{-2}	8.5×10^{-3}	8.5×10^{-4}	0.86	7.3×10^{-4}	0.49

Table F.2.4.2-6. Summary of chemical concentrations for chemical spill and fire at Hanford.

	CHEMICAL CONCENTRATIONS mg/m^3 - 95% METEOROLOGY									
	Ethylene Glycol ERPG-1 127 ERPG-2 * ERPG-3 *	Hydrazine ERPG-1 0.13 ERPG-2 10 ERPG-3 100	Isopropyl Alcohol ERPG-1 983 ERPG-2 2950 ERPG-3 29500	Ammonia ERPG-1 18 ERPG-2 140 ERPG-3 700	CFC-12 ERPG-1 4950 ERPG-2 24750 ERPG-3 247500	Hydrochloric Acid ERPG-1 4.5 ERPG-2 30 ERPG-3 150	Phosgene ERPG-1 0.4 ERPG-2 0.8 ERPG-3 4.0	Sulfuric Acid ERPG-1 2 ERPG-2 10 ERPG-3 30	Hydroquinone ERPG-1 2 ERPG-2 * ERPG-3 *	Sodium Hydroxide ERPG-1 2 ERPG-2 25 ERPG-3 250
Worker	4400	58	2200	150	1600	180	18	2800	7.7	2700
MCW	150	1.1	55	2.5	24	2.7	0.27	78	7.6×10^{-2}	45
MOI (New ECF)**	2.1	1.3×10^{-2}	0.47	1.3×10^{-2}	0.13	1.4×10^{-2}	1.4×10^{-3}	1.1	4.1×10^{-4}	0.28
MOI (FMEF)***	5.5	3.5×10^{-2}	1.8	5.4×10^{-2}	0.51	5.7×10^{-2}	5.7×10^{-3}	2.8	1.5×10^{-3}	0.99
NPA	5.3	3.3×10^{-2}	1.7	5.1×10^{-2}	0.48	5.4×10^{-2}	5.4×10^{-3}	2.7	1.4×10^{-3}	0.94

* IDLH concentrations are not available; therefore, corresponding ERPG-2 and -3 levels could not be determined.
**MOI (New ECF) applies if spent fuel facility is constructed at the 200 Area on the Hanford Site.
***MOI (FMEF) applies if spent fuel facility is constructed at the Fuels and Materials Examination Facility.

Table F.2.4.2-7. Summary of chemical concentrations for chemical spill and fire at the Nevada Test Site.

	CHEMICAL CONCENTRATIONS mg/m³ - 50% METEOROLOGY									
	Ethylene Glycol ERPG-1 127 ERPG-2 * ERPG-3 *	Hydrazine ERPG-1 0.13 ERPG-2 10 ERPG-3 100	Isopropyl Alcohol ERPG-1 983 ERPG-2 2950 ERPG-3 29500	Ammonia ERPG-1 18 ERPG-2 140 ERPG-3 700	CFC-12 ERPG-1 4950 ERPG-2 24750 ERPG-3 247500	Hydrochloric Acid ERPG-1 4.5 ERPG-2 30 ERPG-3 150	Phosgene ERPG-1 0.4 ERPG-2 0.8 ERPG-3 4.0	Sulfuric Acid ERPG-1 2 ERPG-2 10 ERPG-3 30	Hydroquinone ERPG-1 2 ERPG-2 * ERPG-3 *	Sodium Hydroxide ERPG-1 2 ERPG-2 25 ERPG-3 250
Worker	530	6.8	130	5.1	53	5.9	0.59	820	1.2	490
MCW	0.22	1.5×10^{-3}	4.1×10^{-2}	1.1×10^{-3}	1.1×10^{-2}	1.2×10^{-3}	1.2×10^{-4}	0.12	2.1×10^{-4}	0.14
MOI	0.74	5.4×10^{-3}	0.14	4.0×10^{-3}	3.8×10^{-2}	4.4×10^{-3}	4.4×10^{-4}	0.97	7.0×10^{-4}	0.46

Table F.2.4.2-8. Summary of chemical concentrations for chemical spill and fire at the Nevada Test Site.

	CHEMICAL CONCENTRATIONS mg/m³ - 95% METEOROLOGY									
	Ethylene Glycol ERPG-1 127 ERPG-2 * ERPG-3 *	Hydrazine ERPG-1 0.13 ERPG-2 10 ERPG-3 100	Isopropyl Alcohol ERPG-1 983 ERPG-2 2950 ERPG-3 29500	Ammonia ERPG-1 18 ERPG-2 140 ERPG-3 700	CFC-12 ERPG-1 4950 ERPG-2 24750 ERPG-3 247500	Hydrochloric Acid ERPG-1 4.5 ERPG-2 30 ERPG-3 150	Phosgene ERPG-1 0.4 ERPG-2 0.8 ERPG-3 4.0	Sulfuric Acid ERPG-1 2 ERPG-2 10 ERPG-3 30	Hydroquinone ERPG-1 2 ERPG-2 * ERPG-3 *	Sodium Hydroxide ERPG-1 2 ERPG-2 25 ERPG-3 250
Worker	4400	58	2200	150	1600	180	18	2800	7.7	2700
MCW	5.9	3.7×10^{-2}	1.9	5.8×10^{-2}	0.55	6.2×10^{-2}	6.2×10^{-3}	3.0	1.6×10^{-3}	1.1
MOI	7.3	4.6×10^{-2}	2.5	7.8×10^{-2}	0.76	8.4×10^{-2}	8.4×10^{-3}	3.8	2.2×10^{-3}	1.4

*IDLH concentrations are not available; therefore, corresponding ERPG-2 and -3 levels could not be determined.

Table F.2.4.2-9. Summary of chemical concentrations for chemical spill and fire at Oak Ridge.

	CHEMICAL CONCENTRATIONS mg/m^3 - 50% METEOROLOGY									
	Ethylene Glycol ERPG-1 127 ERPG-2 * ERPG-3 *	Hydrazine ERPG-1 0.13 ERPG-2 10 ERPG-3 100	Isopropyl Alcohol ERPG-1 983 ERPG-2 2950 ERPG-3 29500	Ammonia ERPG-1 18 ERPG-2 140 ERPG-3 700	CFC-12 ERPG-1 4950 ERPG-2 24750 ERPG-3 247500	Hydrochloric Acid ERPG-1 4.5 ERPG-2 30 ERPG-3 150	Phosgene ERPG-1 0.4 ERPG-2 0.8 ERPG-3 4.0	Sulfuric Acid ERPG-1 2 ERPG-2 10 ERPG-3 30	Hydroquinone ERPG-1 2 ERPG-2 * ERPG-3 *	Sodium Hydroxide ERPG-1 2 ERPG-2 25 ERPG-3 250
Worker	3300	49	890	38	400	45	4.5	2300	6.4	2300
MCW	34	0.27	7.1	0.21	2.0	0.22	2.2×10^{-2}	21	3.0×10^{-2}	19
MOI	310	2.8	68	2.1	21	2.4	0.24	190	0.38	210
NPA	440	4.3	100	3.2	32	3.7	0.37	280	0.60	310

Table F.2.4.2-10. Summary of chemical concentrations for chemical spill and fire at Oak Ridge.

	CHEMICAL CONCENTRATIONS mg/m^3 - 95% METEOROLOGY									
	Ethylene Glycol ERPG-1 127 ERPG-2 * ERPG-3 *	Hydrazine ERPG-1 0.13 ERPG-2 10 ERPG-3 100	Isopropyl Alcohol ERPG-1 983 ERPG-2 2950 ERPG-3 29500	Ammonia ERPG-1 18 ERPG-2 140 ERPG-3 700	CFC-12 ERPG-1 4950 ERPG-2 24750 ERPG-3 247500	Hydrochloric Acid ERPG-1 4.5 ERPG-2 30 ERPG-3 150	Phosgene ERPG-1 0.4 ERPG-2 0.8 ERPG-3 4.0	Sulfuric Acid ERPG-1 2 ERPG-2 10 ERPG-3 30	Hydroquinone ERPG-1 2 ERPG-2 * ERPG-3 *	Sodium Hydroxide ERPG-1 2 ERPG-2 25 ERPG-3 250
Worker	4400	58	2200	150	1600	180	18	2800	7.7	2700
MCW	110	0.75	41	1.9	18	2.0	0.20	58	5.4×10^{-2}	32
MOI	930	8.4	400	22	220	24	2.4	540	0.82	410
NPA	1300	13	590	33	340	38	3.8	790	1.3	630

*IDLH concentrations are not available; therefore, corresponding ERPG-2 and -3 levels could not be determined.

Table F.2.4.2-11. Summary of chemical concentrations for chemical spill and fire at the Barnwell Plant.

	CHEMICAL CONCENTRATIONS mg/m^3 - 50% METEOROLOGY									
	Ethylene Glycol ERPG-1 127 ERPG-2 * ERPG-3 *	Hydrazine ERPG-1 0.13 ERPG-2 10 ERPG-3 100	Isopropyl Alcohol ERPG-1 983 ERPG-2 2950 ERPG-3 29500	Ammonia ERPG-1 18 ERPG-2 140 ERPG-3 700	CFC-12 ERPG-1 4950 ERPG-2 24750 ERPG-3 247500	Hydrochloric Acid ERPG-1 4.5 ERPG-2 30 ERPG-3 150	Phosgene ERPG-1 0.4 ERPG-2 0.8 ERPG-3 4.0	Sulfuric Acid ERPG-1 2 ERPG-2 10 ERPG-3 30	Hydroquinone ERPG-1 2 ERPG-2 * ERPG-3 *	Sodium Hydroxide ERPG-1 2 ERPG-2 25 ERPG-3 250
Worker	1500	19	370	14	150	16	1.6	1000	2.9	1200
MCW	0.89	6.4×10^{-3}	0.17	4.9×10^{-3}	4.6×10^{-2}	5.2×10^{-3}	5.2×10^{-4}	0.83	9.0×10^{-4}	0.59
MOI	6.1	4.3×10^{-2}	1.2	3.4×10^{-2}	0.32	3.6×10^{-2}	3.6×10^{-3}	4.9	4.9×10^{-3}	3.2
NPA	6.1	4.3×10^{-2}	1.2	3.4×10^{-2}	0.32	3.6×10^{-2}	3.6×10^{-3}	4.9	4.9×10^{-3}	3.2

Table F.2.4.2-12. Summary of chemical concentrations for chemical spill and fire at the Barnwell Plant.

	CHEMICAL CONCENTRATIONS mg/m^3 - 95% METEOROLOGY									
	Ethylene Glycol ERPG-1 127 ERPG-2 * ERPG-3 *	Hydrazine ERPG-1 0.13 ERPG-2 10 ERPG-3 100	Isopropyl Alcohol ERPG-1 983 ERPG-2 2950 ERPG-3 29500	Ammonia ERPG-1 18 ERPG-2 140 ERPG-3 700	CFC-12 ERPG-1 4950 ERPG-2 24750 ERPG-3 247500	Hydrochloric Acid ERPG-1 4.5 ERPG-2 30 ERPG-3 150	Phosgene ERPG-1 0.4 ERPG-2 0.8 ERPG-3 4.0	Sulfuric Acid ERPG-1 2 ERPG-2 10 ERPG-3 30	Hydroquinone ERPG-1 2 ERPG-2 * ERPG-3 *	Sodium Hydroxide ERPG-1 2 ERPG-2 25 ERPG-3 250
Worker	4400	58	2200	150	1600	180	18	2800	7.7	2700
MCW	11	6.4×10^{-2}	3.5	0.13	1.3	0.14	1.4×10^{-2}	5.4	3.2×10^{-3}	2.0
MOI	28	0.18	10	0.41	3.9	0.44	4.4×10^{-2}	15	1.1×10^{-2}	6.9
NPA	28	0.18	10	0.41	3.9	0.44	4.4×10^{-2}	15	1.1×10^{-2}	6.9

*IDLH concentrations are not available; therefore, corresponding ERPG-2 and -3 levels could not be determined.

In addition to comparing the airborne concentrations to their respective ERPG or other appropriate values, each substance was evaluated to determine if it has the potential for future carcinogenic health impacts. It was determined that exposure to hydrazine could result in an increased likelihood for developing cancer. Tables F.2.4.2-13 and F.2.4.2-14 provide the future potential likelihood for developing cancer from exposure to hydrazine for the worker, MCW, and MOI at the alternate locations under 50% and 95% meteorological conditions, respectively.

Table F.2.4.2-13. Future potential likelihood for developing cancer from hydrazine - 50% meteorology.

	INEL Expended Core Facility	Savannah River	Hanford*	Nevada Test Site	Oak Ridge	Barnwell Plant
Worker	9.3×10^{-5}	3.6×10^{5}	3.6×10^{-5}	1.3×10^{-5}	9.3×10^{-5}	3.6×10^{-5}
MCW	3.0×10^{-8}	4.8×10^{7}	6.8×10^{-7}	2.8×10^{-9}	5.1×10^{-7}	1.2×10^{-8}
MOI	1.5×10^{-8}	1.3×10^{8}	7.6×10^{-9}	8.1×10^{-9}	4.2×10^{-6}	6.4×10^{-8}

Table F.2.4.2-14. Future potential likelihood for developing cancer from hydrazine - 95% meteorology.

	INEL Expended Core Facility	Savannah River	Hanford*	Nevada Test Site	Oak Ridge	Barnwell Plant
Worker	3.8×10^{-4}	3.8×10^{-4}	3.8×10^{-4}	3.8×10^{-4}	3.8×10^{-4}	3.8×10^{-4}
MCW	2.0×10^{-7}	6.7×10^{6}	4.6×10^{-6}	1.6×10^{-7}	3.2×10^{-6}	2.7×10^{-7}
MOI	7.8×10^{-8}	1.0×10^{-7}	4.4×10^{-8}	1.6×10^{-7}	2.9×10^{-5}	6.1×10^{-7}

* MOI shown applies to new ECF if spent fuel facility is constructed at the 200 Area on the Hanford Site. A future potential carcinogenic risk of 1.1×10^{-8} (50% meteorology) and 1.2×10^{-7} (95% meteorology) applies to a spent fuel facility constructed at the Fuels and Materials Examination Facility.

F.2.4.2.2 Fire Involving Diesel Fuel.

F.2.4.2.2.1 Accident Description. A catastrophic failure of the diesel fuel storage tank facility was postulated to occur. This could result in the spilling of the entire quantity of diesel fuel and a subsequent fire. The airborne release of toxic chemicals resulting from the fire was evaluated with respect to the on-site workers, MCW, NPA, and MOI as applicable for the accident site.

F.2.4.2.2.2 Source Term. The material involved in this accident was diesel fuel with the fire generating the following toxic chemicals due to combustion:

- Carbon monoxide
- Oxides of nitrogen (90% nitric oxide and 10% nitrogen dioxide)
- Lead
- Sulfur dioxide.

F.2.4.2.2.3 Conditions and Key Parameters.

- For alternate DOE sites and the Barnwell Plant, the diesel fuel was stored in bulk storage tanks.
- For shipyards, the diesel fuel was stored in a portable diesel power unit.
- For the ship accident, the diesel fuel was stored in large tanks adjacent to the hold.
- For alternate DOE sites and the Barnwell Plant, 1950 gallons of diesel fuel could be spilled.
- For shipyards, 315 gallons of diesel fuel could be spilled.
- For the ship accident, 121,000 gallons of diesel fuel could be spilled.
- For all facilities, the entire quantity of diesel fuel was spilled and ignited in open air.
- For alternate DOE sites and the Barnwell Plant, the spill area was 261 square feet.
- For shipyards, the spill area was 66 square feet.
- For the ship accident, the spill area used was 4812 square feet.
- For alternate DOE sites and the Barnwell Plant, the entire amount of diesel fuel was consumed by the fire over a 2-hour period.
- For shipyards, the entire amount of diesel fuel was consumed by the fire over a 1-hour period.

- For the ship accident, the entire amount of diesel fuel was consumed by the fire over a 6-hour period.
- For all facilities, the releases per gallon of fuel burned were as follows:
  Carbon monoxide = 0.34 pound
  Oxides of nitrogen = 1.58 pounds
  Lead = 4.2×10^{-6} pound
  Sulfur dioxide = 0.105 pound.
- For alternate DOE sites, the Barnwell Plant, and shipyards, the airborne release of toxic chemicals occurred at ground level.
- For the ship accident, the airborne release of toxic chemicals occurred at 48 feet above the sea (i.e., at the middle of the flame height above the cargo hatch) for evaluation of land-based exposures. For shipboard exposures, a release height of zero was used.
- For all facilities, standard rural terrain was used and building wake effects were not considered.
- For all facilities, wind speeds and atmospheric stability classifications were based on both 50% and 95% meteorology (Section F.1.3.5).
- For all facilities, no evacuation of downwind populations occurred and the biological effects of chemical exposure act uniquely and do not affect the individual in a cumulative way.
- For all facilities, to determine the health impacts, the estimated concentrations were compared against the Emergency Response Planning Guidelines (ERPG) levels 1, 2, and 3 concentration limits or alternates.

F.2.4.2.2.4 Results. The airborne concentrations, averaged over the duration of each exposure, were calculated using EPIcode for the combustion products resulting from the fire for the worker, MCW, NPA, and MOI (as applicable for the accident site) under both 50% and 95% meteorology. The airborne concentrations were compared to respective ERPG values where available. However, ERPG values have not been derived for some of the constituents listed. The effects of these constituents were assessed by comparison with other appropriate values for toxic effects as discussed in Section F.2.3.3.

Tables F.2.4.2-15 through -38 list the downwind concentrations at various locations and corresponding ERPG (or equivalent) values. Results for the diesel fuel fire at fuel examination sites indicate that the toxic chemical concentrations for sulfur dioxide and oxides of nitrogen may exceed ERPG-3 levels for the worker. At Savannah River and Hanford, the MCW also may be exposed to a nitric oxide concentration exceeding ERPG-3 levels under 95% meteorological conditions. The NPA and MOI exposures at all the fuel examination sites would be expected to be below ERPG-2 levels except for Oak Ridge. At this location under 95% meteorological conditions, the NPA and MOI may be exposed to concentrations of sulfur dioxide and oxides of nitrogen that exceed ERPG-3 and concentrations of carbon monoxide that exceed ERPG-2. Under 50% meteorological conditions at Oak Ridge, the NPA and MOI may be exposed to concentrations of nitric oxide that exceed ERPG-3 and concentrations of sulfur dioxide and nitrogen dioxide that exceed ERPG-2. Results for the diesel fuel fire at shipyards show that for the worker and NPA categories, the toxic chemical concentrations for sulfur dioxide and oxides of nitrogen may exceed ERPG-3 levels. For the MOI, however, these concentrations are expected to be less than the ERPG-3 levels with the exception that under 95% meteorological conditions the ERPG-3 level for nitric oxide may be exceeded at the Norfolk shipyard. Results for the ship diesel fuel fire show that shipboard (worker) concentrations of carbon monoxide, sulfur dioxide, and oxides of nitrogen may exceed ERPG-3 levels, but the shore (MOI) concentrations are expected to be less than ERPG-3 levels. For the individuals on board the ship that might be exposed to toxic chemicals at levels above ERPG-3, it is expected that actual toxic chemical exposures would be much less due to the mitigative measures that would be implemented (Section F.2.4.3).

Additional information on the toxic properties for the chemicals that dominate the toxic effects is provided below.

Sulfur dioxide is a colorless gas with a pungent odor. It is a poison, and it is also an eye, skin, and mucous membrane irritant. It chiefly affects the upper respiratory tract and bronchi and at higher concentrations, sulfur dioxide causes respiratory paralysis (TOXnet 1993).

Nitric oxide and **nitrogen dioxide** occur together in dynamic equilibrium. Nitric oxide is a colorless gas, and nitrogen dioxide is a reddish brown gas. Both chemicals are eye, skin, and mucous membrane irritants and primarily affect the respiratory system. Exposure to 47 mg/m^3 of nitrogen dioxide can cause respiratory irritation and chest pain, 93 mg/m^3 can cause lung injuries, and 187 mg/m^3 can be fatal (TOXnet 1993).

In addition to comparing the airborne concentrations to their respective ERPG or other appropriate values, each substance was evaluated to determine if it has the potential for future carcinogenic impacts. It was determined that exposure to lead could result in an increased likelihood for developing cancer. However, sufficient information to quantify this likelihood was not available in IRIS. Therefore, the concentrations of lead resulting from the accident were compared against the NAAQS value for lead. For the lead concentrations provided in Tables F.2.4.2-15 through F.2.4.2-38, no NAAQS is exceeded.

F.2.4.3 Mitigative Measures for Toxic Chemicals. Mitigative measures for potential releases of toxic materials involve administrative controls for personnel protection and emergency response. For personnel protection, controls involve safety review committees for planned activities that establish requirements, safe work permits, and procedures for required clothing (rubber boots, gloves, face shields, eye protection) that can mitigate the effects of potential releases of toxic materials. Procedures may also require provisions for prestationing mitigative devices such as eyewash stations and emergency showers. All of the alternate facilities being evaluated employ emergency response programs to mitigate impacts of potential toxic chemical accidents to workers and the public. Emergency planning, emergency preparedness, and emergency response programs are in place and involve established resources such as warning communications, fire departments, and emergency command centers. The cargo ships used for naval spent nuclear fuel have smoke detection and fire fighting equipment on board. They also have fire suppression systems in their holds which use inert gas to smother fires. In addition, less freely available oxygen in the ship's cargo hold would tend to slow the combustion rate of the diesel fuel. Port facilities would also have available additional fire fighting equipment, public warning systems, and emergency response programs.

Table F.2.4.2-15. Summary of chemical concentrations for fire involving diesel fuel at the INEL Expended Core Facility.

	CHEMICAL CONCENTRATIONS mg/m³ - 50% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	480	150	2000	220	3.9×10^{-3}
MCW	0.25	7.7×10^{-2}	1.0	0.11	9.5×10^{-7}
MOI	0.15	4.8×10^{-2}	0.65	7.3×10^{-2}	6.1×10^{-7}
NPA	0.16	5.0×10^{-2}	0.69	7.7×10^{-2}	6.1×10^{-7}

Table F.2.4.2-16. Summary of chemical concentrations for fire involving diesel fuel at the INEL Expended Core Facility.

	CHEMICAL CONCENTRATIONS mg/m³ - 95% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	1200	370	5100	560	4.6×10^{-3}
MCW	1.45	0.45	6.1	0.68	3.0×10^{-7}
MOI	0.66	0.20	2.7	0.30	4.7×10^{-8}
NPA	0.66	0.20	2.7	0.30	4.7×10^{-8}

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-17. Summary of chemical concentrations for fire involving diesel fuel at Savannah River.

	CHEMICAL CONCENTRATIONS mg/m³ - 50% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	200	62	850	94	2.0×10^{-3}
MCW	3.6	1.1	15	1.7	3.6×10^{-5}
MOI	0.13	4.1×10^{-2}	0.55	6.1×10^{-2}	7.5×10^{-7}
NPA	0.13	4.1×10^{-2}	0.55	6.1×10^{-2}	7.5×10^{-7}

Table F.2.4.2-18. Summary of chemical concentrations for fire involving diesel fuel at Savannah River.

	CHEMICAL CONCENTRATIONS mg/m³ - 95% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	1200	370	5100	560	4.6×10^{-3}
MCW	49	15	200	23	6.9×10^{-5}
MOI	0.90	0.28	3.8	0.42	1.1×10^{-7}
NPA	0.90	0.28	3.8	0.42	1.1×10^{-7}

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-19. Summary of chemical concentrations for fire involving diesel fuel at Hanford.

	CHEMICAL CONCENTRATIONS mg/m^3 - 50% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	200	62	840	94	2.0×10^{-3}
MCW	5.2	1.6	21	2.4	4.1×10^{-5}
MOI (New ECF)**	8.3×10^{-2}	2.4×10^{-2}	0.34	3.7×10^{-2}	2.5×10^{-7}
MOI (FMEF)***	0.11	3.3×10^{-2}	0.44	4.9×10^{-2}	8.1×10^{-7}
NPA	0.16	4.8×10^{-2}	0.65	7.3×10^{-2}	7.6×10^{-7}

Table F.2.4.2-20. Summary of chemical concentrations for fire involving diesel fuel at Hanford.

	CHEMICAL CONCENTRATIONS mg/m^3 - 95% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	1200	370	5100	560	4.6×10^{-3}
MCW	32	9.7	130	15	3.9×10^{-5}
MOI (New ECF)**	0.34	0.10	1.4	0.15	4.9×10^{-8}
MOI (FMEF)***	1.0	0.32	4.3	0.48	1.5×10^{-7}
NPA	0.78	0.24	3.2	0.36	5.0×10^{-7}

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.
** MOI (New ECF) applies if spent fuel facility is constructed at the 200 Area on the Hanford Site.
*** MOI (FMEF) applies if spent fuel facility is constructed at the Fuels and Materials Examination Facility.

Table F.2.4.2-21. Summary of chemical concentrations for fire involving diesel fuel at the Nevada Test Site.

	CHEMICAL CONCENTRATIONS mg/m³ - 50% METEOROLOGY				
	Carbon Monoxide ERPG-I 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	73	22	300	34	8.3×10^{-4}
MCW	2.3×10^{-2}	7.0×10^{-3}	9.6×10^{-2}	1.1×10^{-2}	2.2×10^{-7}
MOI	8.0×10^{-2}	2.4×10^{-2}	0.33	3.7×10^{-2}	7.3×10^{-7}

Table F.2.4.2-22. Summary of chemical concentrations for fire involving diesel fuel at the Nevada Test Site.

	CHEMICAL CONCENTRATIONS mg/m³ - 95% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	1200	370	5100	560	4.6×10^{-3}
MCW	1.1	0.34	4.6	0.52	1.7×10^{-7}
MOI	1.4	0.43	5.9	0.65	2.7×10^{-7}

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-23. Summary of chemical concentrations for fire involving diesel fuel at Oak Ridge.

	CHEMICAL CONCENTRATIONS mg/m^3 - 50% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	480	150	2000	220	3.9×10^{-3}
MCW	3.8	1.2	16	1.8	3.0×10^{-5}
MOI	37	11	150	18	3.3×10^{-4}
NPA	54	17	230	26	5.0×10^{-4}

Table F.2.4.2-24. Summary of chemical concentrations for fire involving diesel fuel at Oak Ridge.

	CHEMICAL CONCENTRATIONS mg/m^3 - 95% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	1200	370	5100	560	4.6×10^{-3}
MCW	24	7.3	98	11	2.6×10^{-5}
MOI	230	70	950	110	5.3×10^{-4}
NPA	340	100	1400	160	8.7×10^{-4}

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-25. Summary of chemical concentrations for fire involving diesel fuel at the Barnwell Plant.

	CHEMICAL CONCENTRATIONS mg/m^3 - 50% METEOROLOGY				
	Carbon Monoxide ERPG-I 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	200	62	840	94	2.0×10^{-3}
MCW	9.5×10^{-2}	2.9×10^{-2}	0.40	4.4×10^{-2}	9.3×10^{-7}
MOI	0.65	0.20	2.7	0.30	5.0×10^{-6}
NPA	0.65	0.20	2.7	0.30	5.0×10^{-6}

Table F.2.4.2-26. Summary of chemical concentrations for fire involving diesel fuel at the Barnwell Plant.

	CHEMICAL CONCENTRATIONS mg/m^3 - 95% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	1200	370	5100	560	4.6×10^{-3}
MCW	2.0	0.62	8.4	0.94	5.4×10^{-7}
MOI	5.8	1.7	24	2.7	3.2×10^{-6}
NPA	5.8	1.7	24	2.7	3.2×10^{-6}

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-27. Summary of chemical concentrations for fire involving diesel fuel at Kenneth A. Kesselring Site.

	CHEMICAL CONCENTRATIONS mg/m³ - 50% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	44	13	180	20	4.8×10^{-4}
MOI	0.25	7.7×10^{-2}	1.0	0.11	2.3×10^{-6}
NPA	0.25	7.7×10^{-2}	1.0	0.11	2.3×10^{-6}

Table F.2.4.2-28. Summary of chemical concentrations for fire involving diesel fuel at Kenneth A. Kesselring Site.

	CHEMICAL CONCENTRATIONS mg/m³ - 95% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	500	150	2100	230	1.9×10^{-3}
MOI	3.9	1.2	17	1.8	3.1×10^{-6}
NPA	3.9	1.2	17	1.8	3.1×10^{-6}

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-29. Summary of chemical concentrations for fire involving diesel fuel at Norfolk Naval Shipyard.

	CHEMICAL CONCENTRATIONS mg/m^3 - 50% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	44	13	180	20	4.8×10^{-4}
MOI	4.3	1.3	18	2.0	4.7×10^{-5}
NPA	4.3	1.3	18	2.0	4.7×10^{-5}

Table F.2.4.2-30. Summary of chemical concentrations for fire involving diesel fuel at Norfolk Naval Shipyard.

	CHEMICAL CONCENTRATIONS mg/m^3 - 95% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	500	150	2100	230	1.9×10^{-3}
MOI	47	14	200	22	2.8×10^{-4}
NPA	47	14	200	22	2.8×10^{-4}

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-31. Summary of chemical concentrations for fire involving diesel fuel at Pearl Harbor Naval Shipyard.

	CHEMICAL CONCENTRATIONS mg/m³ - 50% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	200	61	830	92	1.6×10^{-3}
MOI	3.3	1.0	13	1.5	1.7×10^{-5}
NPA	12	3.6	49	5.4	1.4×10^{-4}

Table F.2.4.2-32. Summary of chemical concentrations for fire involving diesel fuel at Pearl Harbor Naval Shipyard.

	CHEMICAL CONCENTRATIONS mg/m³ - 95% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	500	150	2100	230	1.9×10^{-3}
MOI	11	3.4	47	5.3	1.4×10^{-5}
NPA	500	150	2100	230	1.9×10^{-3}

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-33. Summary of chemical concentrations for fire involving diesel fuel at Portsmouth Naval Shipyard.

	CHEMICAL CONCENTRATIONS mg/m³ - 50% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	33	10	140	15	3.6×10^{-4}
MOI	1.7	0.51	7.0	0.78	1.7×10^{-5}
NPA	2.7	0.83	11	1.2	3.0×10^{-5}

Table F.2.4.2-34. Summary of chemical concentrations for fire involving diesel fuel at Portsmouth Naval Shipyard.

	CHEMICAL CONCENTRATIONS mg/m³ - 95% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	500	150	2100	230	1.9×10^{-3}
MOI	24	7.2	99	11	3.7×10^{-5}
NPA	73	22	300	34	1.7×10^{-4}

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-35. Summary of chemical concentrations for fire involving diesel fuel at Puget Sound Naval Shipyard.

	CHEMICAL CONCENTRATIONS mg/m^3 - 50% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	33	10	140	15	3.6×10^{-4}
MOI	1.5	0.47	6.3	0.71	1.5×10^{-5}
NPA	13	4.0	54	6.1	1.4×10^{-4}

Table F.2.4.2-36. Summary of chemical concentrations for fire involving diesel fuel at Puget Sound Naval Shipyard.

	CHEMICAL CONCENTRATIONS mg/m^3 - 95% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	500	150	2100	230	1.9×10^{-3}
MOI	21	6.5	89	9.8	3.2×10^{-5}
NPA	200	61	830	92	5.8×10^{-4}

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

Table F.2.4.2-37. Summary of chemical concentrations for fire involving diesel fuel aboard ship in Puget Sound.

	CHEMICAL CONCENTRATIONS mg/m^3 - 50% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	900	280	3800	420	9.9×10^{-3}
MOI	4.0	1.2	17	1.9	4.1×10^{-5}

Table F.2.4.2-38. Summary of chemical concentrations for fire involving diesel fuel aboard ship in Puget Sound.

	CHEMICAL CONCENTRATIONS mg/m^3 - 95% METEOROLOGY				
	Carbon Monoxide ERPG-1 29 ERPG-2 172 ERPG-3 1720	Sulfur Dioxide ERPG-1 0.79 ERPG-2 7.9 ERPG-3 39	Nitric Oxide ERPG-1 31 ERPG-2 * ERPG-3 123	Nitrogen Dioxide ERPG-1 5.6 ERPG-2 9.4 ERPG-3 94	Lead ERPG-1 0.15 ERPG-2 70 ERPG-3 700
Worker	9900	3100	41000	4600	3.8×10^{-2}
MOI	28	8.8	120	13	1.7×10^{-4}

* ERPG-2 level not assigned since one-tenth the IDLH level would be less than the ERPG-1 level.

F.3 AIRCRAFT CRASH PROBABILITIES

F.3.1 Introduction

The probability of an airplane crashing into a fuel storage area or a fuel examination facility at the various alternate site locations is presented in this section. An airplane crash into these regions is of concern since it might result in the release of corrosion products from the stored fuel or the release of radioactive fission products from the fuel. The method outlined in "A Methodology for Calculation of the Probability of Crash of an Aircraft into Structures in Weapon Storage Areas" (Sandia 1983) has been used to predict the crash probabilities for this analysis. This calculational methodology takes into consideration the crash probabilities associated with landing and takeoff operations at nearby airports and crashes during in-flight operations.

The aircraft crash probability analysis presented herein is based on the examination of large civilian aircraft and military aircraft crossing the space within a 10-mile radius of each site. The crash probability of general aviation aircraft is not included in this assessment since aircraft of this type generally do not possess sufficient mass or attain sufficiently high velocities to produce a serious radiological threat in the event that they crash into a fuel storage area or a fuel examination facility. Further, the crash probability contribution due to air travel beyond 10 miles was determined to be very small based on the models and conditions used in this analysis, and therefore has been omitted.

F.3.2 Methodology

The Sandia report provides the methodology which has been used for this assessment (Sandia 1983). In this report, the following expressions are given for calculating the crash probability associated with takeoff and landing operations at a given airport runway, and in-flight operations along a given airway:

$$P_{to} = \sum Ni_{to} \bullet Pn_{to} \bullet A \bullet c(a) \bullet e^{-|xij|/\theta(x,a)} \bullet e^{-|yij|/\theta(y,a)}$$

$$P_{l} = \sum Ni_{l} \bullet Pn_{l} \bullet A \bullet c(a) \bullet e^{-|xij|/\theta(x,a)} \bullet e^{-|yij|/\theta(y,a)}$$

$$P_{if} = \sum Nk \bullet Pn_{if} \bullet A \bullet c(if) \bullet e^{-|xkj|/\theta(x,if)}$$

where: subscript "to" refers to airport takeoff operations

subscript "1" refers to airport landing operations

subscript "if" refers to in-flight operations

Ni	=	the number of runway operations per year
Nk	=	the number of in-flight operations per year
Pn	=	the crash probability per operation given in Table F.3-1
x_{ij}	=	the perpendicular distance from the centerline of the runway to the target in miles
x_{kj}	=	the perpendicular distance from the airway to the target in miles
y_{ij}	=	the perpendicular distance from the end of the runway to the target in miles
c(a)	=	crash density constant given in Table F.3-2
c(if)	=	crash density constant given in Table F.3-3
$\theta(x,a)$	=	crash density constant given in Table F.3-2
$\theta(y,a)$	=	crash density constant given in Table F.3-2
$\theta(x,if)$	=	crash density constant given in Table F.3-3
A	=	effective crash area in square miles.

Table F.3-1. Crash parameter Pn.

Operation	Military High Performance	Large Civilian and Military
to	1.6×10^{-6}	0.6×10^{-6}
l	3.1×10^{-6}	2.3×10^{-6}
if	3.9×10^{-8}/mile	0.5×10^{-8}/mile

Table F.3-2. Crash density constants.

Zone (1)	Operation	Military High Performance			Large Civilian and Military		
		c(a)	θ(x,a)	θ(y,a)	c(a)	θ(x,a)	θ(y,a)
I	to	0.043	3.0	3.0	0.28	0.7	1.4
	l	0.11	1.0	3.0	0.28	0.7	1.4
II	to	0	---	---	0	---	---
	l	0.006	1.0	3.0	0.014	0.7	1.4

(1) Refer to Figure F.3-1 for crash zones.

Table F.3-3. Crash density constants.

Operation	Military High Performance		Large Civilian and Military	
	c(if)	θ(x,if)	c(if)	θ(x,if)
if	0.5	1.0	0.8	0.63

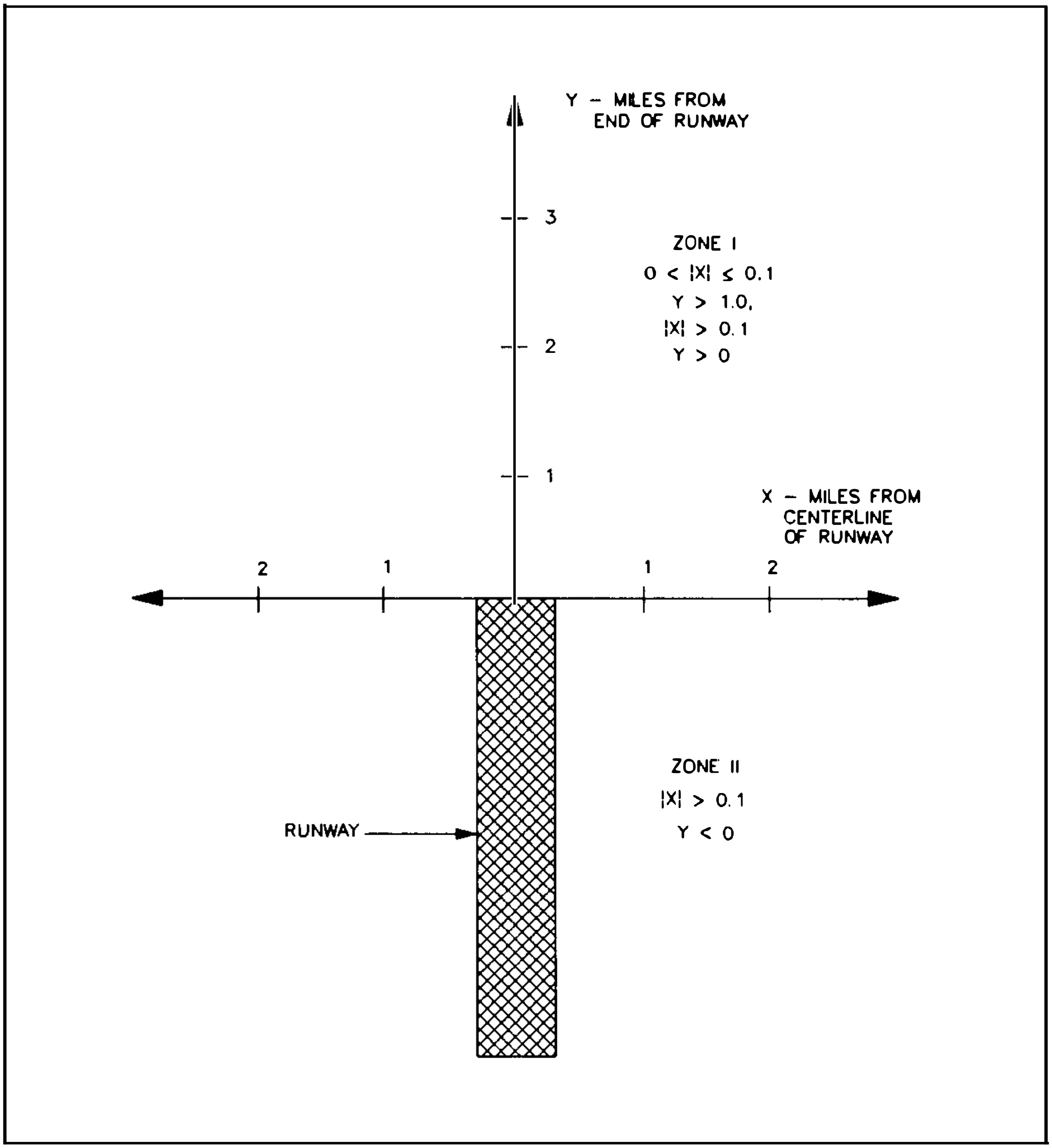

Figure F.3-1. Crash zones.

Using these relationships, the crash probability for takeoff, landing, and in-flight operations is the product of the number of operations per year, times the crash probability per operation per year, times the effective crash area per square mile, times the crash probability density per square statute mile. To determine the crash probability associated with a given site requires the repeated application of these relationships for each airport runway and for each airway. These individual crash components are then summed to arrive at a total overall crash probability for a site.

In the Sandia report, the effective crash area is identified as the sum of the effective skid area of the plane, the effective plan view associated with the target, and the effective shadow area of the crash (Sandia 1983). The following expression relates these terms and is valid for crash attitude angles greater than zero. If the crash attitude angle is zero, an airplane would be flying along parallel to the ground at an altitude equal to or greater than the height of the target; therefore, the airplane would clear the object and there would be no crash.

$$A = (L + A_w) \bullet (W + S_k + H \bullet \cot \phi)$$

where: L = target length dimension

W = target width dimension

H = target height

A_w = aircraft wingspan

ϕ = crash attitude angle

S_k = aircraft skid distance.

F.3.3 Site Specific Information

The existence and location of airports and airways within 10 statute miles of a site have been obtained from Sectional Aeronautical Maps published by the National Oceanic and Atmospheric Administration (NOAA), and from detailed site specific maps which identify nearby airports (NOAA 1993a; NOAA 1993b; NOAA 1993c; NOAA 1993d; NOAA 1993e; NOAA 1993f; NOAA 1993g; USGS 1983a; USGS 1983b). These same sources of information were also used to obtain the distances from airport runways and airways to the sites of interest. Information regarding air traffic along airways within this region was obtained from the Federal Aviation Administration (FAA). Airplane holding patterns and approach and departure routes that were identified by the FAA were converted into equivalent airways for this analysis. Information regarding the number of takeoff and landing operations at each airport runway was obtained from the cognizant airport officials (i.e., airport manager or base commander), or from the FAA. Tables F.3-4 and F.3-5 summarize the airport and airway traffic information that was obtained.

Table F.3-4. Airport landings and takeoffs per site location per year.

Site Location	Airport	Large Civilian Aircraft		Large Military Aircraft		Military High Performance Aircraft	
		No. Landings	No. Takeoffs	No. Landings	No. Takeoffs	No. Landings	No. Takeoffs
Barnwell Plant	Barnwell County	0	0	0	0	0	0
Hanford 200 Area 400 Area	None Richland County	- 0	- 0	- 0	- 0	- 0	- 0
INEL	[1]	150	150	0	0	0	0
Kesselring	Saratoga County	0	0	0	0	0	0
Nevada Test Site	None	-	-	-	-	-	-
Norfolk	Norfolk Intl	21200	21200	0	0	0	0
	Chambers	850	850	6600	6600	11100	11100
Oak Ridge	None	-	-	-	-	-	-
Pearl Harbor	Honolulu Intl / Hickam Air Force Base	101300	101300	5750	5750	8650	8650
	Barbers Point NAS	0	0	20500	20500	850	850
	Ford Island	0	0	0	0	0	0
Portsmouth	Pease Intl	16400[3]	16400[3]	2450[2]	2450[2]	2450[2]	2450[2]
	Little-brook	0	0	0	0	0	0
Puget Sound	Bremerton Natl	4[4]	4[4]	4[4]	4[4]	4[4]	4[4]
	Apex	0	0	0	0	0	0
	Port Orchard	0	0	0	0	0	0
Savannah River	None	-	-	-	-	-	-

(1) FAA testing of new commercial aircraft at NOAA tower.
(2) Split between aircraft types is estimated to be equal. Precise breakdown not furnished by airport.
(3) Operations based on total civilian aircraft. Breakdown of only large aircraft not furnished by airport.
(4) Operations based on this aircraft type being available only during annual air show.

Table F.3-5. Airway air traffic per site location per year.

Site Location	Large Civilian	Large Military	Military High Performance
Barnwell Plant	5900	2600	3300
Hanford 200 Area	2200	0	0
400 Area	3200	100	0
INEL	0	0	0
Kesselring	98600	144	0
Nevada Test Site	22000	9000	19000
Norfolk	17000	350	550
Oak Ridge	86900	5900	4700
Pearl Harbor	0	0	1750
Portsmouth	11000	0	0
Puget Sound	12800	0	0
Savannah River	5900	2600	3300

The effective crash area associated with various types of fuel storage at shipyards and prototypes was based on the storage facility footprints identified in Table D-1 of Attachment D. Length and width dimensions associated with the target area were calculated from these footprints by treating the storage area as square (i.e., equal length and width dimensions). The height of the dry storage containers was based on that of an existing M-140 shipping container, and the height of the water pool facility superstructure was based on the approximate height of the Expended Core Facility at INEL. For the water pool facility, a crash into the building might damage the fuel either by the airplane directly striking it or by the airplane causing sufficient damage to the building to cause part of the building structure to collapse and strike the fuel. The crash attitude angle used was 15 degrees, based on the recommended value identified in the Sandia report (Sandia 1983). A reduced aircraft skid distance of 300 feet was used. This skid distance is based on a review of the proposed site locations and reflects the fact that nearby buildings, dry docks, or retaining walls will generally limit the length of the aircraft skid to 300 feet or less prior to impact.

The effective crash area associated with fuel examination at the Expended Core Facility at INEL or similar facilities to be constructed at the Barnwell Plant, Hanford, Oak Ridge, the Nevada Test Site, or Savannah River was based on the vulnerable part of the facility being 667 feet long, 194 feet wide, and 60 feet high. This represents the portion of the Expended Core Facility that contains the combined dry cell, shielded cell, and water pool as identified in Attachment B. For these facilities, a crash into the building might damage the fuel either by the airplane directly striking it or by the airplane causing sufficient damage to the building to cause part of the building structure to collapse and strike the fuel. The effective crash area associated with dry storage or shipping containers waiting to be handled at these fuel examination facilities is based on the height and width of an existing M-140 shipping container and the modeling approach that two such containers could be located outside of the fuel processing facility and separated by a reasonably large distance. The crash attitude angle that was used was 15 degrees. For these facilities and containers, airplane skid distances of 2200 feet for military high performance aircraft and 1600 feet for large military and large civilian aircraft were used. These skid distances correspond to the maximum expected skid distance based on the information presented in the Sandia report (Sandia 1983).

F.3.4 Aircraft Specific Information

Aircraft wingspans which are representative of large civilian aircraft, military high performance aircraft (i.e., tactical fighter and tactical fighter trainer), and large military aircraft (i.e., cargo, transport, refueling, and bomber) have been taken into account separately in computing the overall crash probabilities for each site. Wingspans for these three class of aircraft have been based on average values computed from individual planes within each class. Data from "Aviation Week & Space Technology" served as the basis for determining these wingspans (AWST 1992). The calculated average wingspans were: 40 feet for military high-performance aircraft, 131 feet for large military aircraft, and 135 feet for large civilian aircraft. For large military and civilian aircraft, an effective wingspan that was 75% of the average wingspan was used in the probability calculations. This effective wingspan reflects the fact that only the region between the most outboard wing-mounted engines has the potential to seriously damage a fuel storage area or a fuel examination facility.

F.3.5 Results

Tables F.3-6 and F.3-7 present the crash probability results for the four methods of fuel storage at shipyards and prototypes and for fuel examination facilities. The probabilities listed within these tables represent the combined takeoff, landing, and in-flight crash probabilities associated with each method of fuel storage at each site. Following the DOE NEPA oversight guidance, consequences for beyond design basis accidents are calculated where the probability is 10^{-7} or greater per year. These consequences are discussed in Section F.1.4 of this attachment. For cases less likely than 10^{-7} per year, calculations of consequences are not included.

The probability calculated for airplane crashes at different facilities located within a particular DOE site may vary somewhat. This situation exists at INEL where low altitude testing of commercial jet airliners has been conducted near the NOAA tower. This tower is located about 1.5 miles from ICPP, and 2.3 miles from ECF. As a result of this difference in distance, the crash probabilities are expected to be about a factor of two higher at ICPP than at ECF. Further, two different methodologies have been in general use for determination of aircraft accident probabilities. In addition to the Sandia methodology used in this appendix, a technique developed by the NRC in the 1970's has been applied at some facilities. Comparison of the two methods has shown that results can differ by a factor of two to four, with the NRC method generally producing higher probabilities than the Sandia method. This difference stems from the somewhat more detailed nature of the Sandia method. Therefore, calculated aircraft crash probabilities at ICPP are expected to be about a factor of four to eight higher than those calculated for ECF.

Crash probabilities fall in the design basis range (i.e., probability of occurrence $\geq 10^{-6}$ per year) at Pearl Harbor for all types of fuel storage, at Norfolk for fuel storage in shipping containers on railcars, and at Oak Ridge and Savannah River for the fuel examination facility dry cell and water pool. The radiological consequences associated with an airplane crash into these areas are addressed in detail in Section F.1.4.

Crash probabilities fall in the beyond design basis range (i.e., probability of occurrence between 10^{-6} and 10^{-7} per year) at Norfolk for fuel storage in immobile dry storage containers, shipping containers on a concrete pad, and in the water pool facility, at Kesselring for fuel storage in shipping containers on railcars and in the water pool facility, at Portsmouth for shipping containers on railcars, at the Nevada Test Site for the fuel examination facility dry cell and water pool, and the fuel examination facility dry storage containers at Oak Ridge and Savannah River. The radiological consequences associated with an airplane crash into these areas are also addressed in detail in Section F.1.4.

Crash probabilities with a likelihood of occurrence less than 10^{-7} per year are not evaluated since it is expected that they would contribute very very little to the risk. This is the case for immobile dry storage and shipping containers on a concrete pad at Kesselring and Portsmouth, the water pool facility at Portsmouth, all types of fuel storage at Puget Sound, the fuel examination facilities at Barnwell, Hanford, and INEL, and the fuel examination facility dry storage containers at the Nevada Test Site.

Table F.3-6. Crash probabilities for various fuel storage options per site location per year.

Site Location	Immobile Dry Storage Containers	Shipping Containers on Concrete Pad	Shipping Containers on Railcars	Water Pool Facility
Kesselring	9×10^{-8}	8×10^{-8}	1×10^{-7}	2×10^{-7}
Norfolk	6×10^{-7}	5×10^{-7}	1×10^{-6}	4×10^{-7}
Pearl Harbor	1×10^{-5}	1×10^{-5}	N/A	2×10^{-5}
Portsmouth	6×10^{-8}	6×10^{-8}	1×10^{-7}	7×10^{-8}
Puget Sound	3×10^{-8}	3×10^{-8}	8×10^{-8}	3×10^{-8}

Table F.3-7. Crash probabilities for fuel examination facilities per site location per year.

Site Location	Shielded Cell, Dry Cell, and Water Pool	Dry Storage Containers
Barnwell Plant	9×10^{-8}	1×10^{-8}
Hanford 200 Area	6×10^{-10}	2×10^{-10}
400 Area	4×10^{-8}	1×10^{-8}
INEL (ECF)	7×10^{-8}	2×10^{-8} 5×10^{-8} (1)
Nevada Test Site	4×10^{-7}	5×10^{-8}
Oak Ridge	1×10^{-6}	3×10^{-7}
Savannah River	2×10^{-6}	3×10^{-7}

(1) Crash probability based on 582 dry storage containers stored in a square array several hundred yards away from ECF. Array footprint is 168,800 square feet.

F.4 FUGITIVE DUST

The INEL-ECF is a large laboratory facility used to receive, examine, and ship naval nuclear fuel and irradiated test specimen assemblies. This section provides the results of an evaluation of fugitive dust emissions that could be generated during the construction of a similar laboratory facility at an alternate location (Hanford, Savannah River, the Nevada Test Site, the Barnwell Plant, or Oak Ridge).

F.4.1 Computer Modeling to Estimate Fugitive Dust Emissions

Factors such as locations of affected persons, terrain, meteorological conditions, release conditions, and grain size distributions are required as input parameters for calculations to determine particulate concentrations from fugitive dust emissions during construction activities. This section describes the computer model used to perform fugitive dust concentration estimates. Specific input parameters used in this analysis are summarized in Section F.4.2.

The Fugitive Dust Model (FDM) was the computer code chosen to evaluate fugitive dust emissions from construction activities at an alternate DOE location. FDM is a computerized air quality model specifically designed for estimating fugitive dust emissions from point, line, or area sources (EPA 1992c).

FDM is designed to work with properly prepared meteorological data such as the EPA RAMMET program or card images of meteorological data in either hourly or Stability Array (STAR) format. FDM is based on the well-known Gaussian plume formulation for computing concentrations, but the model has been specifically adapted to incorporate an improved gradient transfer deposition algorithm. Emissions for each source are apportioned by the user into a series of particle size classes. A gravitational settling velocity and a deposition velocity are subsequently calculated by FDM for each class, and dust concentrations and depositions are then calculated for locations selected by the user.

FDM is the preferred model for estimating conditions resulting from particulate matter emissions from fugitive sources such as excavation and soil handling. The ISC2 Code (Section

F.2.2.2) can also be used for this purpose; however, FDM was judged to be superior to the ISC2 Code for this evaluation.

F.4.2 Conditions and Key Parameters

- Construction area was 30 acres.
- Construction activities occurred over a 3- to 5-year period.
- An emission factor of 2.0 tons per acre-month was used.
- Grain sizes used were as follows:

Average Diameter (μm)	% of Total
1.25	3
3.75	5
7.5	15
12.5	10
20.0	67

- Meteorological conditions used were the 5-year average STAR data sets.
- Roughness heights were 2 centimeters for Hanford and Nevada Test Site and 30 centimeters for Savannah River, the Barnwell Plant, and Oak Ridge.

F.4.3 Results

The fugitive dust concentrations were calculated using FDM for the worker, MCW, NPA, and MOI using normal meteorology. Table F.4-1 lists the fugitive dust concentrations at various locations. These airborne concentrations were compared against the TLV-TWA concentration for particulates. The TLV-TWA concentration of 10 mg/m^3 was not exceeded at any of the specified locations for fugitive dust that could be generated during construction activities at the alternate locations. Since these concentrations were extremely low, it can also be concluded that similar results would be expected for the alternate shipyard locations since the facilities to be constructed would be smaller.

Table F.4-1. Summary of fugitive dust concentrations for construction activities at alternate locations.

Fugitive Dust Concentration mg/m³					
	Savannah River	Hanford*	Nevada Test Site	Oak Ridge	Barnwell Plant
Worker	2.7	3.5	1.6	3.1	2.7
MCW	3.6×10^{-2}	7.3×10^{-2}	8.1×10^{-5}	2.9×10^{-3}	5.2×10^{-4}
MOI	2.8×10^{-4}	1.3×10^{-4}	2.9×10^{-4}	0.22	3.2×10^{-3}
NPA	1.4×10^{-4}	2.2×10^{-4}	Not applicable	1.6	3.2×10^{-3}

*MOI shown is for a new spent fuel facility constructed at the 200 Area on the Hanford Site. The MOI concentration is 3.0×10^{-4} mg/m³ for a new spent fuel facility constructed at the Fuels and Materials Examination Facility.

F.5 OCCUPATIONAL ACCIDENTS

Occupational accidents can occur in the workplace during the construction or operation of any industrial facility. In order to assess the possible extent of occupational accidents during construction and non-construction operations at naval spent nuclear fuel facilities, projections of the number of fatalities and injuries or illnesses were made for each alternative. The projections are presented in this section. The projections are based on average occupational fatality and injury incidence rate data published by the DOE (DOE 1993a) for DOE and DOE contractor operations. The incidence rates that were used in the analyses are provided below. A more detailed discussion of the basis for these incidence rates is presented in Volume 1.

Average occupational injury/illness and fatality rates[a]

	All Labor Categories		Construction Workers	
	Total Injury/Illness	Fatalities	Total Injury/Illness	Fatalities
DOE and Contractors[b]	3.2	0.0032	6.2	0.011

[a] All incidence rates are given per 100 worker-years
[b] 1988-1992 averages (DOE 1993a)

The term "injury/illness" as used in this analysis corresponds to the DOE definition of a recordable injury illness. Specifically, an injury or illness case represents any work-related death, illness, or any work-related injury which would result in loss of consciousness, restriction of work or motion, transfer to another job, or medical treatment beyond first aid.

F.5.1 Accident Evaluation

F.5.1.1 Construction. The average number of construction-related fatalities and injury or illnesses and the 40-year total were calculated. The methods of calculating construction-related fatalities and injuries or illnesses are presented below.

The number of construction workers that would be required to construct or modify each naval spent nuclear fuel storage and examination facility was calculated for every year that construction would take place during the period 1995 through 2035. The sum of these workers represents the total number of construction workers. The 40-year total of construction fatalities was obtained by multiplying the total number of construction workers by the construction fatality rate for DOE and DOE contractors.

The annual average number of construction workers for each facility was obtained by dividing the total number of construction workers by the number of years that construction would take place. The product of the annual average number of construction workers and the construction fatality rate for DOE and DOE contractors was calculated to provide the annual average number of construction fatalities.

The annual average and 40-year total construction injuries or illnesses were calculated in the same manner as construction fatalities except that the construction injury or illness accident rate for DOE and DOE contractors.

F.5.1.2 Storage and Examination Facility Operations. The average number of fatalities and injuries or illnesses and the 40-year total fatalities and injuries or illnesses were calculated for operation of naval spent nuclear fuel storage and examination facilities. The methods of calculating the operational fatalities and injuries or illness are presented below.

The accident rates for DOE and DOE contractor operations other than construction were used because examination and storage facility operations would more likely be performed by DOE and DOE contractor personnel (or Navy personnel in the case of shipyards). The number of workers that would be required to operate each naval spent nuclear fuel storage and examination facility was calculated for every year during the period 1995 through 2035 and summed over the 40-year period to obtain the total number of workers. The 40-year total of fatalities was obtained by multiplying the total number of workers by the DOE fatality rate.

The annual average number of workers for each facility was obtained by dividing the total number of workers by the number of operational years (40 years). The product of the annual average number of workers and the DOE fatality rate represents the annual average number of operational fatalities.

The annual average and 40-year total estimated injuries or illnesses associated with facility operations were calculated in the same manner as fatalities associated with facility operations except that the DOE injury or illness accident rate was used.

F.5.2 Results

This section presents tabulated results of calculations of construction and operating fatalities and injuries or illnesses for each alternative. Table F.5-1 provides the projections of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations for each alternative. Tables F.5-2 through F.5-5 present the results of calculations of occupational fatalities and injuries or illnesses for construction activities and storage and examination operations at naval sites. The results of all calculations show that the number of fatalities and injuries or illnesses for construction activities and storage and examination operations would be low for any alternative.

Table F.5-1. Occupational fatalities and injuries/illnesses by alternative - construction activities and storage and examination facility operations.

Alternative	Fatalities				Injuries/Illnesses			
	Construction		Operations		Construction		Operations	
	Annual Average	40-Year Total	Annual Average	40-Year Total	Annual Average	40-Year Total	Annual Average	40-Year Total
1. No Action	3.9×10^{-3}	6.9×10^{-3}	2.5×10^{-3}	9.8×10^{-2}	2.2	3.9	2.5	9.8×10^{1}
2. Decentralization[(1)]								
• No Exam	3.1×10^{-2}	2.2×10^{-1}	6.6×10^{-3}	2.6×10^{-1}	1.8×10^{1}	1.2×10^{2}	6.6	2.6×10^{2}
• Limited Exam	4.2×10^{-2}	2.5×10^{-1}	8.3×10^{-3}	3.3×10^{-1}	2.4×10^{1}	1.4×10^{2}	8.3	3.3×10^{2}
• Full Exam	3.4×10^{-2}	2.2×10^{-1}	2.1×10^{-2}	8.3×10^{-1}	1.9×10^{1}	1.3×10^{2}	2.1×10^{1}	8.3×10^{2}
3. 1992/1993 Planning Basis	2.6×10^{-3}	5.3×10^{-3}	1.7×10^{-2}	6.6×10^{-1}	1.5	3.0	1.7×10^{1}	6.6×10^{2}
4. Regionalization								
• INEL	2.6×10^{-3}	5.3×10^{-3}	1.7×10^{-2}	6.6×10^{-1}	1.5	3.0	1.7×10^{1}	6.6×10^{2}
• Nevada Test Site	4.7×10^{-2}	3.3×10^{-1}	1.7×10^{-2}	6.7×10^{-1}	2.7×10^{1}	1.9×10^{2}	1.7×10^{1}	6.7×10^{2}
• Oak Ridge	4.7×10^{-2}	3.3×10^{-1}	1.7×10^{-2}	6.7×10^{-1}	2.7×10^{1}	1.9×10^{2}	1.7×10^{1}	6.7×10^{2}
5. Centralization								
• INEL	2.6×10^{-3}	5.3×10^{-3}	1.7×10^{-2}	6.6×10^{-1}	1.5	3.0	1.7×10^{1}	6.6×10^{2}
• Hanford	4.7×10^{-2}	3.3×10^{-1}	1.7×10^{-2}	6.7×10^{-1}	2.7×10^{1}	1.9×10^{2}	1.7×10^{1}	6.7×10^{2}
• Savannah River	4.7×10^{-2}	3.3×10^{-1}	1.7×10^{-2}	6.7×10^{-1}	2.7×10^{1}	1.9×10^{2}	1.7×10^{1}	6.7×10^{2}
• Nevada Test Site	4.7×10^{-2}	3.3×10^{-1}	1.7×10^{-2}	6.7×10^{-1}	2.7×10^{1}	1.9×10^{2}	1.7×10^{1}	6.7×10^{2}
• Oak Ridge	4.7×10^{-2}	3.3×10^{-1}	1.7×10^{-2}	6.7×10^{-1}	2.7×10^{1}	1.9×10^{2}	1.7×10^{1}	6.7×10^{2}

(1) The water pool storage mode was used in the calculation since the maximum number of construction and operational workers would be involved.

Table F.5-2. Occupational fatalities for construction activities at Naval Nuclear Propulsion Program sites.

	ECF		Puget Sound		Pearl Harbor		Portsmouth		Norfolk		Kesselring	
Storage	**Annual Average**	**40-Year Total**	**Annual Average**	**40-Year Total**	**Annual Average**	**40-Year Total**	**Annual Average**	**40-Year Total**	**Annual Average**	**40-Year Total**	**Annual Average**	**40-Year Total**
Storage Modes												
1. Railcar Storage			7.7×10^{-4}	2.3×10^{-3}	7.7×10^{-4}	7.7×10^{-4}	7.7×10^{-4}	7.7×10^{-4}	7.7×10^{-4}	2.3×10^{-3}	7.7×10^{-4}	7.7×10^{-4}
2. Shipping Containers on Concrete Pads			3.3×10^{-4}	6.6×10^{-4}	3.3×10^{-4}	6.6×10^{-4}	3.3×10^{-4}	6.6×10^{-4}	3.3×10^{-4}	6.6×10^{-4}	3.3×10^{-4}	6.6×10^{-4}
3. Immobile Storage Containers			3.3×10^{-4}	6.6×10^{-4}	3.3×10^{-4}	6.6×10^{-4}	3.3×10^{-4}	6.6×10^{-4}	3.3×10^{-4}	6.6×10^{-4}	3.3×10^{-4}	6.6×10^{-4}
4. Water Pool Storage			8.1×10^{-3}	5.7×10^{-2}	5.3×10^{-3}	3.7×10^{-2}	5.3×10^{-3}	3.7×10^{-2}	7.7×10^{-3}	5.4×10^{-2}	4.9×10^{-3}	3.4×10^{-2}
Examination Modes												
1. Full Exam	2.6×10^{-3}	5.3×10^{-3}										
2. Limited Exam			1.1×10^{-2}	3.2×10^{-2}								

Table F.5-3. Occupational fatalities for storage and examination facility operations at Naval Nuclear Propulsion Program sites.

	ECF		Puget Sound		Pearl Harbor		Portsmouth		Norfolk		Kesselring	
Storage	Annual Average	40-Year Total	Annual Average	40-Year Total	Annual Average	40-Year Total	Annual Average	40-Year Total	Annual Average	40-Year Total	Annual Average	40-Year Total
Storage Modes[1]												
1. Railcar Storage			1.9×10^{-5}	7.7×10^{-4}	1.9×10^{-5}	7.7×10^{-4}	1.9×10^{-5}	7.7×10^{-3}	1.9×10^{-5}	7.7×10^{-4}	1.9×10^{-5}	7.7×10^{-4}
2. Shipping Containers on Concrete Pads			2.7×10^{-5}	1.1×10^{-3}	2.0×10^{-5}	8.0×10^{-4}	2.0×10^{-5}	8.0×10^{-4}	3.3×10^{-5}	1.3×10^{-3}	1.9×10^{-5}	7.7×10^{-4}
3. Immobile Storage Containers			2.2×10^{-4}	8.8×10^{-3}	1.2×10^{-4}	4.8×10^{-3}	1.3×10^{-4}	5.0×10^{-3}	2.6×10^{-4}	1.0×10^{-2}	6.9×10^{-5}	2.8×10^{-3}
4. Water Pool Storage			1.0×10^{-3}	4.1×10^{-2}	8.0×10^{-4}	3.2×10^{-2}	8.1×10^{-4}	3.2×10^{-2}	9.5×10^{-4}	3.8×10^{-2}	6.3×10^{-4}	2.5×10^{-2}
Examination Modes												
1. Full Exam	1.7×10^{-2}	6.6×10^{-1}										
2. Limited Exam			1.8×10^{-3}	7.1×10^{-2}								

[1] Decentralization (No Exam) used for representative case.

Table F.5-4. Occupational injuries/illnesses for construction activities at Naval Nuclear Propulsion Program sites.

	ECF		Puget Sound		Pearl Harbor		Portsmouth		Norfolk		Kesselring	
Storage	Annual Average	40-Year Total	Annual Average	40-Year Total	Annual Average	40-Year Total	Annual Average	40-Year Total	Annual Average	40-Year Total	Annual Average	40-Year Total
Storage Modes												
1. Railcar Storage			4.3×10^{-1}	1.3×10^{0}	4.3×10^{-1}	4.3×10^{-1}	4.3×10^{-1}	4.3×10^{-1}	4.3×10^{-1}	1.3×10^{0}	4.3×10^{-1}	4.3×10^{-1}
2. Shipping Containers on Concrete Pads			1.9×10^{-1}	3.7×10^{-1}	1.9×10^{-1}	3.7×10^{-1}	1.9×10^{-1}	3.7×10^{-1}	1.9×10^{-1}	3.7×10^{-1}	1.9×10^{-1}	3.7×10^{-1}
3. Immobile Storage Containers			1.9×10^{-1}	3.7×10^{-1}	1.9×10^{-1}	3.7×10^{-1}	1.9×10^{-1}	3.7×10^{-1}	1.9×10^{-1}	3.7×10^{-1}	1.9×10^{-1}	3.7×10^{-1}
4. Water Pool Storage			4.6×10^{0}	3.2×10^{1}	3.0×10^{0}	2.1×10^{1}	3.0×10^{0}	2.1×10^{1}	4.4×10^{0}	3.1×10^{1}	2.8×10^{0}	1.9×10^{1}
Examination Modes												
1. Full Exam	1.5×10^{0}	3.0×10^{0}										
2. Limited Exam			5.9×10^{0}	1.8×10^{1}								

Table F.5-5. Occupational injuries/illnesses for storage and examination facility operations at Naval Nuclear Propulsion Program sites.

	ECF		Puget Sound		Pearl Harbor		Portsmouth		Norfolk		Kesselring	
Storage	Annual Average	40-Year Total	Annual Average	40-Year Total	Annual Average	40-Year Total	Annual Average	40-Year Total	Annual Average	40-Year Total	Annual Average	40-Year Total
Storage Modes[1]												
1. Railcar Storage			1.9×10^{-2}	7.7×10^{-1}	1.9×10^{-2}	7.7×10^{-1}	1.9×10^{-2}	7.7×10^{-1}	1.9×10^{-2}	7.7×10^{-1}	1.9×10^{-2}	7.7×10^{-1}
2. Shipping Containers on Concrete Pads			2.7×10^{-2}	1.1	2.0×10^{-2}	8.0×10^{-1}	2.0×10^{-2}	8.0×10^{-1}	3.3×10^{-2}	1.3	1.9×10^{-2}	7.7×10^{-1}
3. Immobile Storage Containers			2.2×10^{-1}	8.8	1.2×10^{-1}	4.8	1.3×10^{-1}	5.0	2.6×10^{-1}	1.0×10^{-1}	6.9×10^{-2}	2.8
4. Water Pool Storage			1.0	4.1×10^{1}	8.0×10^{-1}	3.2×10^{1}	8.1×10^{-1}	3.2×10^{1}	9.5×10^{-1}	3.8×10^{1}	6.3×10^{-1}	2.5×10^{1}
Examination Modes												
1. Full Exam	1.7×10^{1}	6.6×10^{2}										
2. Limited Exam			1.8	7.1×10^{1}								

[1] Decentralization (No Exam) used for representative case.

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ATTACHMENT G

COMPARISON OF THE NAVAL SPENT NUCLEAR FUEL STORAGE ENVIRONMENTAL ASSESSMENT AND THIS ENVIRONMENTAL IMPACT STATEMENT

The Naval Nuclear Propulsion Program has prepared an environmental assessment of short-term storage of naval spent nuclear fuel until the environmental impact statement, of which this appendix is a part, can be completed and an alternative for management of naval spent nuclear fuel is selected (Federal Register, Vol. 59, No. 19, 4051, January 8, 1994). The environmental assessment considered alternatives for storing, until June 1995, naval spent nuclear fuel removed from nuclear-powered vessels and reactor prototypes at several naval sites. The environmental impact statement, which the appendix including this attachment is a part, considers alternatives for the examination and storage of naval spent nuclear fuel during a 40-year period beginning in June 1995.

Occasions may arise when comparison of the impacts for naval spent nuclear fuel described in these two documents may be desired. However, there are some differences between the environmental assessment and this appendix which should be recognized because they make such a comparison complicated. Failure to recognize these differences may lead to an erroneous conclusion that the two documents are inconsistent or contradictory.

First, and most importantly, the environmental assessment considered only a limited period, less than 2 years, needed to conduct the National Environmental Policy Act process required to reach a decision on the long-term management of Department of Energy (DOE) spent nuclear fuel. This process includes preparation of this environmental impact statement. The environmental impact statement, and therefore this appendix, provides the evaluation of the alternatives to be used for managing spent nuclear fuel for 40 years. As a result, this environmental impact statement considers a wider range of alternatives than the environmental assessment, partly because more alternatives are possible if a longer time is available to implement them and partly because some decisions which could be deferred for a short period such as 2 years should not be deferred for a period as long as 40 years.

The alternatives considered in the environmental impact statement also include more potential sites for management of naval spent nuclear fuel. This provides a wider range of choices, but, as a natural consequence, it also increases the number of potential destinations and the miles traveled by shipments of naval spent nuclear fuel under some alternatives. In the same manner, while the environmental assessment considered temporary storage of naval spent nuclear fuel at Newport News Shipbuilding, storage at Newport News is not included in the alternatives in the environmental impact statement because that shipyard is not federally owned.

The alternatives considered in the environmental impact statement also include storage of naval spent nuclear fuel in water pools and immobile dry storage casks in addition to storage in shipping containers. There is also an evaluation of alternatives for examination of naval spent nuclear fuel in the environmental impact statement. These additional storage modes and examination alternatives were not considered in detail in the environmental assessment because the period covered by that document was short and consequently, the implementation of some of the alternatives would have been impractical. For example, water pool storage facilities could not be funded and constructed at the shipyards in a period of less than 2 years.

Also, as a natural result of the longer period considered in this environmental impact statement, a larger number of naval spent nuclear fuel assemblies and additional types of naval fuel assemblies are included in the analyses. The increase in the amount of naval spent nuclear fuel occurs since a certain number of naval reactors are refueled or defueled each year, so in a greater number of years more fuel becomes available for storage. Similarly, some newer designs for naval nuclear propulsion plants will not be refueled for the first time until some time after 1995, so those types of fuel are not treated in the environmental assessment.

The environmental impact statement addresses some impacts of normal operations and some accidents not discussed in the environmental assessment because the conditions or operation which might cause these effects would not occur under the alternatives considered in the environmental assessment. The environmental impact statement also addresses several types of impacts for each alternative in greater detail than the environmental assessment. This was done because more detailed treatment was judged to be appropriate with the broader scope of alternatives in the environmental impact statement.

The methods used to perform the analyses in the environmental impact statement have been refined in the time since the environmental assessment was prepared. This occurred partly because of the larger number of naval spent nuclear fuel assemblies analyzed and the wider scope of sites and methods of storage to be evaluated, and partly because additional time was available to implement the refinements. In addition to refinements in the methods for performing the calculations, some minor changes in the calculational models were made in order to establish a high degree of consistency with the analytical methods used for the other DOE sites that are part of the environmental impact statement. This consistency is appropriate in some cases in order to establish common grounds for comparison of alternatives. The changes in the calculational methods make a direct comparison of the analytical results presented in the environmental assessment for naval sites with those in this appendix difficult.

GLOSSARY

activation	The process of making a material radioactive by exposing the material to neutrons, protons, or other nuclear particles.
activation products	The radionuclides formed as a result of a material being activated. For example, cobalt-60 is an activation product resulting from neutron activation of cobalt-59.
activity	A measure of the rate at which a material is emitting nuclear radiation. Activity is usually measured in terms of the number of nuclear disintegrations which occur in a quantity of the material over a period of time. The standard unit of activity is the curie (Ci), which is equal to 37 billion (3.7×10^{10}) disintegrations per second.
aggregates	Sand, gravel, or rock which is used in concrete or mortar mixes to achieve increased strength.
airborne emissions	Radioactivity in the form of radioactive particles, gases, or both that is transported by air.
alloy	A mixture of two or more metals.
aquifer	A water-bearing stratum of permeable rock, sand, or gravel located beneath the surface of the earth, which is capable of yielding water to a well or spring.
archaeological areas	Areas of or relating to the scientific study of material remains (as fossil relics, artifacts, monuments) of past human life and activities.
average individual	An individual who could consume items or occupy areas at rates which would be typical for the population of interest.
base flood	A flood which has a 1-percent chance of occurrence in any given year. Also referred to as a 100-year flood.
benthic	Pertaining to the bottom of the ocean.
best estimate	An estimate in which the factors used in determining the estimate were chosen such that the result approximately represents what would be expected.
cladding	A metal casing that surrounds the nuclear fuel.

GLOSSARY (Cont)

coastal zone	The region along the shore, adjacent to the ocean. A coastal zone is usually defined as the region within 3 nautical miles of a shoreline.
concentration factor	A factor which is defined as the concentration of an element or radionuclide in an organism or its tissues divided by the concentration directly available from the organism's environment under equilibrium or steady-state conditions.
conservative estimate	An estimate in which the factors used in determining the estimate were chosen such that the result would be unlikely to be exceeded.
containments	Devices as complex as a glove box or as simple as a plastic bag designed to limit the spread of radioactive contamination to an area as close as possible to the source, and to break the chain of transfer to prevent contaminating other material.
core	The central portion of a nuclear reactor containing the nuclear fuel.
corrosion	The process denoting the destruction of metal by chemical or electrochemical action.
corrosion products	The substances produced by corrosion of a metal. Rust is a common corrosion product resulting from the corrosion of iron.
corrosion-resistant alloy	An alloy which corrodes slowly compared to ordinary alloys. Stainless steel is an example of a corrosion-resistant alloy.
critical organ	The limiting organ for evaluating exposure to ionizing radiation. A critical organ is determined by the following criteria: (1) the organ that accumulates the greatest concentration of a radioactive material, (2) the necessity of the organ to the well being of the entire body, (3) the organ most damaged by the entry of a radionuclide into the body, and (4) the organ damaged by the lowest exposure. Usually, case (1) is the determining factor for choosing the critical organ.
critical pathways	Those pathways which result in the most significant amount of exposure to radiation.
cumulative effects	The changes in the health of an individual(s) from the sum of all yearly exposures to radiation.

curie (Ci)	The curie is the common unit used for expressing the magnitude of radioactive decay in a sample containing radioactive material. Specifically, the curie is that amount of radioactivity equal to 3.7×10^{10} (37 billion) disintegrations per second. This unit does not give any indication of the radiological hazard associated with the disintegration.
defueling	Removal of all nuclear fuel from a nuclear-powered ship.
design earthquake	The maximum intensity earthquake that might occur along the nearest fault to a structure. Structures are built to withstand a design earthquake.
diffusion	The process of spreading out or scattering from regions of higher concentration to regions of lower concentration.
dispersion	The process of scattering or distributing over a large region.
dose	A general term which denotes the quality of radiation or energy absorbed; usually expressed in rems for doses to man.
dose commitment	The total radiation dose accrued by an individual over a specified period of time due to the exposure of the individual to radiation during a given interval of time. This includes the total time the radioactive material would reside in the body, if ingested or inhaled (usually expressed in rems).
dose commitment conversion factor	A factor which converts the quantity of radioactivity taken into the body to the dose to the individual (usually expressed in rems per curie).
dose equivalent	A quantity used to express all radiations on a common scale for calculating the effective absorbed dose. It is defined as the product of the absorbed dose and certain modifying factors and is expressed in rems.
dose rate	The amount of radiation dose delivered in a unit amount of time; for example, in rems per hour.
dose rate conversion factor	A factor which converts the exposure to a given radiation level to the dose that an individual could receive. It is usually expressed in rems per hour per curie per cubic meter (or square meter).

GLOSSARY (Cont)

dredge spoil	Bottom sediments or materials that have been excavated from a waterway.
ecosystem	A community of plant and animal populations together with their physical environment. An organizational unit which can maintain its biological activities independent of other units.
element	A chemical substance that cannot be divided into simpler substances by chemical means. A substance whose atoms all have the same atomic number.
endangered species	A species or subspecies which is in danger of extinction throughout all or a significant portion of its range.
environmental consequences	Changes to the environment as a result of the effects of radiation or radioactive materials.
epidemiological study	A scientific study that deals with the incidence, distribution, and control of disease in a specified population.
exclusion area	An area where access would result in personnel exceeding radiation exposure limits in a very short time.
Expended Core Facility (ECF)	A large laboratory facility, located at the Naval Reactors Facility in Idaho, consisting of water pools and shielded cells used to receive, examine, and ship naval spent nuclear fuel and irradiated test specimen assemblies. Naval spent nuclear fuel is prepared at ECF for storage and shipment to the Idaho Chemical Processing Plant.
exposure, external	The subjecting of the outside of the body of an organism to ionizing radiation.
exposure, internal	The subjecting of the inside of the body of an organism to ionizing radiation.
exposure, occupational	The subjecting of an individual to ionizing radiation in the course of employment.
exposure, radiation	The subjecting of a material or organism to ionizing radiation.
fauna	Animals.

GLOSSARY (Cont)

fissile	A material whose nucleus is capable of being split (fissioned) by neutrons of all energies.
fission	The splitting of a heavy nucleus into two approximately equal parts which is accompanied by the release of a relatively large amount of energy and generally one or more neutrons.
fission products	During operation of a nuclear reactor, heat is produced by the fission (splitting) of "heavy" atoms, such as uranium, plutonium, or thorium. The residue left after the splitting of these "heavy" atoms is a series of intermediate weight atoms generally termed "fission products." Because of the nature of the fission process, many fission products are unstable and, hence, radioactive.
floodplain	The lowlands which adjoin inland and coastal waters and relatively flat areas and floodprone areas of offshore islands which are covered with water from a 1-percent or greater chance flood in any given year.
floodplain/wetlands assessment	An evaluation which consists of a description of a proposed action, a discussion of its effects on the floodplain/wetlands, and a consideration of alternatives.
flora	Plants.
fuel	Fissionable material used or useable to produce energy in a nuclear reactor. It may also refer to a mixture, such as natural uranium, in which only part of the atoms are readily fissionable.
gamma ray	[Symbol γ (gamma)] High-energy, short wavelength electromagnetic radiation. Gamma radiation frequently accompanies beta particle emissions. Gamma rays are very penetrating and are stopped most effectively by dense materials such as lead or uranium. They are essentially similar to x-rays but are usually more energetic and originate from the nucleus. Cobalt-60 is an example of a radionuclide that emits gamma rays.
geology	The study of the origin, history, materials, and structure of the earth.
geophysical survey	An examination of the condition, situation, or value of the earth using the physics of the earth including the fields of meteorology, hydrology, oceanography, seismology, volcanology, magnetism, radioactivity, and geology.

glaciation	The act of having been subjected to glaciers, extreme cold, and ice.
groundwater	Water that exists or flows beneath the earth's surface in the zone of saturation between saturated soil and rock.
half-life, biological	The time required for a biological system, such as an organ or tissue in an organism, to clear by natural (non-radioactive) processes, half the amount of a substance that has entered it.
half-life, radioactive	The time required for half of the atoms of a radioactive material to decay to another nuclear form.
hazardous wastes	Excess chemical material that is dangerous to human health.
health detriment	The sum of all fatal cancers, a fraction of the non-fatal cancers proportional to the severity of the cancer types, and all genetic defects.
health effect	The occurrence of a fatal cancer, a non-fatal cancer, or a genetic defect.
high-efficiency particulate filter	A ventilation system device that can separate a particle size of 0.3 micron from the air into a filter medium at an efficiency of at least 99.97 percent.
hydrology	The study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.
incident-free operations	Routine, day-to-day operations without accidents or other unexpected or unusual occurrences. Synonymous and interchangeable with normal operations.
ion	An atom or molecule which has acquired an electrical charge by gaining or losing electrons.
ionizing radiation	Any radiation which displaces electrons from atoms or molecules, thereby producing ions. Examples include alpha, beta, and gamma radiation. Exposure to ionizing radiation may produce skin or tissue damage.
irradiate	To expose to radiation.

GLOSSARY (Cont)

isotope	One of two or more nuclides which have the same number of protons but have different numbers of neutrons in their nuclei. Therefore, the isotopes of an element have the same atomic number but different atomic weights. Isotopes usually have very nearly the same chemical properties but somewhat different physical properties.
long-lived radioactivity	Radioactive nuclides which decay slowly, therefore having relatively long half-lives.
man-rem	A unit used to measure the radiation exposure to an entire group and to compare the effects of different amounts of radiation on groups of people. It is obtained by multiplying the average dose equivalent (measured in rems) to a given organ or tissue by the number of persons in the population of interest.
maximally exposed individual (MEI)	A theoretical individual who receives the highest radiation exposure from the facility or activity in question.
maximally exposed off-site individual (MOI)	A theoretical individual located at the point on the DOE site or shipyard boundary nearest to the facility or activity in question.
maximum individual	An individual who could consume items or occupy areas at rates which would be at a maximum for the population of interest.
maximum organ	The organ which receives or could receive the largest amount of exposure to radiation.
metric ton	[Abbreviation MT] A unit of mass which is equal to 1000 kilograms or approximately 2205 pounds.
microcurie	[Abbreviation μCi] A unit of activity which is equal to one-millionth (1×10^{-6}) of a curie.
mil	A unit of length which is equal to one-thousandth (1×10^{-3}) of an inch.
millicurie	[Abbreviation mCi] A unit of activity which is equal to one-thousandth (1×10^{-3}) of a curie.
millirem	[Abbreviation mrem] A special unit for measuring dose equivalents which is equal to one-thousandth (1×10^{-3}) of a rem.

GLOSSARY (Cont)

monitoring, environmental	The periodic or continuous determination of the amount of radioactivity or radioactive contamination present in a region.
natural background radiation exposure	The total amount of radiation from cosmic radiation emitted by the sun and the radiation emitted by natural minerals in the earth's crust. Typically, an average annual exposure of 100 mrem to the total body occurs from background radiation.
Naval Nuclear Propulsion Program	A joint program of the Department of Energy and the Department of the Navy which has as its objective the design and development of improved naval nuclear propulsion plants having high reliability, maximum simplicity, and optimum fuel life for installation in ships ranging in size from small submarines to large combatant surface ships. The program is frequently referred to as the Naval Reactors Program.
neutron	An uncharged particle with a mass slightly greater than that of a proton, found in the nucleus of every atom heavier than hydrogen. Neutrons sustain the fission chain reaction in a nuclear reactor.
nuclear disintegration	A spontaneous nuclear transformation which is characterized by the emission of particles and/or energy from the nucleus of an atom.
nuclear fuel	See fuel.
nuclear reactor	A device in which nuclear fission is initiated and controlled to produce heat which is then used to generate power.
nuclear reactor accident	An accident which results in release of fission products from the nuclear fuel.
nuclide	An atomic form of an element which is distinguished by its atomic number, atomic weight, and the energy state of its nucleus. These factors determine the other properties of the element, including its radioactivity.
organ	A group of tissues which together perform one or more definitive functions in a living body.
organism	Any living plant or animal.
overburden	Material overlying a deposit of useful geological materials.
particulate	Pertaining to a very small piece or part of a material.

pathway	The route or course along which radionuclides from defueled nuclear-powered ships could reach man.
percolate	To drain or seep through a material.
permeability	The quality or state of being able to diffuse or pass through a material.
pH	A measure of the relative acidity or alkalinity of a solution. A neutral solution has a pH of 7, acids have pH's less than 7, and bases have pH's greater than 7.
picocurie	[Abbreviation pCi] A unit of activity which is equal to one-trillionth (1×10^{-12}) of a curie.
prototype plants	Land-based naval nuclear reactor plants that are typical of a first design for a naval warship and are used to test equipment and the nuclear fuel prior to use on a shipboard nuclear plant. The prototype plants are also used to train naval officers and enlisted personnel as propulsion plant operators with extensive watchstanding experience and a thorough knowledge of all propulsion plant systems and their operating requirements.
radiation	The emission and propagation of energy through matter or space by means of electromagnetic disturbances which display both wave-like and particle-like behavior. In this context, the "particles" are known as photons. The term has been extended to include streams of fast-moving particles such as alpha and beta particles, free neutrons, and cosmic radiations. Nuclear radiation is that which is emitted from atomic nuclei in various nuclear reactions and includes alpha, beta, and gamma radiation and neutrons.
radiation field	A region where radiation is present.
radiation level	The measured amount of radiation in a region.
radiation survey	The evaluation of an area or object with instruments to detect, identify, and quantify radioactive materials and radiation fields which may be present.
radiation worker	A person specially trained and tested in basic information regarding radiation, its effects, and radiological control techniques and practices.

GLOSSARY (Cont)

radioactive contamination	The deposition of radioactive material in any place where it may harm persons, invalidate experiments, or make products or equipment unsuitable or unsafe for some specific use. The presence of unwanted radioactive matter.
radioactive decay	The process of spontaneous transformation of a radioactive nuclide to a different nuclide or different energy state of the same nuclide. Radioactive decay involves the emission of alpha particles, beta particles, or gamma rays from the nuclei of the atoms. If a radioactive nuclide is transformed to a stable nuclide, the process results in a decrease of the number of original radioactive atoms. Radioactive decay is also referred to as radioactive disintegration.
radioactive waste	Equipment and materials which are radioactive and for which there is no further use. Radioactive wastes are generally classified as high-level waste (those resulting from reprocessing reactor fuel or the used reactor fuel itself), as low-level waste, or as low-level waste containing transuranic elements or uranium-233.
radioactivity	The process of spontaneous decay or disintegration of an unstable nucleus of an atom; usually accompanied by the emission of ionizing radiation.
radioisotope	An unstable isotope of an element that decays or disintegrates spontaneously and emits radiation.
radiological consequences	The changes to the environment or the health of a person(s) as a result of the effects of radiation exposure or radioactive materials.
radionuclides	Atoms that exhibit radioactive properties. Standard practice for naming radionuclides is to use the name or atomic symbol of an element followed by its atomic weight (e.g., cobalt-60 or Co-60, a radionuclide of cobalt).
reactor vessel (or reactor pressure vessel)	A very strong, thick-walled steel structure which contains the nuclear fuel and cooling water under high pressure during reactor operations.
rem	A unit of measure used to indicate the amount of radiation exposure a person receives (an acronym for roentgen equivalent man).
risk	The product of the consequences of an event multiplied by the probability of that event.

GLOSSARY (Cont)

river stage	The level of the surface of a river in relation to some reference elevation.
sediment	Particles of organic or inorganic origin that accumulate in loose form.
seismicity	The quality or state of shaking or vibrating caused by an earthquake.
shipping container	A specially designed large, stainless steel or lead-lined, steel-shelled cask that is transported in the vertical position on a well-type or depressed center railcar. The container is certified by the Department of Energy and the Department of Transportation for the shipment of naval spent nuclear fuel.
short-lived radioactivity	Radioactive nuclides which decay rapidly, therefore having relatively short half-lives.
socioeconomics	The welfare of human beings as related to the production, distribution, and consumption of goods and services.
special nuclear material	Materials containing nuclides such as plutonium-239, uranium-233, or uranium enriched to a higher percentage than normal in the uranium-235 isotope.
specific activity	The ratio between the amount of radioactive isotope present and the total amount of all other isotopes of that same element, both radioactive and stable. It is usually expressed in microcuries of radioisotope per gram of total element.
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.
steam generator	The portion of the nuclear power plant where the heat from the primary system is transferred to the secondary system without physical contact between the water in the two systems.
survey meter	Any portable instrument which is used to detect radiation and is especially adapted for surveying or inspecting an area to establish the existence and amount of radioactive material present.
tectonic	Pertaining to or designating the rock structures which result from the deformation of the earth's crust.
threatened species	Any species or subspecies which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

topography	The detailed physical description of the surface of a region, including the relative elevations of features. The graphical representation of the physical configuration of a region on a map.
toxic	Relating to or caused by a toxin which is a poisonous substance that is a specific product of the metabolic activities of a living organism and is usually very unstable when introduced into human tissues.
tritium	A radioactive isotope of hydrogen with atoms that are three times the mass of ordinary light hydrogen atoms. Tritium is present in the reactor coolant as the result of neutron interaction with naturally occurring deuterium present in the water.
uranium	[Symbol U] A natural radioactive element with the atomic number 92 and, as found in natural ores, an average weight of approximately 238. The two principal natural isotopes are uranium-235 (0.7 percent of natural uranium) and uranium-238 (99.3 percent of natural uranium). Natural uranium also includes a minute amount of uranium-234.
vadose zone	The unsaturated region of soil located between the ground surface and water table.
water pools	Deep pools of water that are used to inspect and hold spent nuclear fuel modules. Storage racks are located below the water surface to support and position the fuel modules in place for handling and to prevent the formation of a critical mass.
water table	The upper surface boundary of an uncontrolled aquifer, below which groundwater occurs. It is usually defined by the levels at which water stands in wells that barely penetrate the aquifer.
watershed	The region which drains into a river, river system, or body of water.
wetlands	Those areas which are covered by water with a frequency sufficient to support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflow, mudflats, and natural ponds.

x-rays	Penetrating electromagnetic radiations with wavelengths shorter than those of visible light. They are usually produced (as in medical diagnostic x-ray machines) by irradiating a metallic target with large numbers of high-energy electrons. In nuclear reactions, it is customary to refer to photons originating outside the nucleus as x-rays and those originating in the nucleus as gamma rays, even though they are the same.

ABBREVIATIONS AND ACRONYMS

AEA	Atomic Energy Act
AEC	Atomic Energy Commission
ANL-E	Argonne National Laboratory - East
ANL-W	Argonne National Laboratory - West
ATR	Advanced Test Reactor
Btu	British thermal unit
BWR	boiling water reactor
CAA	Clean Air Act
CDE	committed dose equivalent
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	central facilities area
CFR	Code of Federal Regulations
cfs	cubic feet per second
Ci	curies
cms	cubic meters per second
CNS	Charleston Naval Shipyard
CWRM	Commission on Water and Resource Management
DEP	Department of Environmental Protection
DOD	Department of Defense
DOE	Department of Energy
EB	Electric Boat Division of General Dynamics
ECF	Expended Core Facility
EDE	effective dose equivalent
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ERPG	Emergency Response Planning Guideline
FAA	Federal Aviation Administration
FMEF	Fuels and Materials Examination Facility

ABBREVIATIONS AND ACRONYMS (Cont)

FWPCA	Federal Water Pollution Control Act
HEPA	high-efficiency particulate air
ICPP	Idaho Chemical Processing Plant
ICRP	International Commission on Radiological Protection
IDLH	immediately dangerous to life and health
INEL	Idaho National Engineering Laboratory
INEL-ECF	Idaho National Engineering Laboratory Expended Core Facility
INGL	Ingalls Shipbuilding
KAPL	Knolls Atomic Power Laboratory
KSO	Kesselring Site Operation
kv	kilovolts
kw	kilowatts
kwh	kilowatt hours
LET	linear energy transfer
MCW	maximally exposed collocated worker
MEI	maximally (or maximum) exposed individual
mg	milligram
mgd	million gallons of water per day
MINS	Mare Island Naval Shipyard
MMI	Modified Mercalli Index
MOI	maximally exposed off-site individual
mph	miles per hour
MVA	megavolt amperes
MW	megawatts
MWh	megawatt hours
NAAQS	National Ambient Air Quality Standards
NEA	Nuclear Energy Agency
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NNPP	Naval Nuclear Propulsion Program

ABBREVIATIONS AND ACRONYMS (Cont)

NNS	Newport News Shipbuilding
NOAA	National Oceanic and Atmospheric Administration
NOR	Norfolk Naval Shipyard
NPA	nearest public access
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NRF	Naval Reactors Facility
NTS	Nevada Test Site
NYSDEC	New York State Department of Environmental Conservation
OECD	Organization for Economic Co-operation and Development
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PAH	polycyclic (or polynuclear) aromatic hydrocarbons
PCB	polychlorinated biphenyl
pCi	picocuries
PHNS	Pearl Harbor Naval Shipyard
PHWMA	Pearl Harbor Water Management Area
PNS	Portsmouth Naval Shipyard
PSNS	Puget Sound Naval Shipyard
PWR	pressurized water reactor
RCRA	Resource Conservation and Recovery Act
RWMC	Radioactive Waste Management Complex
SAPS	Shippingport Atomic Power Station
SARA	Superfund Amendments and Reauthorization Act
SNF	spent nuclear fuel
SRS	Savannah River Site
SRS-ECF	Savannah River Site Expended Core Facility
TEDE	total effective dose equivalent
TI	transport index

ABBREVIATIONS AND ACRONYMS (Cont)

TLV-TWA	threshold limit value, time-weighted average
TRA	test reactor area
USFWS	United States Fish and Wildlife Service
VOC	volatile organic compound
WIPP	waste isolation pilot plant
WSO	Windsor Site Operation

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April 1995

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

DOE/EIS-0203-F

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Environmental Justice

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L-1 INTRODUCTION

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. In addition to describing environmental justice goals, Executive Order 12898 directs the Administrator of the Environmental Protection Agency to convene an interagency Federal Working Group on Environmental Justice (referred to below as the Working Group). The Working Group is directed to provide guidance to Federal agencies on criteria for identifying disproportionately high and adverse human health or environmental effects on minority populations and low-income populations. The Working Group is also directed to coordinate with each Federal agency to develop an environmental justice strategy, if a strategy is required by the proposed activities. At the time of this analysis, the Working Group had not issued final guidance on the approach to be used in analyzing environmental justice, as directed by the Executive Order. The Working Group has issued draft definitions of terms in the Draft Guidance for Federal Agencies on Terms in Executive Order 12898, dated November 28, 1994. These definitions, with slight modifications, were used in the following analysis. Further, in coordination with the Working Group, DOE is developing internal guidance for the implementation of the Executive Order, which has not yet been adopted. Because both DOE and the Working Group are still in the process of developing guidance, the approach used in this analysis might depart somewhat from whatever guidance is eventually issued.

This section 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. It is divided into two sections: (a) the five sites considered for the management of DOE naval SNF only (under the No Action and Decentralization alternatives, and (b) the five DOE sites being considered for the management of all types of DOE SNF under all alternatives. The five sites considered for the management of naval SNF only are the Norfolk Naval Shipyard, Portsmouth, Virginia; Portsmouth Naval Shipyard, Kittery, Maine; Pearl Harbor Naval Shipyard, Honolulu, Hawaii; Puget Sound Naval Shipyard, Bremerton, Washington; and Kesselring Site, West Milton, New York. The five DOE sites considered for the management of some portion or all DOE SNF are the Savannah River Site, Aiken, South Carolina; Oak Ridge Reservation, Oak Ridge, Tennessee; Idaho National Engineering Laboratory, Idaho Falls, Idaho; Hanford Site, Richland, Washington; and Nevada Test Site, Mercury, Nevada.

This assessment includes potential adverse impacts resulting from both onsite activities and associated transportation of materials. Based on this assessment, it is concluded that none of the alternatives analyzed results in disproportionately high and adverse effects on minority populations or low-income communities surrounding any of the sites under consideration for the management of SNF or associated offsite transportation routes.

L-2 PUBLIC COMMENT RECEIVED ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

Public comment received on the Draft EIS is addressed in Volume 3, "Response to Public Comment," of this Final EIS. Overall comment indicated a widespread concern about past and present DOE activities on human health and the environment. A small number of comments were received related to environmental justice; these indicated the need for an expanded analysis in the Final EIS, which was previously committed to in the Draft EIS. The most specific comments were received from the U.S. Environmental Protection Agency's Office of Enforcement and Compliance Assurance and the Shoshone-Bannock Tribes on the Fort Hall Indian Reservation. Environmental justice comments pertaining to Volume 1 of this EIS were in essence:

- Although the Draft EIS includes discussions on socioeconomic impacts, it does not state whether the alternatives would affect minority communities and low-income communities (Sanderson 1994).

- The DOE should pay particular attention to any environmental impacts that may affect the Cattaraugus Reservation of the Seneca Nation of Indians, located downstream on Cattaraugus Creek from the DOE's West Valley Site in New York State. Tribal residents engage in subsistence fishing on the river and should be given a full opportunity to participate in the National Environmental Protection Agency process (Sanderson 1994).

- The DOE must meet the requirements of Executive Order 12898 on environmental justice and fully consider the comments of the Shoshone-Bannock Tribes on the Draft EIS and consider the impacts of its proposed actions on the Tribes, the Fort Hall Indian Reservation, and on other disadvantaged populations living in proximity to the Idaho National Engineering Laboratory. It was stated that the Indian Tribes are not just another "minority population," but are governments that have a special relationship to the Federal Government and its agencies and have certain authorities to regulate others including the United States Government (Tinno 1994, Wolfley 1994).

Pertinent public comments on the topic of environmental justice have been considered in this assessment, which has been expanded over the discussions in the Draft EIS. Consultations have taken place with the Shoshone-Bannock Tribes on the Fort Hall Indian Reservation and the Seneca Nation of Indians on the Cattaraugus Reservation. As a result of consultations with the Seneca Nation of Indians, DOE and the Navy have received a request by this tribe for notification of impending SNF shipments across the Cattaraugus Reservation. Consultations with the Shoshone-Bannock Tribes on the Fort Hall Indian Reservation are specifically addressed in Section 5.20, Volume 2 of this EIS.

L-3 COMMUNITY CHARACTERISTICS

Demographic information obtained from the U.S. Bureau of Census was used to identify minority populations and low-income communities in the zone of potential impact surrounding each of the sites under consideration. This zone is within a circle that has an 80-kilometer (50-mile) radius. This 80-kilometer (50-mile) radius was selected because it was judged to encompass all of the impacts that may occur. This radius also is based on air impact modeling and socioeconomic impact analysis used throughout this EIS. Transportation impacts are assessed within 800 meters (0.5 miles) of transportation routes for incident-free transportation because impacts beyond this distance are negligible. For transportation accidents, an 80-kilometer (50-mile) radius was used.

L-3.1 Methodology

Demographic maps were prepared using 1990 census data available from the U.S. Bureau of the Census. Figures L-1 through L-10 and Figures L-11 through L-20 illustrate census tract distributions for both minority populations and low-income populations for areas surrounding the five naval SNF-specific and five DOE sites being considered for the management of all or some portion of all DOE SNF respectively. These maps are based on an analysis of 1990 United States Bureau of the Census Tiger Line files, which contain political boundaries and geographical features, and Summary Tape Files 3A (as processed by the U.S. Environmental Protection Agency), which contain demographic information (USBC 1992). Data were resolved to the census tract (see definition in Section 3.2) group level.

An 80-kilometer (50-mile) radius circle appears on each map, defining a zone of potential impact. As discussed above, this zone of potential impact for low-income and minority communities is the same as that used for analysis performed in the EIS. The circle has been indexed to the center location of hypothetical or existing major SNF management facilities at each site or a conservative location to identify the maximum number of minority populations and low-income populations.

L-3.2 Definitions

Definitions used to develop community characteristics are as follows:

Census tract: An area defined for the purpose of monitoring census data that is usually comprised of between 2,500 and 8,000 persons, with 4000 persons being ideal. When first delineated, census tracts are designed to be homogenous with respect to population characteristics, economic status, and living conditions. Census tracts do not cross county boundaries. The spatial size of census tracts varies widely depending on the density of settlement. Census tract boundaries are delineated with the intention of being maintained over a long period of time so that statistical comparisons can be made from census to census.

Minority population: A group of people and/or community experiencing common conditions of exposure or impact that consists of persons of the United States classified by the U. S. Bureau of the Census as Negro/Black/African-American, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, and other nonwhite persons, based on self-classification by the people according to the race with which they most closely identify. For the purposes of analysis, minority populations are defined as those census tracts within the zone of impact for which the percent minority population exceeds the average of all census tracts within the zone of impact or where the percent minority population exceeds 50 percent of the spacial area for any given census tract. In the case of migrant or dispersed populations, a minority population consists of a group that is greater than 50 percent minority.

Low-income population: A group of people and/or community experiencing common conditions of exposure or impact in which 25 percent or more of the population is characterized as living in poverty (FR 1993) The U.S. Bureau of Census characterizes persons in poverty as those whose income is less than a "statistical poverty threshold." Table L-1 presents the U.S. Census poverty thresholds (USBC 1992) used in this analysis. This threshold is a weighted average based on family size and the age of the persons in the family. For instance, the 1990 census threshold for a family of four was a 1989 income of $12,674 .

Population Base: For the purpose of this analysis, census tracts were included in the analysis if 50 percent of the tract fell within the 80-kilometer (50-mile) radius.

Table L-1. Poverty thresholds in 1989 by size of family and number of related children under 18 years.

Size of family unit	Weighted average threshold ($)	Related children under 18 years: None ($)	One ($)	Two ($)	Three ($)	Four ($)	Five ($)	Six ($)	Seven ($)	Eight or more ($)
One person (unrelated individual)	6,310									
Under 65 years	6,451	6,451								
65 years and over	5,947	5,947								
Two persons	8,076									
Household under 65 years	8,343	8,303	8,547							
Household 65 years and over	7,501	7,495	8,515							
Three persons	9,885	9,699	9,981	9,990						
Four persons	12,674	12,790	12,999	12,575	12,619					
Five persons	14,990	15,424	15,648	15,169	14,796	14,572				
Six persons	16,921	17,740	17,811	17,444	17,092	16,569	16,259			
Seven persons	19,162	20,412	20,540	20,101	19,794	19,224	18,5 58	17,828		
Eight persons	21,328	22,830	23,031	22,617	22,253	21,738	21,084	20,403	20,230	
Nine or more persons	25,480	27,463	27,596	27,229	26,921	26,415	25,719	25,089	24,933	23,973

L-3.3 Distribution of Minority Populations Near Candidate Sites

The minority population characteristics within the 80-kilometer (50-mile) radius of candidate sites for the SNF and INEL EIS are presented in Tables L-2 and L-3. Table L-2 lists the number of minority individuals residing near the candidate sites for the management of DOE naval SNF. Table L-3 lists the number of minority individuals residing near the candidate sites for the management of all or some portion of DOE SNF.

The racial and ethnic composition of the minority population residing near the candidate naval sites is predominantly African-American, with the exception of Pearl Harbor where the main ethnic population is Asian and Native Hawaiian.

The racial and ethnic composition of the minority population residing near the candidate sites for the management of all or some portion of DOE SNF is predominantly African-American at the Oak Ridge Reservation and Savannah River Site; Hispanic, American Indian, and Asian at the Idaho National Engineering Laboratory; Hispanic and American Indian at the Hanford Site; and Hispanic and African-American at the Nevada Test Site.

Table L-2. Minority individuals residing near the candidate sites for the management of DOE naval spent nuclear fuel only per the 1990 census.

Candidate Site	Number of census tracts considered	Number of individuals residing within 80 km of site	Number of minority individuals within 80 km of site	Percent of individuals that are minority	See figure
Kesselring Site	304	1,148,924	65,590	6	L-1
Norfolk Naval Shipyard	386	1,631,671	534,585	33	L-2
Puget Sound Naval Shipyard	643	2,960,229	379,461	13	L-3
Portsmouth Naval Shipyard	522	2,412,691	121,516	5	L-4
Pearl Harbor Naval Shipyard	200	836,465	571,482	68	L-5

Table L-3. Minority individuals residing near the candidate sites for the management of all or some portion of DOE spent nuclear fuel per the 1990 census.

Candidate Site	Number of census tracts considered	Number of individuals residing within 80 km of site	Number of minority individuals within 80 km of site	Percent of individuals that are minority	See figure
Savannah River Site	147	619,959	233,955	38	L-6
Oak Ridge Reservation	211	867,231	49,742	6	L-7
Idaho National Engineering Laboratory	37	172,366	11,722	7	L-8
Hanford Site	79	370,807	75,381	20	L-9
Nevada Test Site	4	11,918	759	6	L-10

The spatial distribution by census tract of the minority population within 80 kilometers (50 miles) of each candidate site is shown in Figures L-1 through L-10. As indicated in the legend of each figure, census tracts have been shaded according to the percentage of minority individuals within the area. It should be noted that Bureau of Census tracts often extend into oceans, bays, and lakes to allow for the inclusion of individuals who reside on boats or offshore houses. This is especially noticeable in locations considered only for the management of DOE naval SNF, with the exception of the inland Kesselring Site. Census tract lines have been removed from Puget Sound proper in Figures L-3 and L-13 to improve clarity.

L-3.4 Distribution of Low-Income Individuals Near the Candidate Sites

The low-income population characteristics within the 80-kilometer (50-mile) radius of candidate sites for the SNF and Idaho National Engineering Laboratory EIS are presented in Tables L-4 and L-5. Table L-4 lists the number of low-income individuals residing near the candidate sites

Table L-4. Low-income individuals residing near the candidate sites for the management of naval spent nuclear fuel only per the 1990 census.

Candidate site	Number of census tracts considered	Number of individuals within 80 km of site	Number of low-income individuals within 80 km of site	Percent of individuals that are low-income	See figure
Kesselring Site	304	1,148,924	101,424	9	L-11
Norfolk Naval Shipyard	386	1,631,671	179,336	11	L-12
Puget Sound Naval Shipyard	643	2,960,229	250,452	8	L-13
Portsmouth Naval Shipyard	522	2,412,691	175,830	7	L-14
Pearl Harbor Naval Shipyard	200	836,465	60,093	7	L-15

Table L-5. Low-income individuals residing near the candidate sites for the management of all or some portion of DOE spent nuclear fuel per the 1990 census.

Candidate site	Number of census tracts considered	Number of individuals within 80 km of site	Number of low-income individuals within 80 km of site	Percent of individuals that are low-income	See figure
Savannah River Site	147	619,959	107,764	17	L-16
Oak Ridge Reservation	211	867,231	134,661	16	L-17
Idaho National Engineering Laboratory	37	172,366	23,416	14	L-18
Hanford Site	79	370,807	65,584	18	L-19
Nevada Test Site	4	11,918	1,474	12	L-20

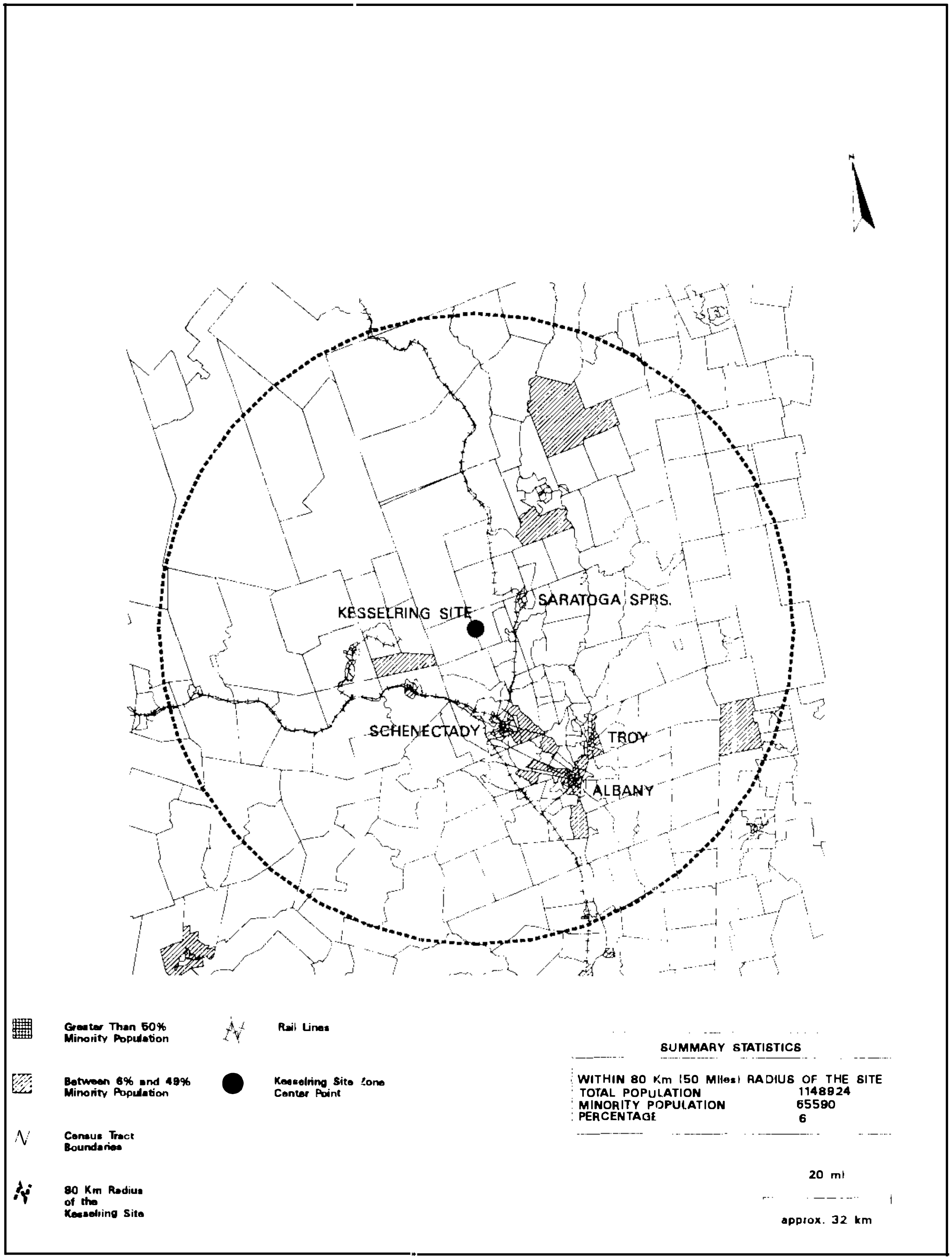

Figure L-1. Minority population distribution within 80 kilometers (50 miles) of the Kesselring Site.

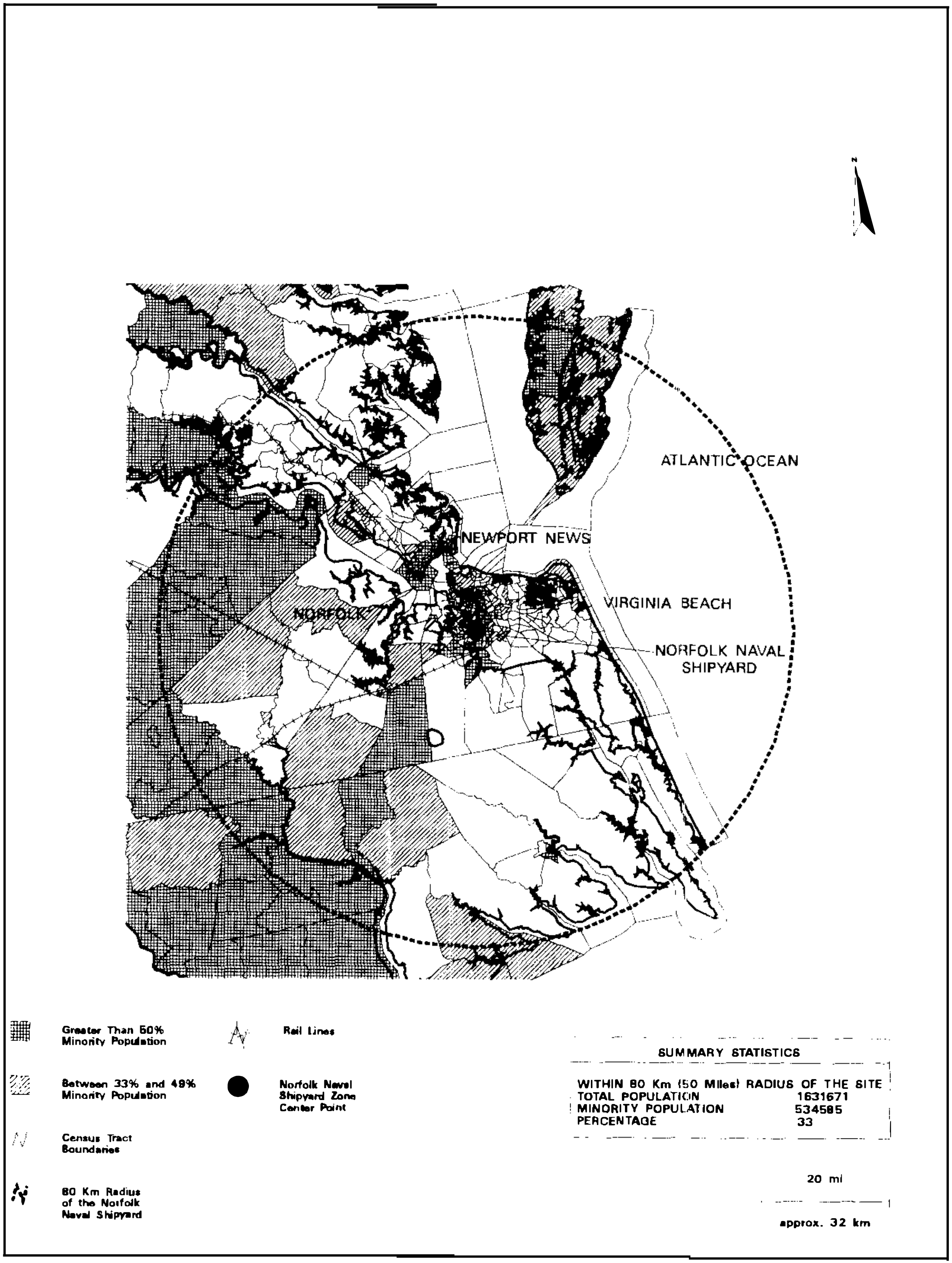

Figure L-2. Minority population distribution within 80 kilometers (50 miles) of the Norfolk Naval Shipyard.

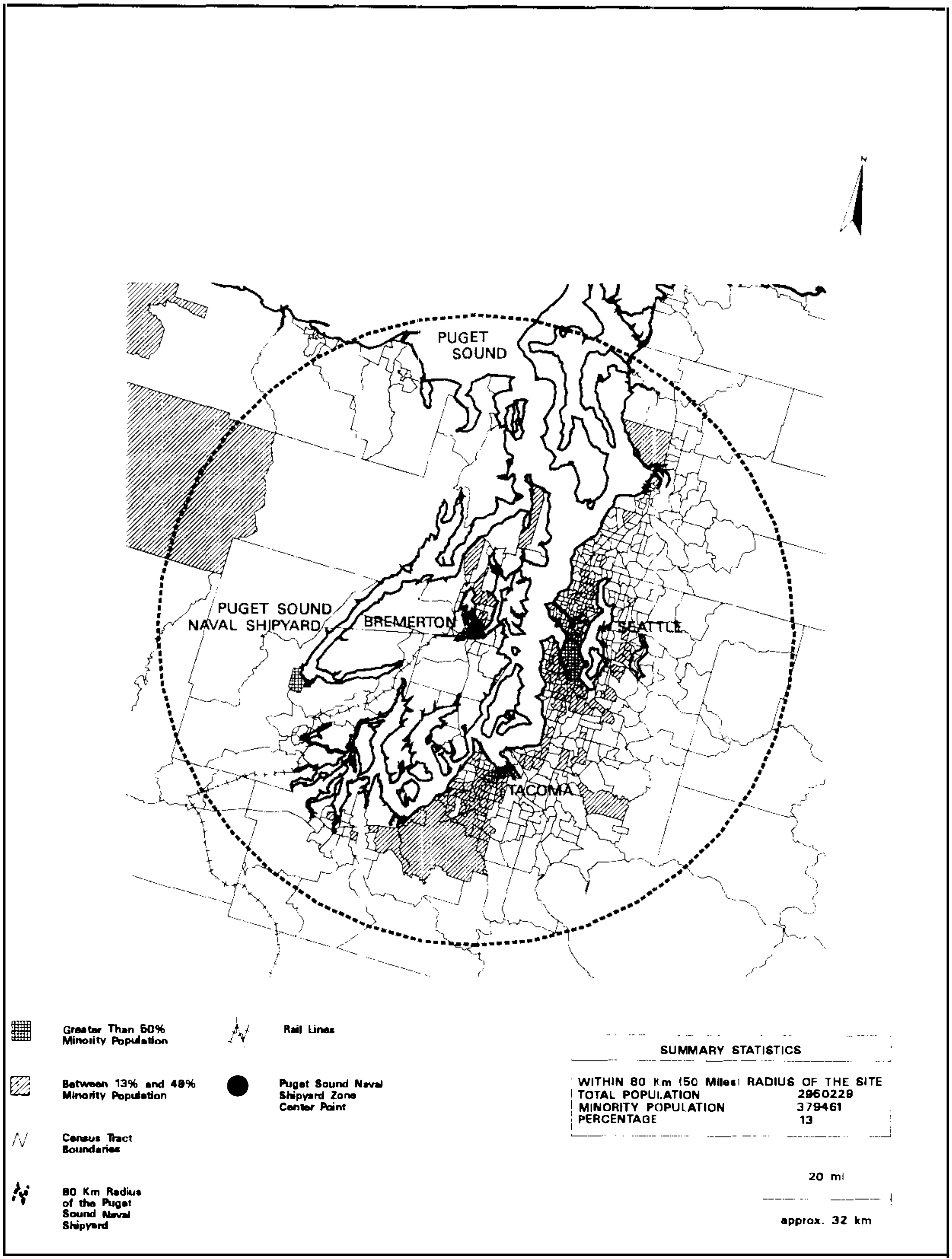

Figure L-3. Minority population distribution within 80 kilometers (50 miles) of the Puget Sound Naval Shipyard.

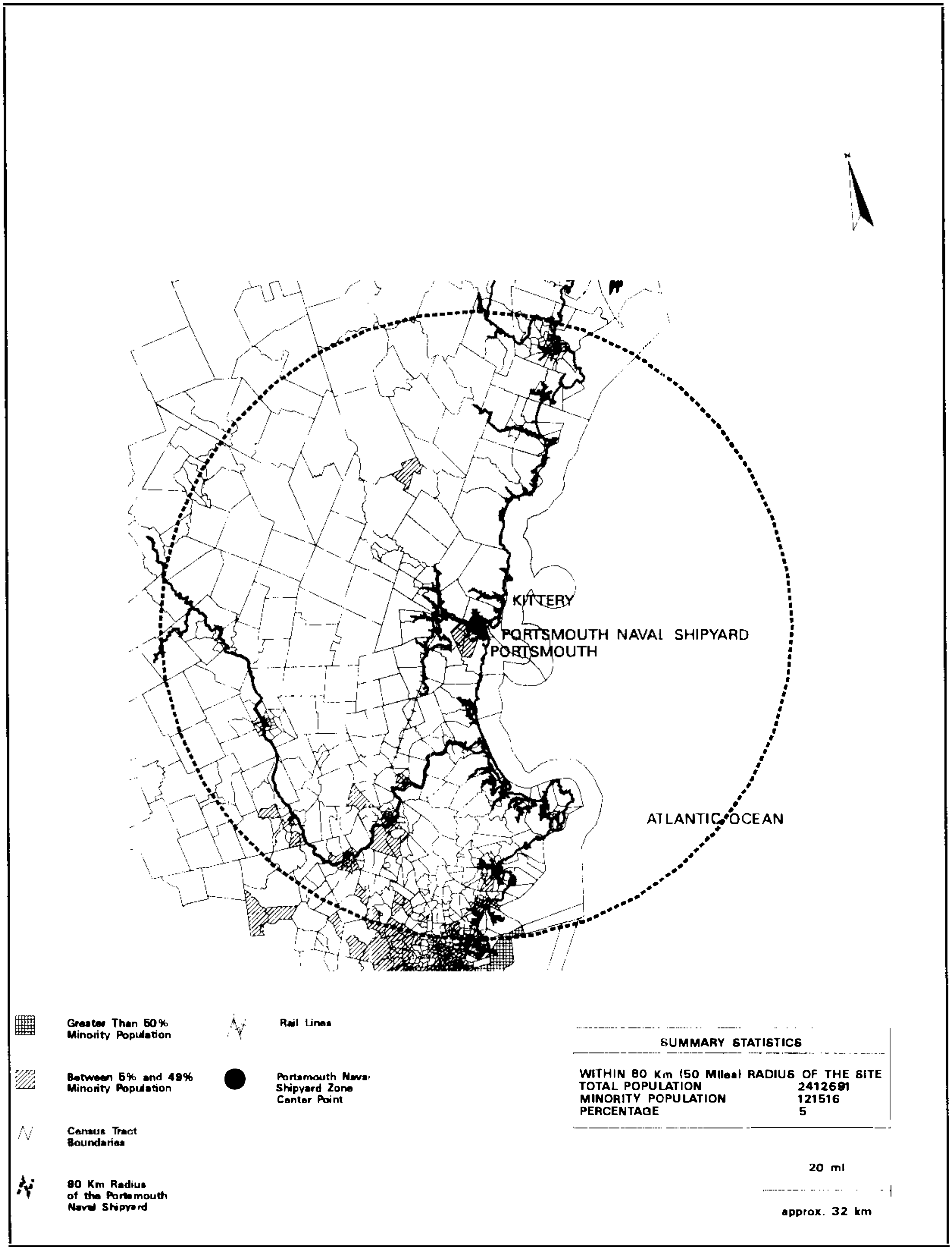

Figure L-4. Minority population distribution with 80 kilometers (50 miles) of the Portsmouth Naval Shipyard.

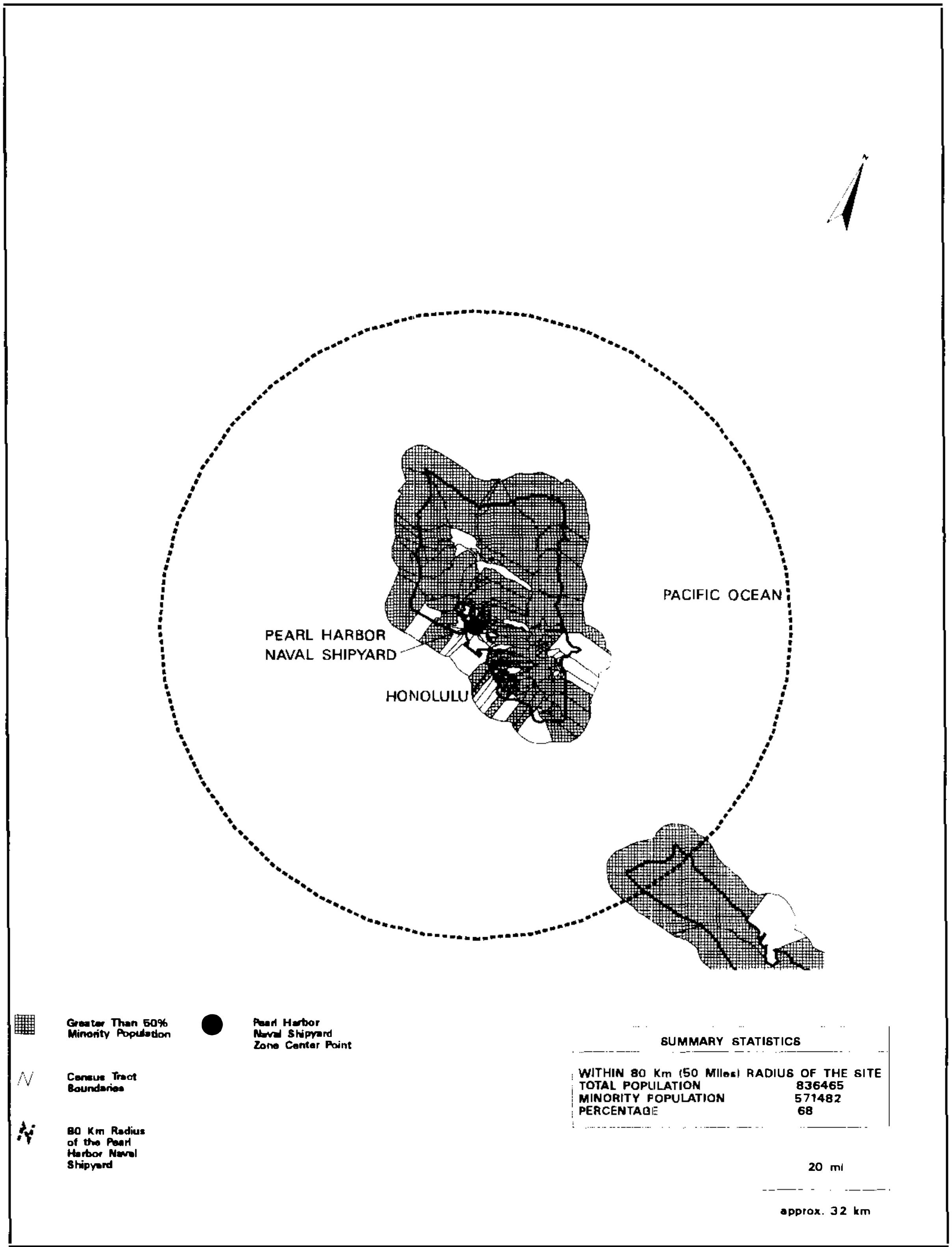

Figure L-5. Minority population distribution within 80 kilometers (50 miles) of the Pearl Harbor Naval Shipyard.

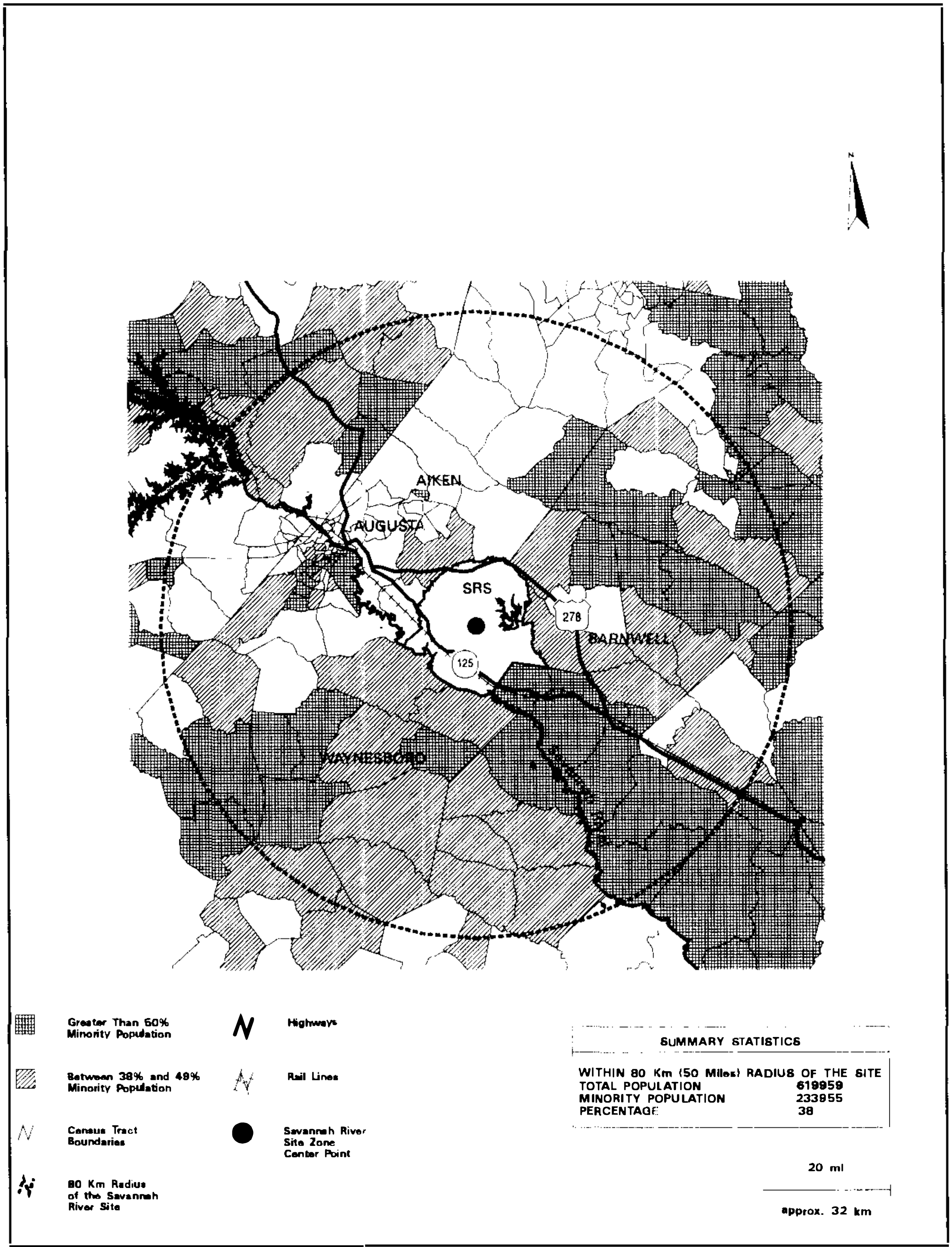

Figure L-6. Minority population distribution within 80 kilometers (50 miles) of the Savannah River Site.

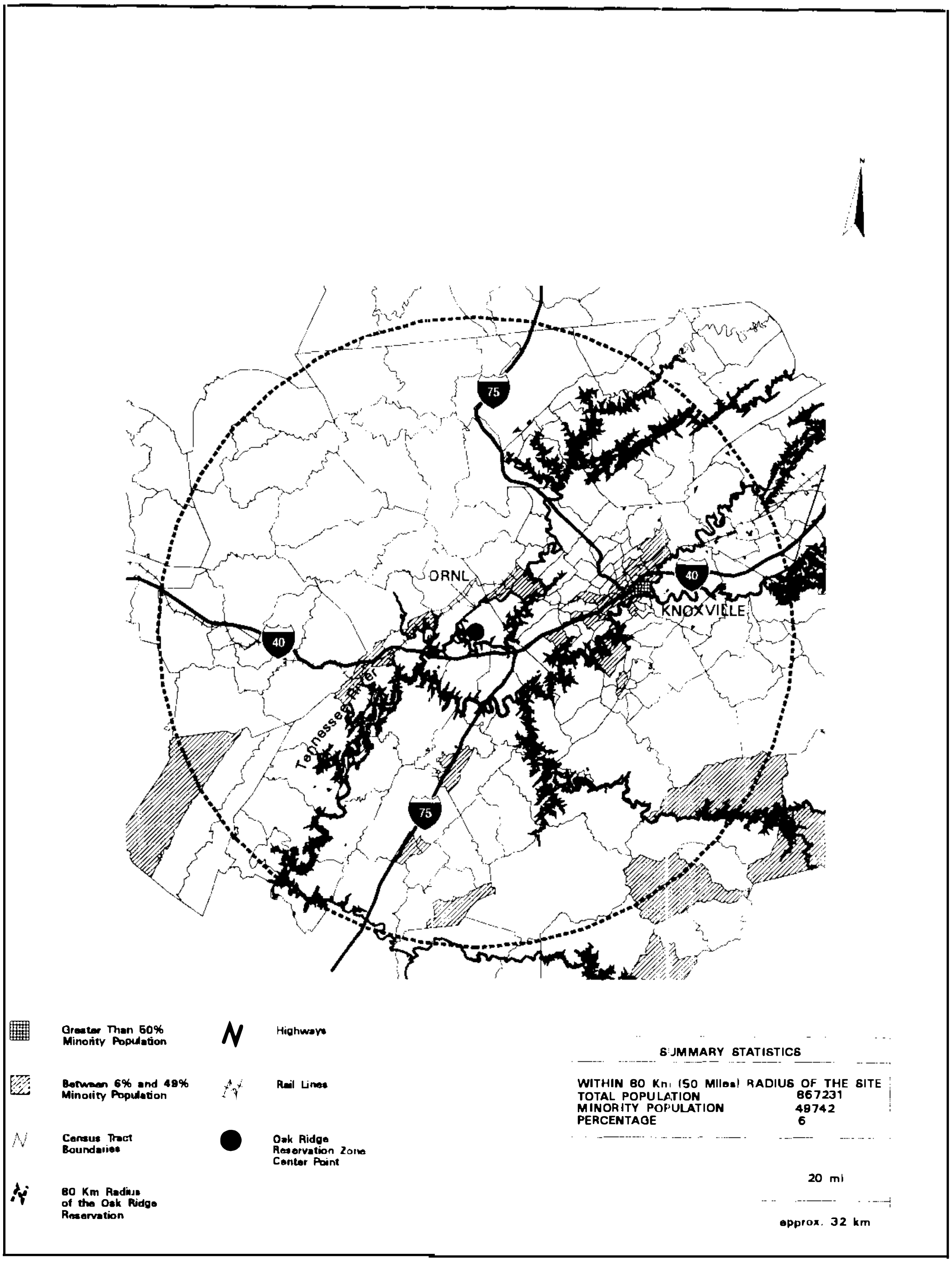

Figure L-7. Minority population distribution within 80 kilometers (50 miles) of the Oak Ridge Reservation.

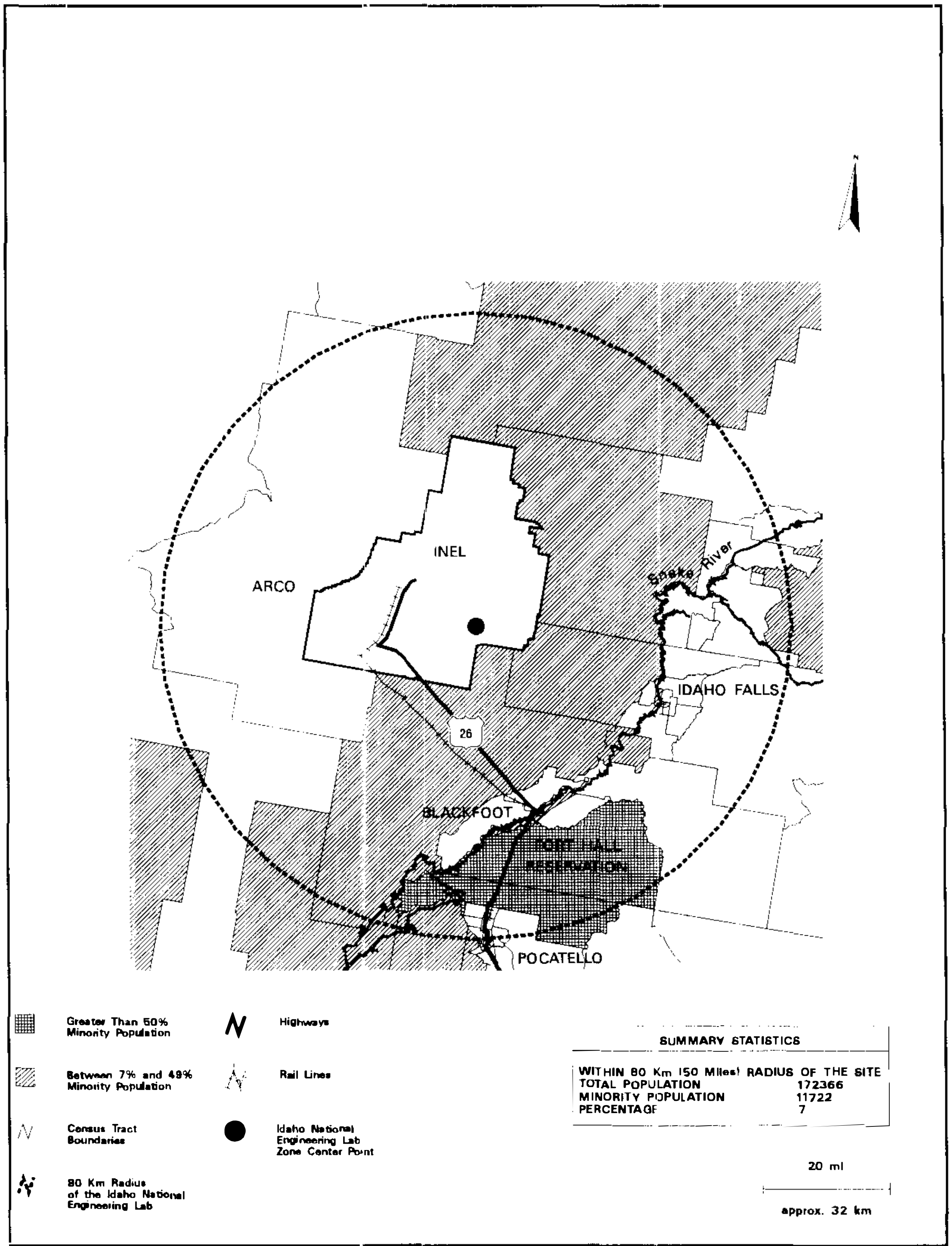

Figure L-8. Minority population distribution within 80 kilometers (50 miles) of the Idaho National Engineering Laboratory.

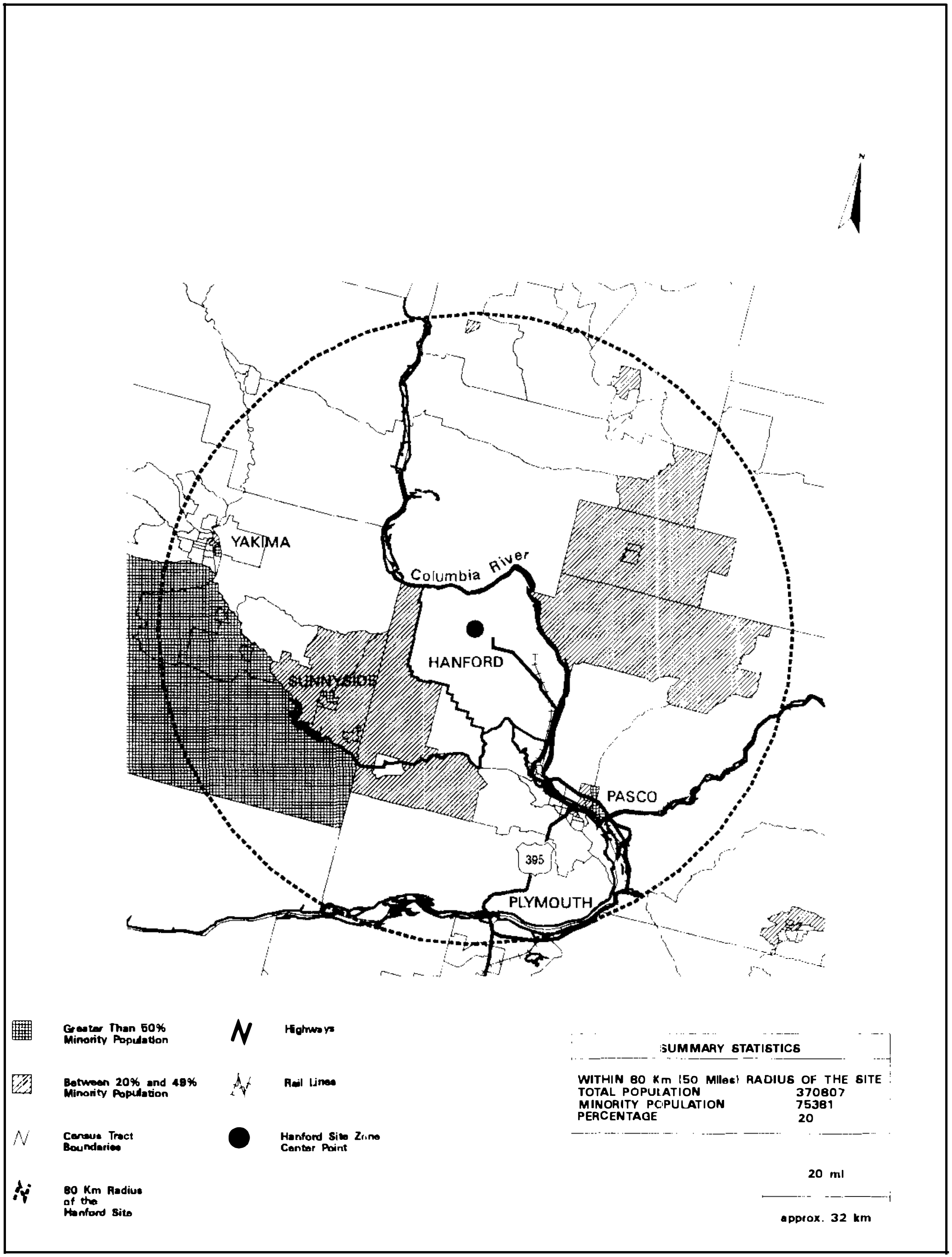

Figure L-9. Minority population distribution within 80 kilometers (50 miles) of the Hanford Site.

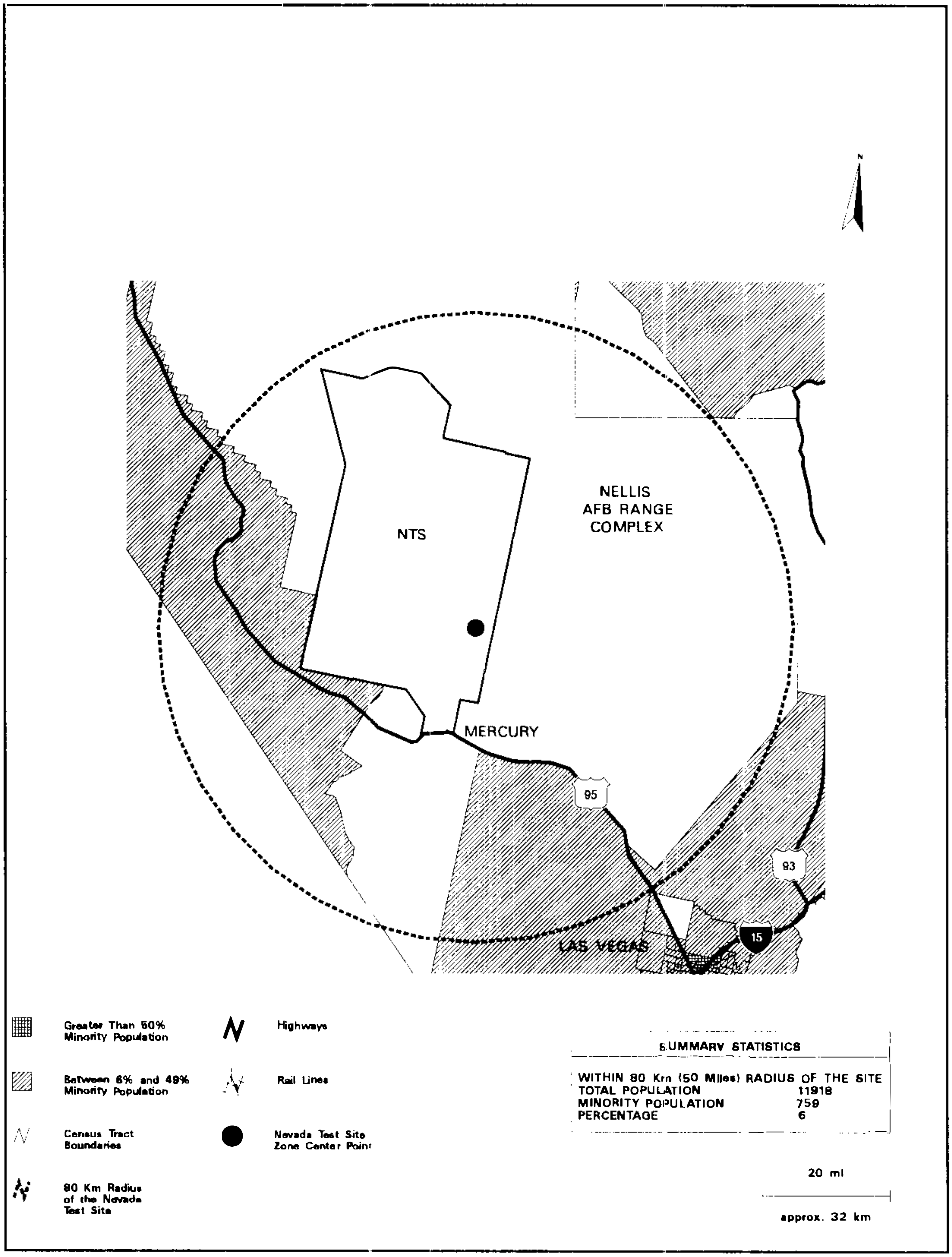

Figure L-10. Minority population distribution within 80 kilometers (50 miles) of the Nevada Test

Site.for the management of naval SNF. Table L-5 lists the number of low-income individuals residing near the candidate sites for the management of all or some portion of DOE SNF.

The spatial distribution by census tract of low-income individuals residing within 80-kilometers (50 miles) of each candidate site are shown in Figures L-11 to L-20. As indicated in the legend of each figure, census tracts have been shaded according to the percentage of low-income population within the area.

L-3.5 Limitations of Demographic Data

As discussed in Section 5.8 of Volume 1 of this EIS, characterization of minority and low-income populations residing within a geographical area is sensitive to the basic definitions and assumptions used in conducting the analysis to identify them. Both the Interagency Working Group and DOE are in the process of preparing final guidelines for use in the evaluation of environmental justice. In the absence of final guidance, the definitions and approaches being used by and within Federal agencies could vary. For example, this EIS and the Draft Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor SNF (Draft FRR SNF EIS) present demographic characterizations obtained from the same U.S. Census Bureau database, but use different definitions and assumptions.

The differences in the definitions and assumptions between this EIS and the Draft FRR SNF EIS are as follows:

1. Although both these EISs use the same 1990 U.S. Census Bureau database, this EIS uses data aggregated at the census tract level (2,500 to 8,000 persons), while the Draft FRR SNF EIS uses data aggregated at the block group level (250 to 550 housing units).

2. In some cases, census blocks or tracts lie partly within the area being analyzed; that is, within the 80-kilometer (50-mile) radius around a potential SNF management site. Because the exact distribution of the populations within such blocks or tracts is not available, the data are insufficient to allow a precise count. To address this situation, this EIS includes a low-income or minority population in its analyses if 50 percent or more of the tract falls within an 80 kilometer (50 mile) radius around the site being considered. In similar situations, the Draft FRR SNF EIS assumes that the general population and the minority population are distributed uniformly throughout a block group, and includes the fraction of the low-income or minority population that corresponds to the fraction of the census block group area that falls within the 80-kilometer (50-mile) radius.

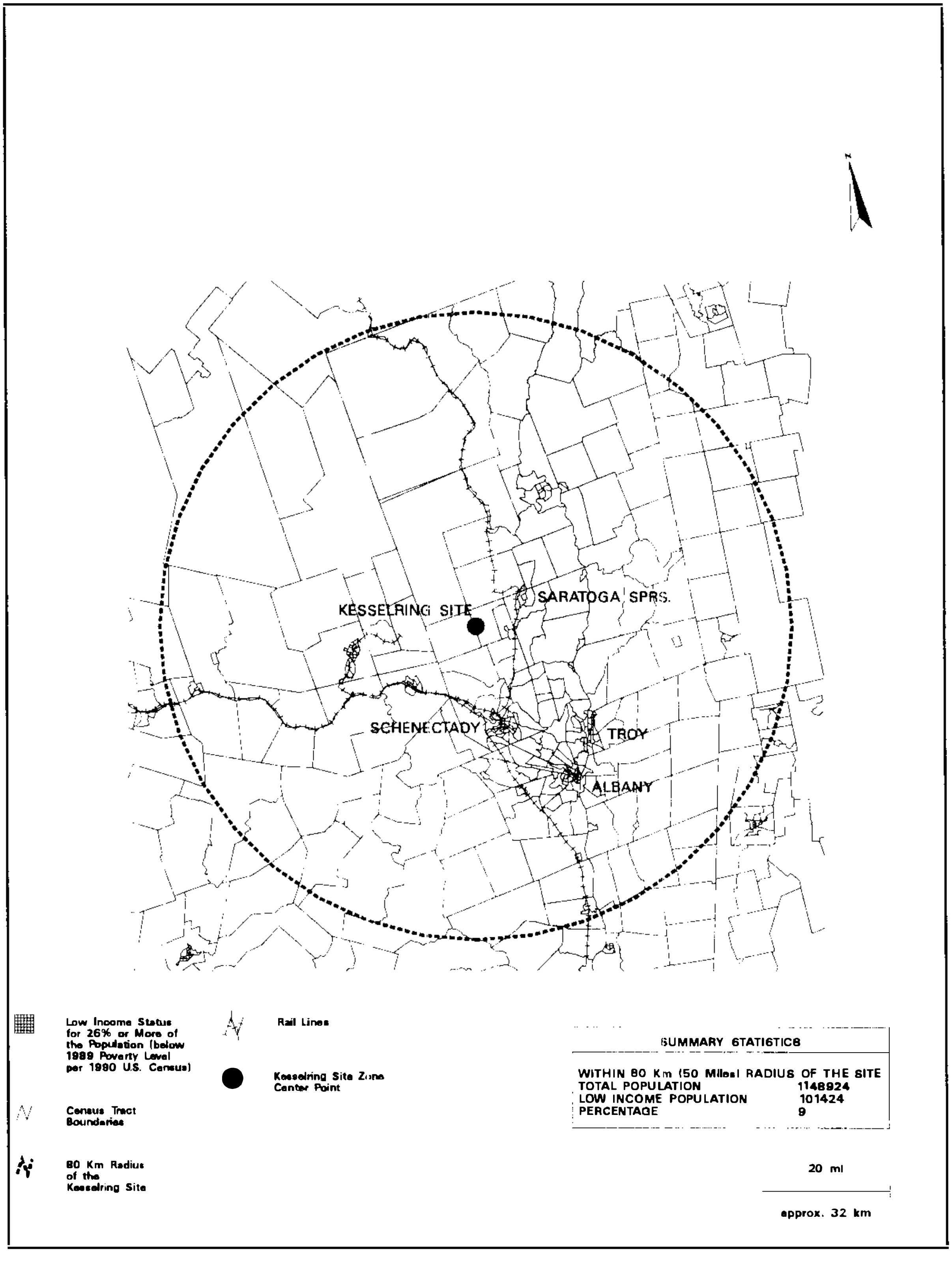

Figure L-11. Low-income population distribution witbin 80 kilometers (50 miles) of the Kesselring Site.

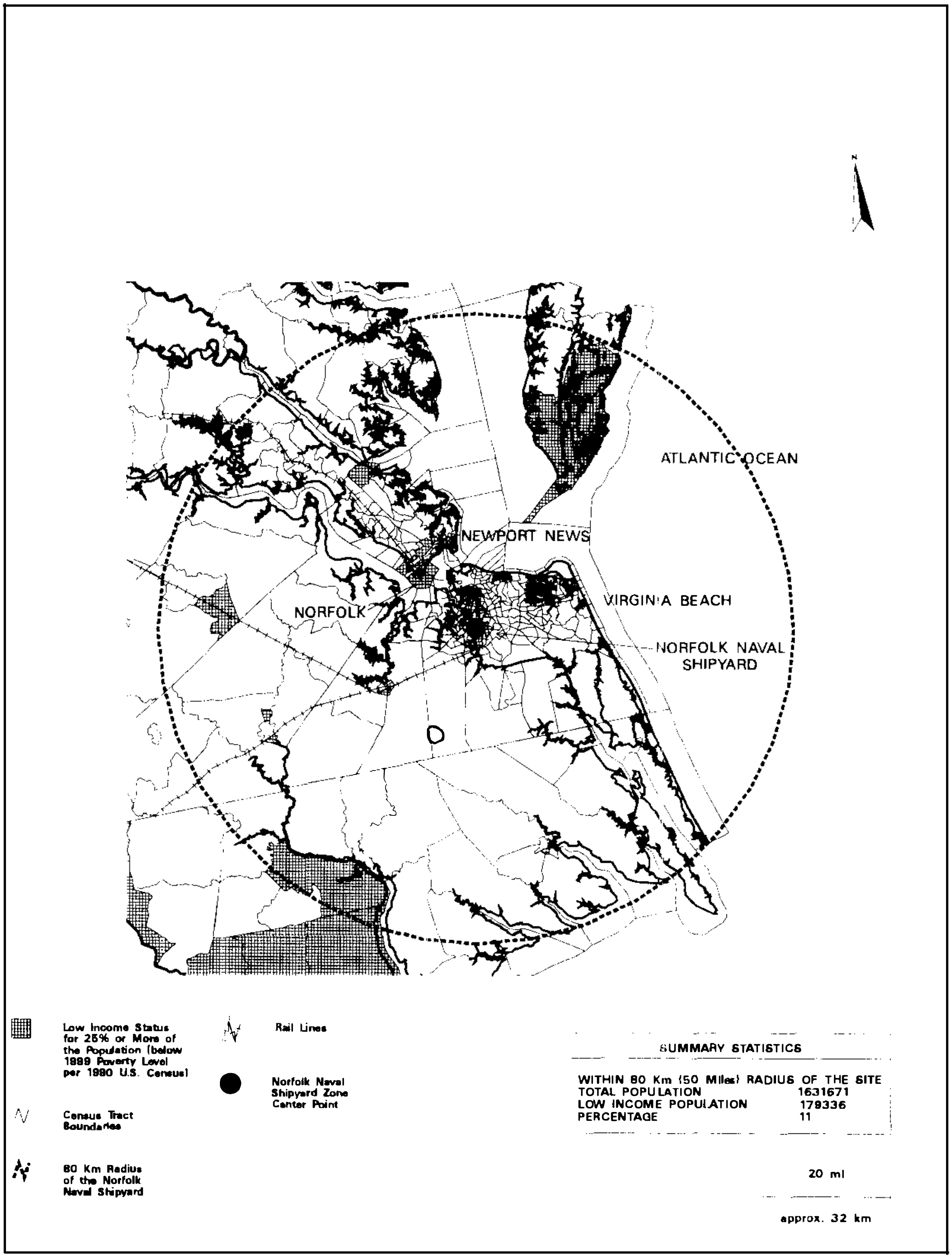

Figure L-12. Low-income population distribution within 80 kilometers (50 miles) of the Norfolk Naval Shipyard.

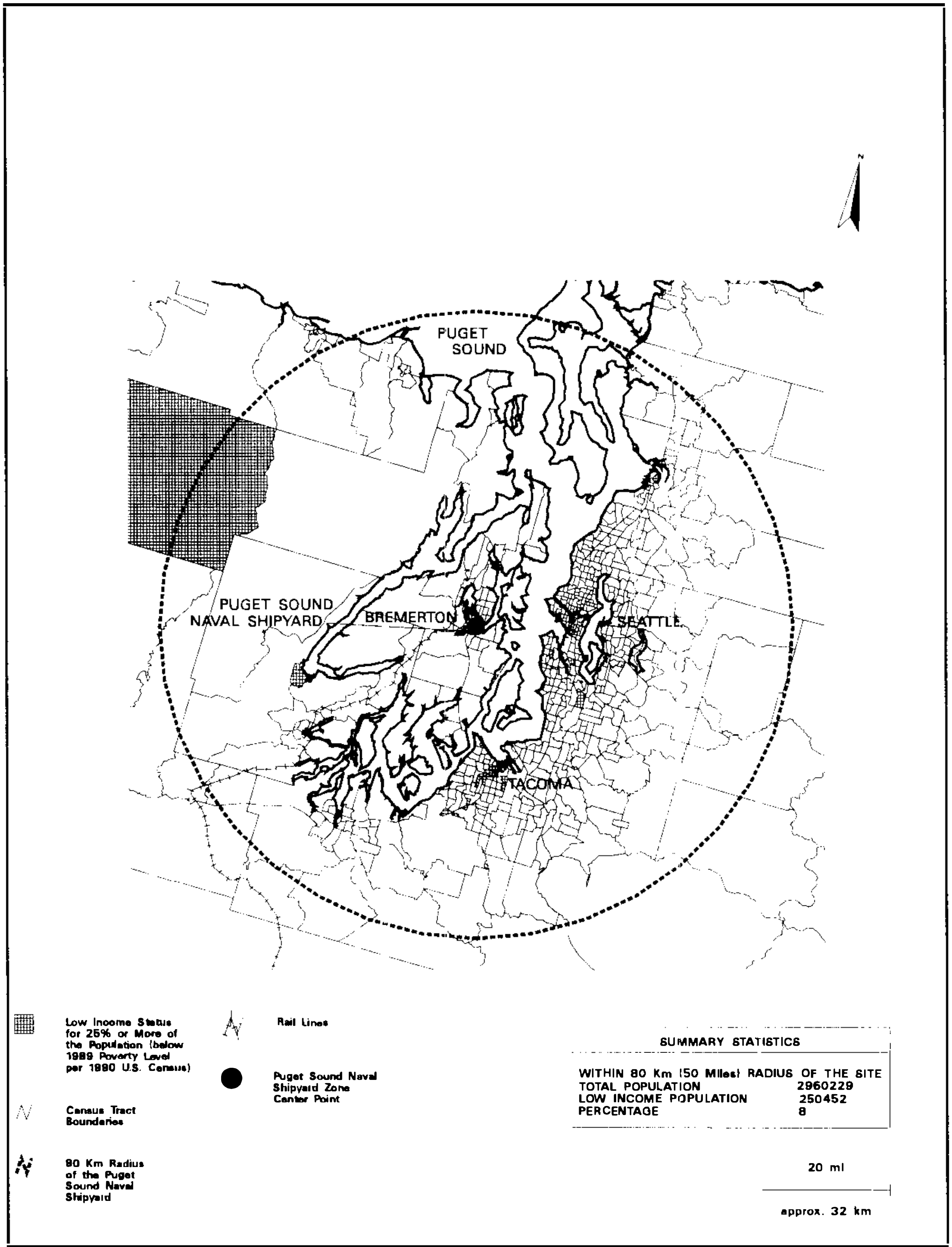

Figure L-13. Low-income population distribution within 80 kilometers (50 miles) of the Puget Sound Naval Shipyard.

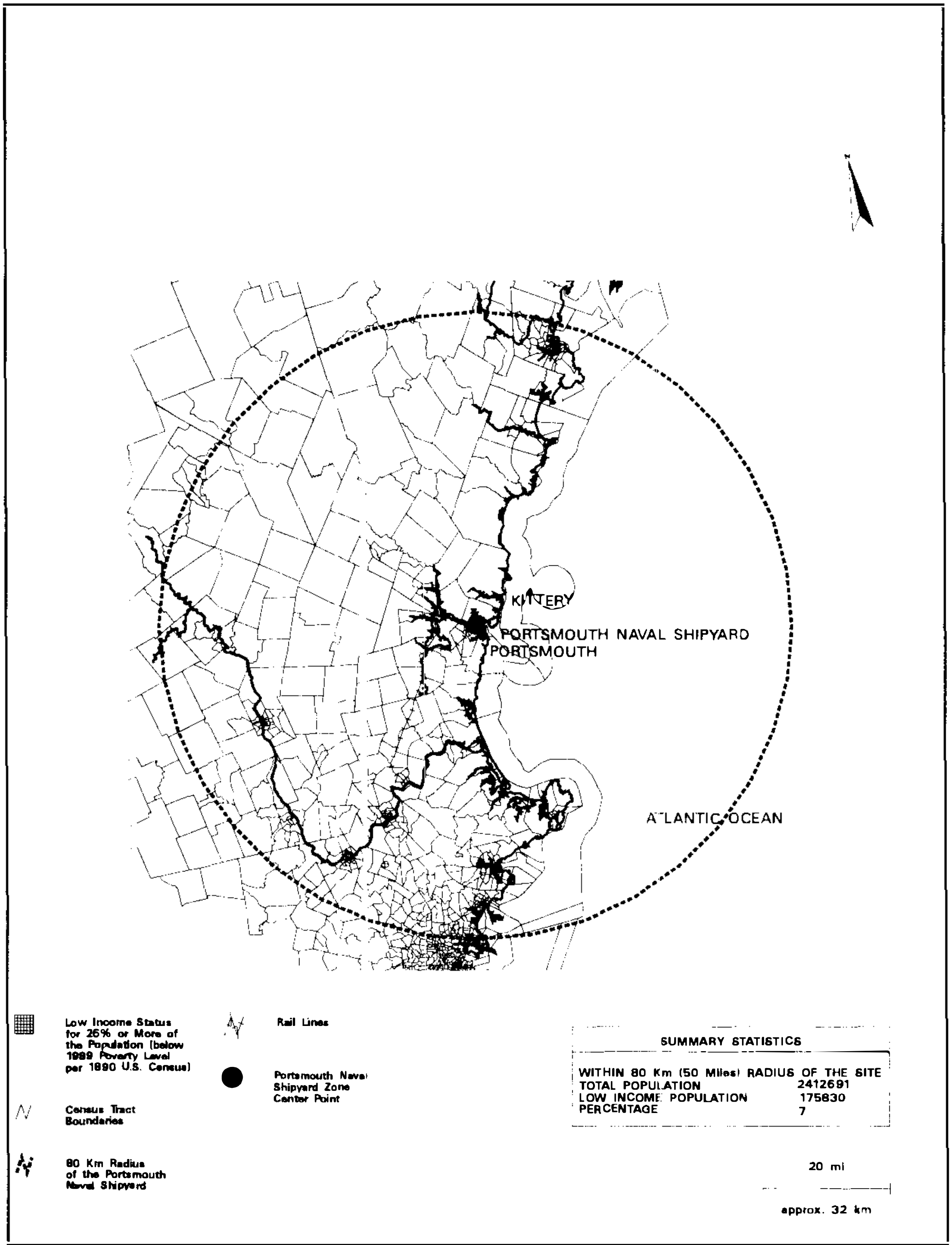

Figure L-14. Low-income population distribution within 80 kilometers (50 miles) of the Portsmouth Naval Shipyard.

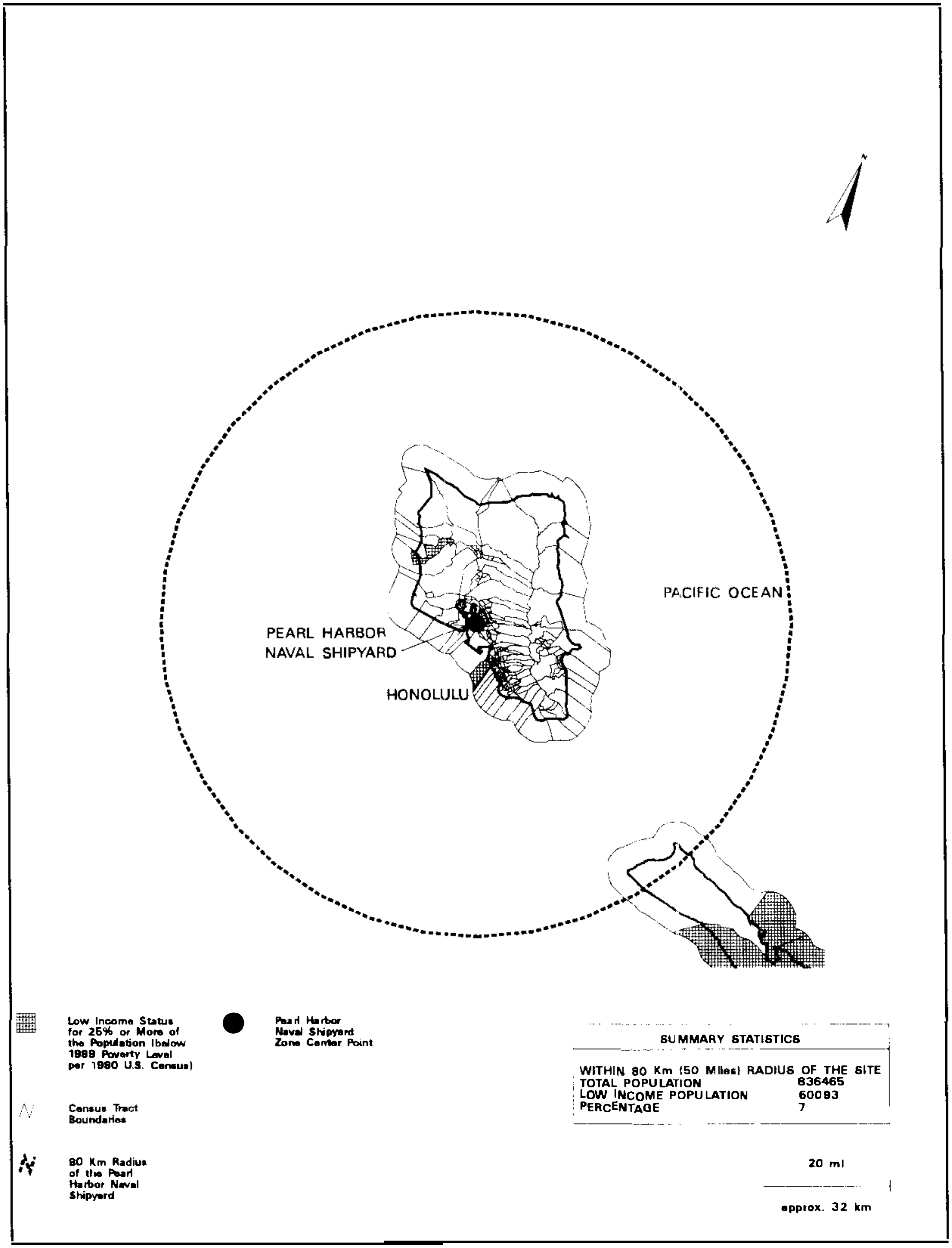

Figure L-15. Low-income population distribution within 80 kilometers (50 miles) of the Pearl Harbor Naval Shipyard.

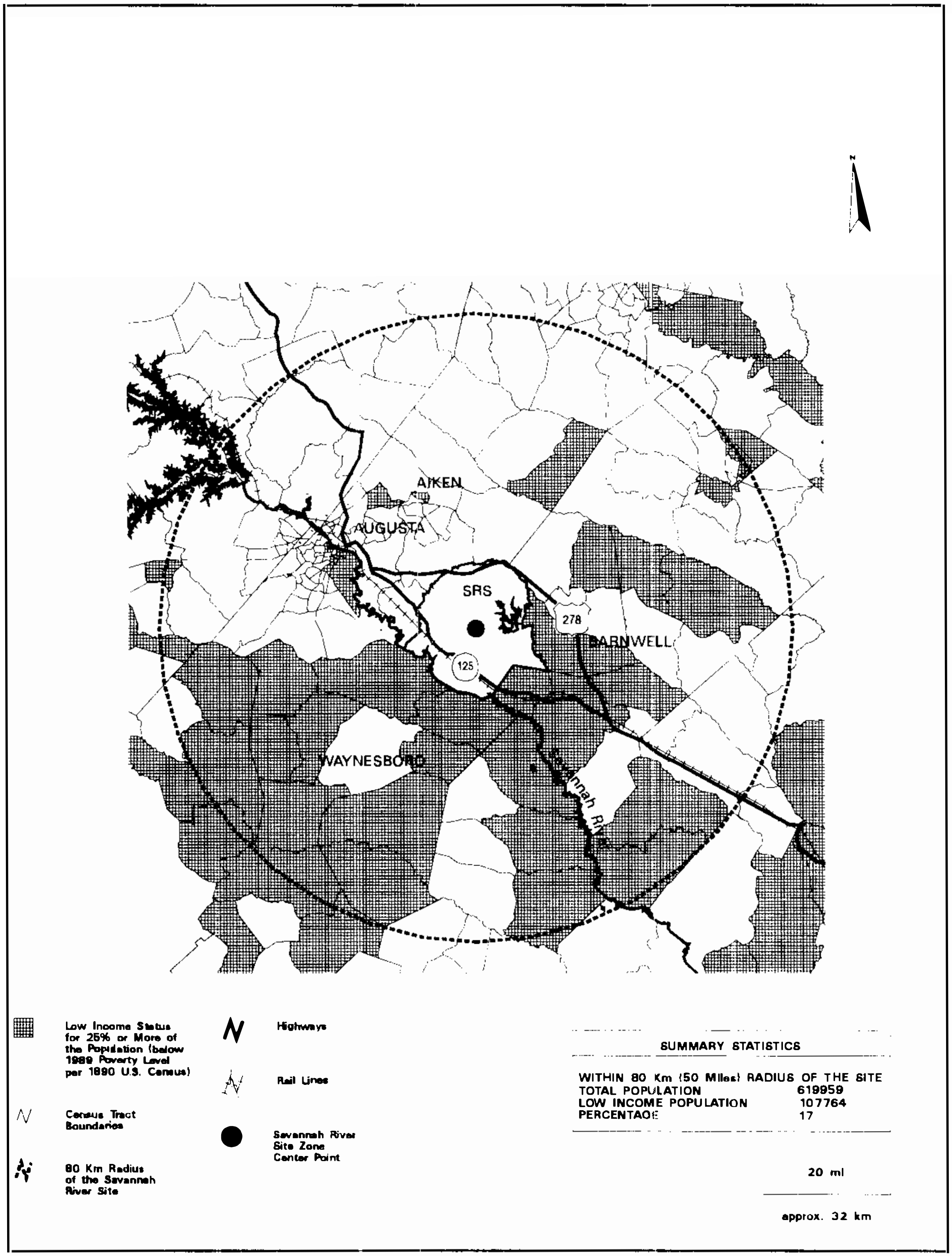

Figure L-16. Low-income population distribution within 80 kilometers (50 miles) of the Savannah River Site.

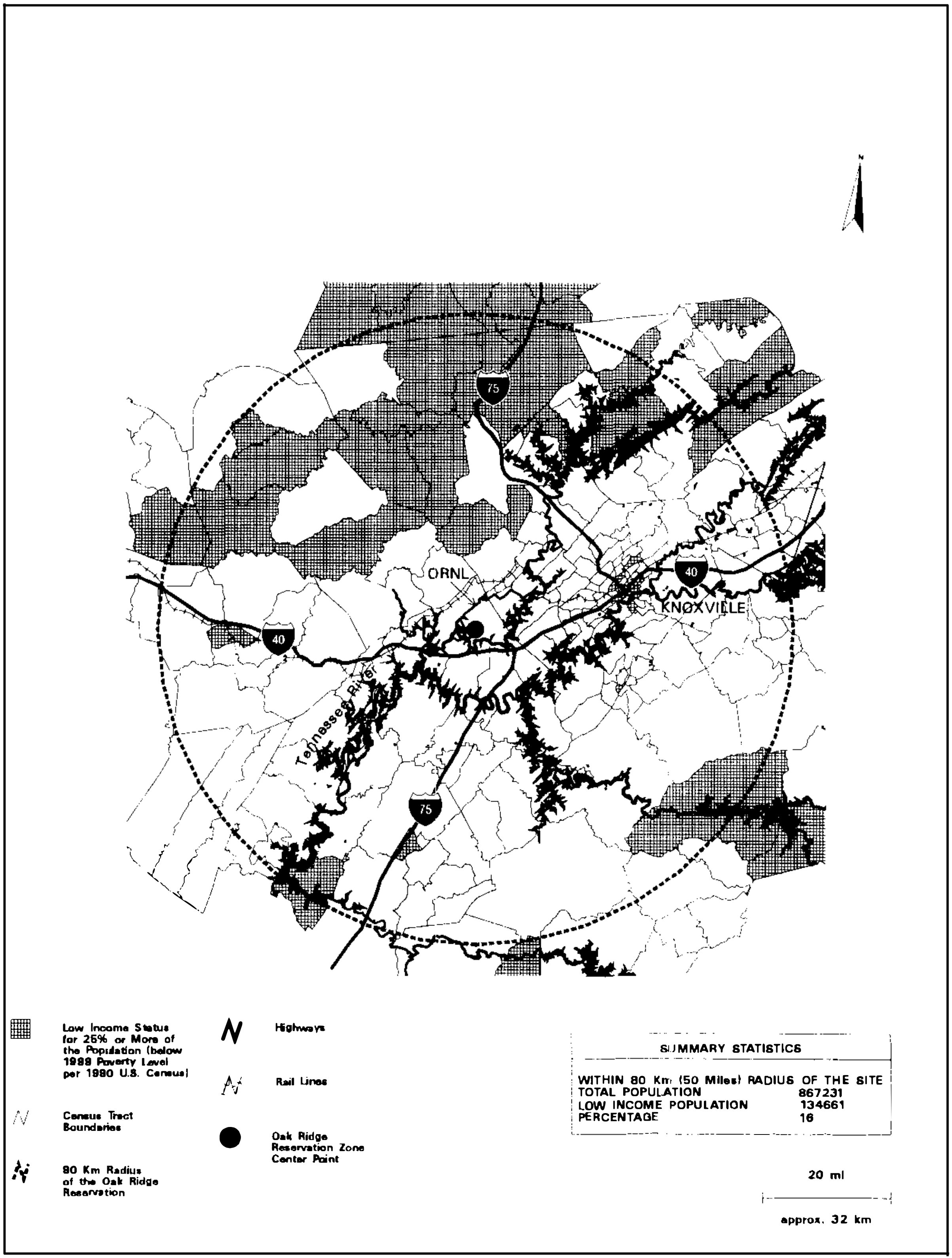

Figure L-17. Low-income population distribution within 80 kilometers (50 miles) of the Oak Ridge Reservation.

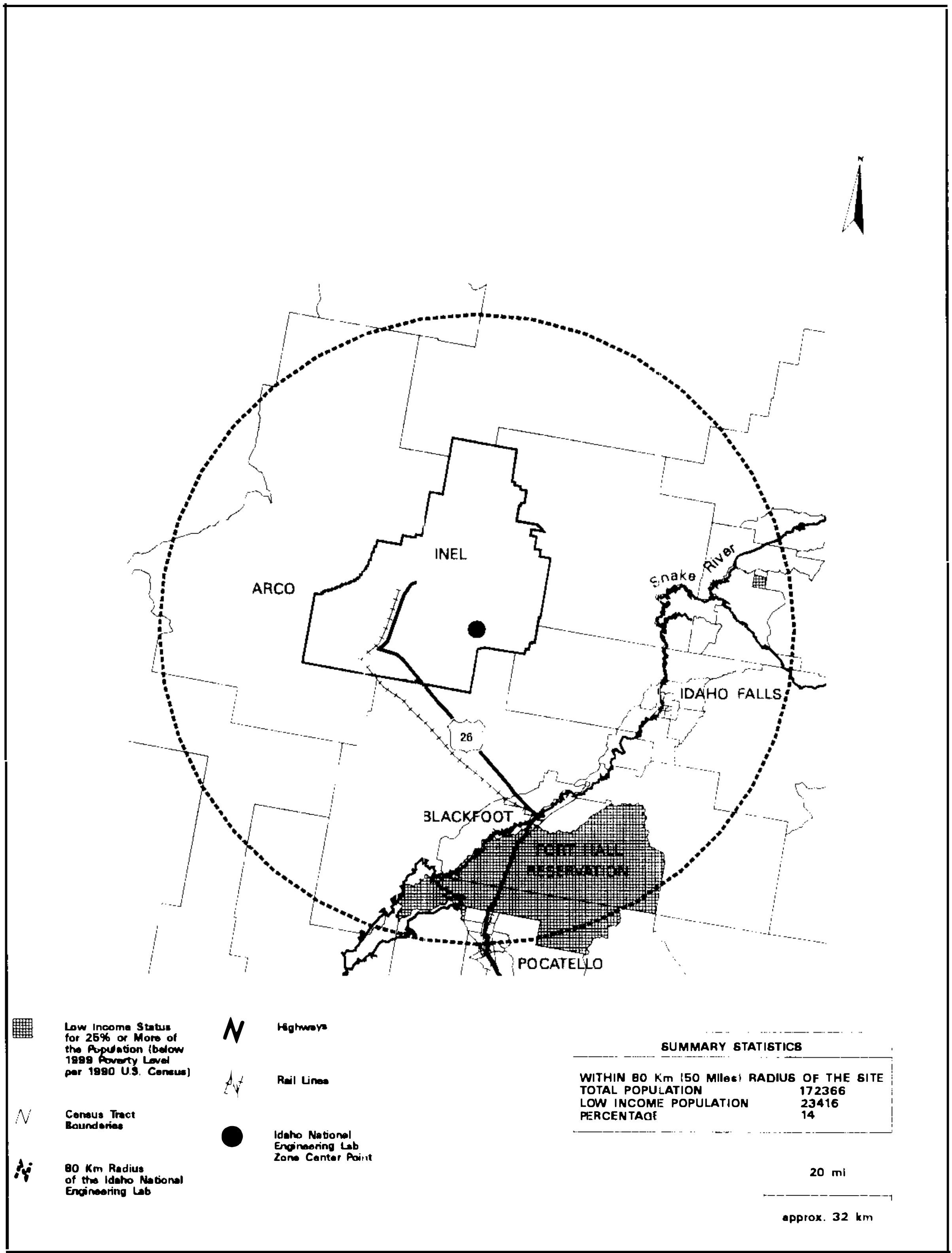

Figure L-18. Low-income population distribution within 80 kilometers (50 miles) of the Idaho National Engineering Laboratory.

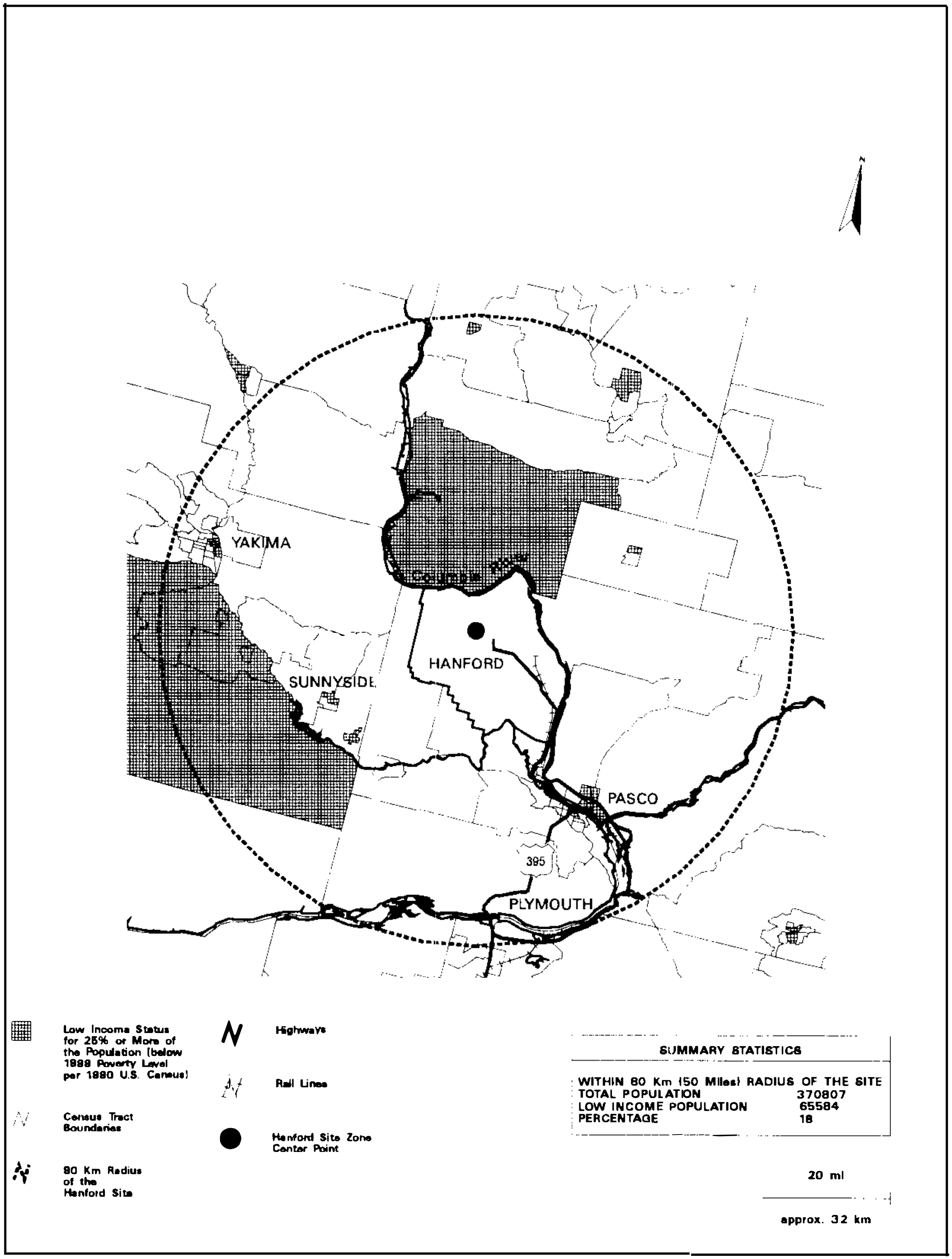

Figure L-19. Low-income population distribution within 80 kilometers (50 miles) of the Hanford Site.

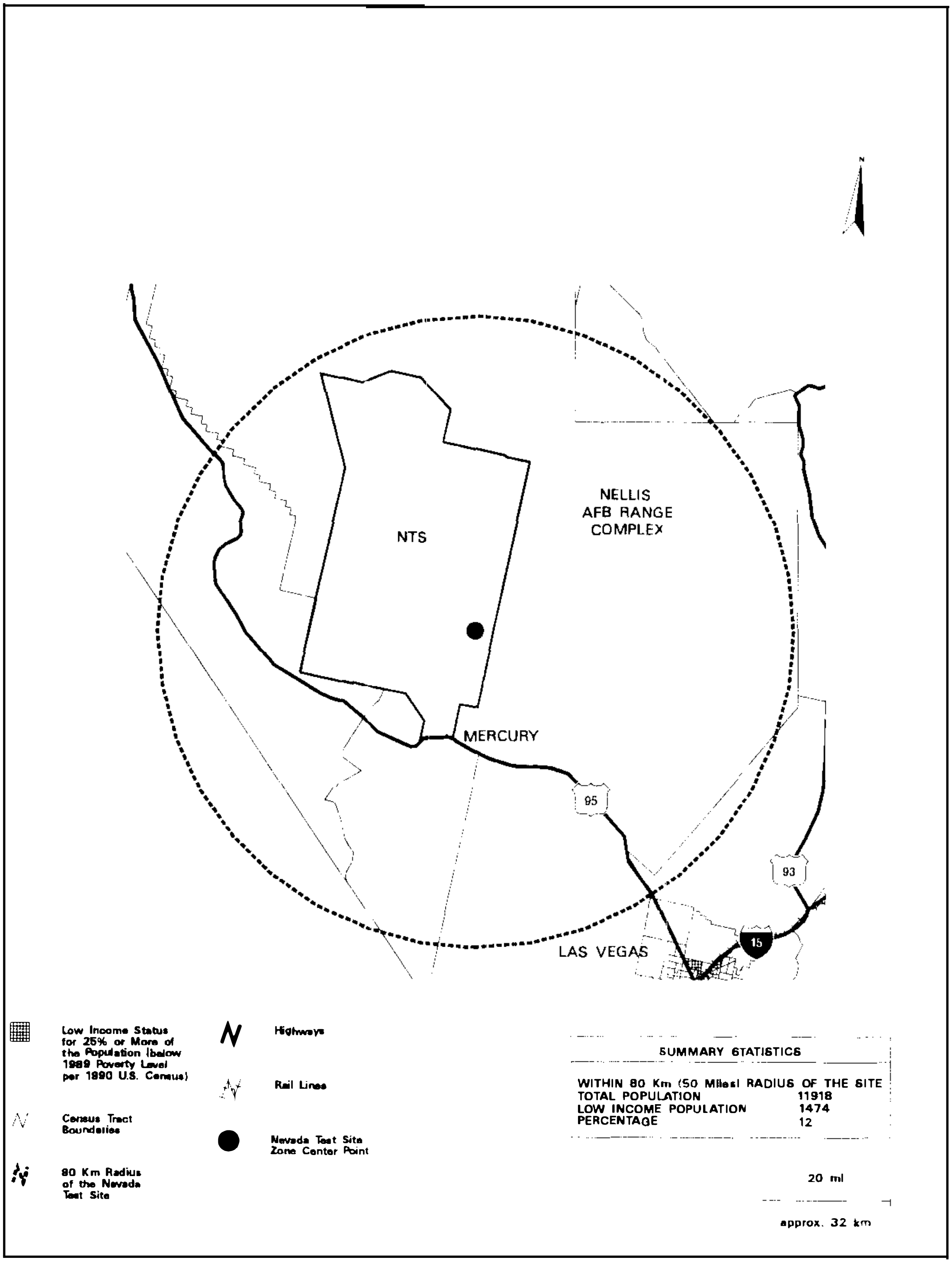

Figure L-20. Low-income population distribution within 80 kilometers (50 meters) of the Nevada Test Site.

3. This EIS defines low-income populations as those in a poverty status as determined annually by the U.S. Census Bureau, based on the Consumer Price Index, and aggregated by the thresholds set forth by the U.S. Census Bureau (that is, a group of people and/or a community experiencing common conditions of exposure or impact, in which 25 percent or more of the population is characterized as living in poverty), a method used by the U.S. Environmental Protection Agency. The Draft FRR SNF EIS uses the definition of low-income community, established by the U. S. Department of Housing and Urban Development, as an area for which the median household income is 80 percent or below the median household income for the metropolitan statistical area (urban) or county (rural). Both definitions are permitted under the draft guidance developed by the Interagency Working Group.

These different definitions and assumptions have resulted in differences in the characterization of low-income and minority populations. The two sets of data are summarized in Tables L-6 and L-7, and the most significant differences are discussed below.

The minority populations identified are reasonably consistent between this EIS and the Draft FRR SNF EIS, except for results obtained at the Nevada Test Site (the largest proportional difference) and the Hanford Site (the largest difference in numbers of individuals), as shown in Table L-6. The range in results for both locations is due to the different aggregations of the demographic data used (census tracts vs. blocks), and the differences in the methods used to account for the populations of tracts or groups lying only partly within the area being analyzed, as discussed above. For example, both sites are located in rural or sparsely populated regions so that census tracts surrounding the sites are relatively large in geographical area. In addition, the outskirts of Las Vegas, Nevada, begin approximately 80 kilometers (50 miles) from the Nevada Test Site, making the analysis particularly sensitive to differences in treatment of census tracts or block groups that lie partly within a circle of 80-kilometer (50-mile) radius centered at that site. Most areas within the zone of impact of the Nevada Test Site are restricted access and unpopulated lands.

As a result of the different definitions used for the identification of low-income populations, the results of these analyses are markedly different, as shown in Table L-7. Both sets of data are correct. They reflect the fact that different definitions and assumptions can result in different characterizations of low-income populations.

Table L-6. Comparison of the DOE Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (SNF & INEL 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) minority characterization results.

Candidate interim storage site	Total individuals residing within 80 kilometers (50 miles)		Minority individuals residing within 80 kilometers (50 miles)		Percentage of minority individuals residing within 80 kilometers (50 miles)	
	SNF & INEL EIS	Draft FRR SNF EIS	SNF & INEL EIS	Draft FRR SNF EIS	SNF & INEL EIS	Draft FRR SNF EIS
Hanford Site	370,807	383,934	75,381	95,042	20.3	24.8
Idaho National Engineering Laboratory	172,366	176,311	11,722	15,449	6.8	8.8
Savannah River Site	619,959	566,823	233,955	214,016	37.7	37.8
Nevada Test Site	11,918	12,421	759	2,005	6.4	16.1
Oak Ridge Reservation	867,231	863,758	49,742	53,185	5.7	6.2

Table L-7. Comparison of the DOE Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (SNF & INEL 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) low-income characterization results.

Candidate interim storage site	Total population residing within 80 kilometers (50 miles)		Low-income group residing within 80 kilometers (50 miles)		Percentage of low-income group residing within 80 kilometers (50 miles)	
	SNF & INEL EIS (individuals)	Draft FRR SNF EIS (households)	SNF & INEL EIS (individuals)	Draft FRR SNF EIS (households)	SNF & INEL EIS (individuals)	Draft FRR SNF EIS (households)
Hanford Site	370,807	136,496	65,584	57,667	17.7	42.2
Idaho National Engineering Laboratory	172,366	55,109	23,416	22,452	13.6	40.7
Savannah River Site	619,959	197,937	107,764	82,930	17.4	41.9
Nevada Test Site	11,918	4,194	1,474	2,024	12.4	48.3
Oak Ridge Reservation	867,231	335,589	134,661	147,537	15.5	44.0

L-4 ENVIRONMENTAL JUSTICE ASSESSMENT

This assessment of potential environmental justice impacts addresses activities associated with the programmatic management of DOE SNF discussed in this EIS.

L-4.1 Methodology and Definitions

Analysis of environmental justice concerns was based on a qualitative assessment of the impacts reported in Section 5 of Volume 1 of the EIS regarding the proposed action and its alternatives. This analysis was performed to identify any disproportionately high and adverse human health or environmental impacts on minority populations or low-income populations surrounding each of the 10 candidate sites.

For this assessment, the following definitions were used:

Disproportionately high and adverse human health effects: Adverse health effects are measured in risks and rates that could result in latent cancer fatalities, as well as other fatal or nonfatal adverse impacts to human health. Disproportionately high and adverse human health effects occur when the risk or rate for a minority population 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 impacts: An adverse environmental impact is a deleterious environmental impact determined to be unacceptable or above generally accepted norms. A disproportionately high impact refers to an impact (or risk of an impact) in a low-income or minority community that significantly exceeds that on the larger community. In assessing cultural and aesthetic environmental impacts, account shall be taken of impacts that uniquely affect geographically dislocated or dispersed low-income or minority populations.

In this assessment, DOE reviewed the human health effects and environmental impacts associated with the siting of the alternatives analyzed in Volume 1 of this EIS. This review included potential impacts arising under each of the major disciplines evaluated for the alternatives, including land use, socioeconomics, water resources, air resources, ecology, health and safety, facility operations, cultural resources, and transportation, which are the sciences pertinent to the identification of environmental impacts in the EIS. Regarding health effects, both normal facility operations and accident conditions were examined, with accident scenarios evaluated in terms of the risk to the public. Likewise, the examination of transportation included both normal and potential accident conditions for both truck and rail transportation of DOE SNF. Special exposure pathways were evaluated with respect to subsistence consumption of fish, game, or native plants.

L-4.2 Results

Potential radiological impacts because of both facility operations and reasonably foreseeable accident conditions are small for all management alternatives and potential sites considered in this EIS. Likewise, the number of potential fatalities due to both radiological and nonradiological exposures to truck or rail transportation are small. There is also little probability of adverse impacts because of subsistence consumption of fish, game, or native plants.

L-4.2.1 Results of Environmental Justice Assessment Near the Alternative Sites Considered for the Management of Naval Spent Nuclear Fuel Only

The five sites evaluated for the management of naval SNF only are specifically addressed in Appendix D to Volume 1 of the EIS. Additional environmental justice matters pertaining to the naval sites are included in Appendix D. It should be noted that, with one exception, these five alternative sites are only considered for storage of naval SNF under the No Action and Decentralization alternatives. The one exception is the partial examination of naval SNF at the Puget Sound Naval Shipyard under Decentralization alternative 2B. Under all other alternatives, these five sites would transport naval SNF to one or several of the larger five DOE sites analyzed in this EIS, and evaluated from an environmental justice perspective in Section L-4.2.2.

L-4.2.1.1 Incident-Free Human Health Effects and Environmental Impacts. As discussed in Appendix D to Volume 1 of this EIS, the impacts on human health or the environment resulting from operations associated with the management of naval SNF at any of the five locations limited to the storage of naval SNF would be small under any of the alternatives considered. This includes the impacts of incident-free transportation. For example, it is unlikely that a single fatal cancer would occur as a result of naval SNF management activities under any alternative at any one of the five sites. Also, it is unlikely that a single fatal cancer would occur as a result of activities associated with naval SNF examination under any alternative considered in the EIS. In fact, naval SNF could be managed at any of the five sites for between 7,100 and 43,500 years (depending on the site) before a single fatal cancer would be expected. Because the impacts as a result of incident-free operations present no significant risk and do not constitute a reasonably foreseeable adverse impact to the surrounding population, no disproportionately high and adverse effects would be expected for any particular segment of the population, minority populations and low-income populations included (see Tables L-2 and L-4).

L-4.2.1.2 Human Health Effects and Environmental Impacts Because of Accidents. As discussed in Appendix D, the impacts on human health and the environment resulting from the risk of facility or transportation accidents at any of the five locations limited to the storage of naval SNF would be small under any of the alternatives considered. As explained in the EIS, the risk to the public is defined as the potential consequence of an accident multiplied by its probability of occurrence. This risk calculation represents the expected impact to members of the public. Based on this risk calculation, it is unlikely that a single fatal cancer would occur from reasonably foreseeable facility or transportation accidents related to naval SNF management activities under any of the alternatives. Because the potential impacts as a result of an accident for any of the alternatives considered would present no significant risk and do not constitute a reasonably foreseeable adverse impact to the surrounding population, no disproportionately high and adverse effects would be expected for any particular segment of the population, minority populations and low-income populations included (see Tables L-2 and L-4).

L-4.2.1.3 Effects of Natural Motive Forces. Impact analysis indicates that there would not be disproportionately high and adverse impacts on human health and the environment resulting from the prevailing winds or the direction of surface or subsurface water flow. This is true for site operations because the effects of routine operations on air and water quality are so small. It is also true for accident conditions because the consequences of any accident, however unlikely its chance of occurrence, would depend on the random conditions at the time it occurred. The wind conditions at the Pearl Harbor Naval Shipyard are variable, but the predominant wind direction is toward the southwest, away from land and residential areas. The wind directions at the other four sites are highly variable with no strongly dominant direction.

L-4.2.1.4 Effects on Subsistence Consumption of Fish and Wildlife. Available data do not show potential for disproportionately high and adverse impacts to minority and low-income communities related to subsistence consumption of fish and wildlife in the vicinity of these five sites under any alternative. Environmental monitoring in the vicinity of these relatively small and restricted sites has shown no detectable difference in the amounts of radionuclides present in the environment from levels in similar parts of their respective regions.

L-4.2.2 Results of Environmental Justice Assessment Near the Alternative Sites Considered for the Management of All or Some Portion of DOE Spent Nuclear Fuel

The five sites evaluated for the management of all or some portion of DOE SNF are specifically addressed in Appendices A (Hanford Site), B (Idaho National Engineering Laboratory), C (Savannah River Site), and F (Nevada Test Site and the Oak Ridge Reservation) to Volume 1 of the EIS. It should be noted that these five alternative sites are considered for the management of DOE SNF under all alternatives analyzed in this EIS. The one exception is the Nevada Test Site, which is not considered in the No Action, Decentralization, and 1992/1993 Planning Basis alternatives because no SNF is currently managed at that site.

L-4.2.2.1 Facility Operations. This EIS considers the impacts from the operations of both existing and new facilities on a site-by-site basis as appropriate for programmatic decisionmaking. Site-specific implementation of the programmatic strategy for the management of SNF for the 40-year interim period between 1995 and 2035 will be subject to additional National Environmental Policy Act review, as appropriate on a case-by-case basis. Both incident-free operations and reasonably foreseeable accidents were analyzed in terms of risk to both workers and the public. The potential impacts calculated for both incident-free operations and the risk of reasonably foreseeable accidents present no significant risk and do not constitute a reasonably foreseeable adverse impact to the surrounding population as discussed below. Therefore, no disproportionately high and adverse effects would be expected for any particular segment of the population, minority populations and low-income populations included.

L-4.2.2.1.1 Incident-Free Operations—In Table K-2 of Volume 1 of this EIS, it is shown that under all the alternatives, the estimated number of latent cancer fatalities from the normal operation of DOE SNF management facilities would range from approximately zero to about two latent cancer fatalities over the 40 year period, or about 0.05 latent cancer fatalities per year. Therefore, no disproportionately high and adverse effects would be expected for any particular segment of the population, minority populations and low-income populations included (see Tables L-3 and L-5).

L-4.2.2.1.2 Reasonably Foreseeable Accidents—As explained in Section 5.1.1.4 of this EIS, the risk to the public is defined as the potential consequence multiplied by the probability of occurrence. This risk calculation represents the expected impact to members of the public. The calculated risk of latent cancer fatalities associated with reasonably foreseeable facility accidents is small for all alternatives. The evaluated facility accident with the highest risk (breach of a fuel assembly for the Centralization alternative at the Savannah River Site) would result in an estimated 0.0072 latent cancer fatality per year, which equates to one fatal cancer in 140 years of operation. Impacts from high-consequence, low-probability accident scenarios would be adverse should they occur; however, the impacts to specific population locations would be subject to meteorological conditions on the day of the accident. Whether or not such impacts would have disproportionately high and adverse effects with respect to any particular segment of the population, minority and low-income populations included, would be subject to natural motive forces, including random meteorological factors (see Tables L-3 and L-5).

L-4.2.2.1.3 Natural Motive Forces—Offsite health effect impacts from operations and reasonably foreseeable accidents are propagated by natural motive forces such as meteorological conditions and water pathways, both surface and subsurface. Impacts because of incident-free operations are dominated by prevailing patterns in these natural motive forces, whereas the impacts of an accident, should one occur, would be random based on the meteorological conditions at the time of and following occurrence. The following conditions are prevalent at each of the five large DOE sites under consideration:

- Prevailing winds for the Idaho National Engineering Laboratory are primarily from the southwest, although winds at the Test Area North are frequently from the north and west-northeast. Local rivers and streams drain mountain watersheds to the north and west of the Idaho National Engineering Laboratory, but most surface water is diverted for irrigation before it reaches the site boundaries. Groundwater in the underlying Snake River Plain Aquifer generally flows to the south and southwest (see Figures L-8 and L-18).

- Prevailing wind conditions at the Savannah River Site are from the northeast and west-southwest. Both onsite surface streams and groundwater aquifers generally drain in a southwesterly direction, toward the Savannah River, which flows southeast to Savannah, Georgia (see Figures L-6 and L-16).

- The prevailing wind direction at the Oak Ridge Reservation is from the southwest, with a secondary pattern from the northeast during the winter, spring, and summer months. The situation is reversed in the fall. Surface and shallow subsurface water in an area susceptible to the potential siting of SNF management facilities would flow south into Grassy Creek and then to the Clinch River. The Clinch River flows southwest and west around the reservation and subsequently to the Tennessee River. Deeper groundwater tends to remain relatively stationary because of high retention times (see Figures L-7 and L-17).

- Prevailing winds at the Nevada Test Site are from the south during the summer and the north during the winter. Surface topography usually results in a wind reversal from the south in the day to the north during the night. Almost all surface water is transient and short-lived in nature. In an area susceptible to the siting of SNF management facilities, surface water would flow east towards Frenchman Lake, where it would be lost by evaporation or recharge to the local groundwater system which discharges to the southwest. Water discharged beneath the site would likely either evaporate or remain indefinitely because of the great depth of the groundwater at the site (see Figures L-10 and L-20).

- Prevailing winds at the area of interest on the Hanford Site are from the northeast in all months of the year, with the second predominant pattern occurring from the southwest, primarily during the spring and fall. Roughly two-thirds of any surface water runoff would drain to the Columbia River, with the rest draining to the Yakima River and joining the Colombia River below the Hanford Site. Groundwater systems underlying the Hanford Site tend to flow toward the Columbia River in a southeast and northeast direction (see Figures L-9 and L-19).

As indicated in Appendix K of this EIS, the risk of impacts from incident-free routine operations and from reasonably foreseeable accidents is so small that the propagation by motive forces is essentially of no consequence.

L-4.2.2.2 Transportation. Transportation corridors associated with shipment of SNF management by either truck or rail can be classified as roughly 80 percent rural, 17 percent suburban, and 3 percent urban. Specific details of mileage and percentages by route are contained in Table I-1 of Appendix I to Volume 1 of the EIS.

L-4.2.2.2.1 Incident-Free Transportation—For incident-free transportation, the total number of potential fatalities would be the sum of the health effects because of exposure to radiation and vehicular emissions. The total number of shipments over the 40-year period would vary from about 200 during the transition period for naval SNF under the No Action alternative to about 7,400 shipments if all of DOE's SNF were managed at the Nevada Test Site under the Centralization alternative. The DOE's preferred alternative would result in a total of approximately 3,700 shipments among the sites. The estimated total latent cancer fatalities resulting from incident-free transportation is less than two under the maximum shipment (Centralization) alternative, while the preferred alternative results in less than one fatality.

L-4.2.2.2.2 Transportation Accidents—It is worth noting that the risk of fatalities associated with vehicular accidents during the transport of SNF is higher than the risk of cancer caused by radiation exposure because of such accidents, although both are very small. Also, the risks associated with radiation because of transportation accidents is even less than the small risk associated with facility accidents. The reasonably foreseeable transportation accident scenario with the largest consequences (SNF rail shipment accident occurring in an suburban area) would lead to 55 latent cancer fatalities; however, the probability of this scenario occurring is about 1 in 10 million. The overall risk (probability multiplied by consequence) of all accidents analyzed, including the above scenario, over the total 40-year timeframe analyzed is much less than one fatality. Over this 40-year timeframe, up to two fatalities could result from vehicular traffic accidents themselves without any radiological releases. When and where an accident occurred, if one in fact occurred, would be completely random with respect to the immediate and surrounding population, as well as the motive forces that could propagate the impacts during the timeframe of occurrence. Although adverse impacts could occur in the unlikely event of a high-consequence accident, any potential disproportionality with respect to any population, minority and low-income populations included, is subject to the randomness of the combination of factors that can produce such impacts.

L-4.2.2.3 Subsistence Consumption of Fish, Wildlife, or Native Plants. The calculations in this EIS estimate dose and risk from ingestion of radioactive materials based on site-specific agricultural data and assume a typical dietary pattern. Subsistence consumption of fish, wildlife, and native plant species is not explicitly addressed in these analyses. However, the calculations in this EIS include several conservative assumptions that bound the potential for ingestion of radioactivity through these special exposure pathways. In particular, these calculations assume that a very high proportion of the diet is based on locally grown produce and locally grazed livestock, both of which are produced at locations representing the highest calculated concentrations of radioactivity. Nevertheless, there may be some differences between the uptakes of grazed livestock and free-ranging game. No human populations in the immediate vicinity of the any of the five DOE sites are known to subsist entirely on locally harvested fish or wildlife. Fishing is not usually allowed on DOE sites, but some hunting is allowed under controlled conditions.

Game species, locally grazed livestock, fish, locally grown foodstuffs, and native plants around DOE sites are routinely sampled for radionuclides. Concentrations of radionuclides in samples have generally been small, and are seldom elevated above those observed at locations distant from these sites where the principal source of non-natural radionuclides is very small amounts of residual global fallout from past nuclear weapons tests. Data from monitoring programs are reported annually in site-specific environmental reports.

If SNF management activities were to increase wildlife losses because of vehicle collisions with game, there might be a disproportionate impact to minority or low-income communities that rely primarily on hunted game. However, the maximum potential increases in shipments of SNF would be small additions to current rail and highway traffic, so the overall impact to wildlife would be small. Potential mitigation measures for any resulting adverse impact to low-income or minority populations include distributing the deceased animals to hunters in the vicinity known to partially subsist on game, controlling subsequent hunts, or relocating game if necessary.

L-4.2.2.4 Other Considerations. In addition to the above, reviews of other technical disciplines pursuant to the methodology in Section 4.1 did not indicate any significant adverse impacts because of land use, socioeconomics, water and air resources, ecology, cultural resources, or cumulative impacts. Therefore, no disproportionately high and adverse impacts were identified for any segment of the population. Of particular interest are the following:

L-4.2.2.4.1 Socioeconomics—Depending upon the various alternative evaluated, the total labor force involved in SNF management could decrease by up to 180 jobs or increase by more than 2,100 jobs averaged over the 10-year implementation period between 1995 and 2005. Affirmative action programs would distribute such effects proportionately among workers, whereas coordination of planning activities with local communities would be intended to avoid placing undue burdens on local community resources. DOE may also provide support to local agencies if necessary to mitigate localized impacts.

L-4.2.2.4.2 Land Use, Ecology, and Cultural Resources—None of the alternatives would have a significant adverse impact on land use, ecology, and cultural resources because of the limited amount of previously undisturbed land which would be needed for use onsite (no offsite lands are involved) and mitigative programs already in place. These programs include working closely under agreements with State Historical Preservation Officers and Tribal governments regarding preservation of historic and cultural resources. Consultations with Tribal governments have expanded the DOE's awareness of Tribal interests and values with respect to nature, religion, and the land, and are designed to avoid or relocate these resources as possible. If avoidance were not possible, data recovery (such as archiving artifacts) or other mitigation measures may be developed in consultation with affected Tribes and the respective State Historical Preservation Officer, as appropriate. Similarly, the DOE is aware of sensitive ecological resources, and avoids wetlands and endangered plant or animal specie habitats. Disturbance of certain ecological resources (which are not federally listed as threatened or endangered) is possible, but not likely. The reasonably foreseen environmental impacts, if any, to land use, ecological resources, or cultural resources are expected to be small under any of the alternatives.

L-4.2.2.4.3 Cumulative Impacts—Based on the analysis of the impacts for each of the disciplines analyzed in this EIS, along with the impact of other past, present, and reasonably foreseeable future activities at each of the alternative sites, no reasonably foreseeable cumulative adverse impacts are expected to the surrounding populations, minority populations and low-income populations included (see Tables L-2 through L-5).

L-4.2.2.5 Impacts Because of Perception. Potential adverse impacts may result from the public's perception of risk associated with nuclear industry activities in general and DOE's activities in particular. For example, a SNF management facility has the potential to increase awareness of the nuclear industry, leading to concerns of potential adverse effects to the conduct of local commerce, whether it be tourism, agriculture, or the like. From both a National Environmental Policy Act and an environmental justice perspective, both the character and substance of these potential impacts is not discernable. Therefore, it is not possible to identify any quantifiably adverse or disproportionately high distribution of any impacts of such perceived risk.

In order to better understand and help mitigate unfounded perceptions, the DOE is working to enhance the general population's understanding of the potential impacts of DOE programs in general and the proposed action in particular, with emphasis on minority populations, low-income groups, and Tribal governments.

L-4.2.3 Perspective

To place the impacts in perspective with respect to risks encountered in everyday life, in 1990, there were approximately 510,000 cancer deaths in the United States population, of which about 64,000 were among the nonwhite population. This equates to an average of roughly 1,132 cancer fatalities (of which 142 would affect minority populations) in an area comparable to that included in the 80 kilometer (50 mile) radius around any of the sites considered in this EIS. Additionally, in 1992, there were about 40,000 traffic fatalities in the United States, of which about 7,400 were among the non-white population. This equates to an average of roughly 89 traffic fatalities (of which 16 would affect minority populations) in an area comparable to that included in the 80-kilometer (50-mile) radius around any of these sites. Based on the risk of additional fatalities provided in Sections L-4.2.1, L-4.2.2.1.2, and L-4.2.2.2.2, the risk to the surrounding population because of DOE SNF management activities would not appreciably increase this total, even if all impacts were associated with minority or low-income populations.

L-5 CONCLUSIONS

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. 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, and thus do not present an environmental justice concern.

The approach to evaluating environmental justice used in this EIS may differ from future guidance issued by the Interagency Working Group or the DOE. Nevertheless, as demonstrated by the different approaches discussed in Section L-3.5, the conclusions are not expected to change because the impacts resulting from the proposed action under all alternatives present no significant risk to the potentially affected populations. As a result, no disproportionately high and adverse effects would be expected for any particular segment of the populations, including minority populations and low-income populations.

L-6 REFERENCES

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1. APPENDIX F INTRODUCTION

This appendix addresses the interim storage of spent nuclear fuel (SNF) at two U.S. Department of Energy sites, the Nevada Test Site (NTS) and the Oak Ridge Reservation (ORR). These sites are being considered to provide a reasonable range of alternative settings at which future SNF management activities could be conducted. These locations are not currently involved in management of large quantities of SNF; NTS has none, and ORR has only small quantities. But NTS and ORR do offer experience and infrastructure for the handling, processing and storage of radioactive materials, and they do exemplify a broad spectrum of environmental parameters. This broad spectrum of environmental parameters will provide a perspective on whether and how such location attributes may relate to potential environmental impacts. Consideration of these two sites will permit a programmatic decision to be based upon an assessment of the feasible options without bias to the current storage sites.

This appendix is divided into three parts. Part One is the Appendix F introduction. Part Two contains chapters one through five for the NTS, as well as the NTS references in chapter six and acronyms and abbreviations in Chapter 7. Part Three contains chapters one through five for the ORR, as well as the ORR references in chapter six and abbreviations and acronyms in Chapter 7. A Table of Contents, List of Figures, and List of Tables are included in Parts Two and Three. This approach permitted the inclusion of both sites in one appendix while maintaining chapter numbering consistent with Volume 1 and Appendices A, B, and C.

Currently, no SNF is stored at the NTS and only small quantities of SNF generated by research reactors at ORR are stored there. In order to receive, handle, and store spent nuclear fuel from other DOE sites on an interim basis, new facilities would need to be constructed at the NTS and ORR. Since the basic facilities to receive and handle the spent fuel, as well as any safety-related and emergency containment, cleanup, and recanning facilities, are approximately equivalent for all alternatives being considered, only the size of the storage facility will vary for each alternative, with the Centralization Alternative requiring the largest storage facility. As discussed in Chapter 3, only the Centralization Alternative for spent fuel storage at either the NTS or ORR is analyzed quantitatively in this volume; the Regionalization Alternative is evaluated qualitatively. The results of this appendix are then summarized in Volume 1.

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NEVADA TEST SITE

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FIGURES

FIGURES (continued)

TABLES

TABLES (continued)

TABLES (continued)

1. INTRODUCTION

This part assesses the impacts of construction and operation of proposed spent nuclear fuel (SNF) facilities at the Nevada Test Site (NTS). The NTS is being evaluated for these facilities because of the area available, the isolation of population centers, the apparently suitable site environmental parameters, previous U.S. Department of Energy activities involving radioactive materials at the site, and the planned long-term government control of the site.

This part is organized as follows. Chapter 1 is the introduction, Chapter 2 sets the stage for the area under analysis by providing an overview of the NTS and discussions of the Regulatory Framework and SNF Management Program, and Chapter 3 explains the SNF alternatives being considered at the site.

Chapter 4 describes the human and natural environment that could be affected as a result of the introduction of an SNF facility at the NTS. Environmental parameters such as water resources, socioeconomics, biological resources and air quality are examples of those characterized.

Chapter 5 enumerates the environmental consequences that might be anticipated, the cumulative impacts, the unavoidable adverse impacts, the relationship between short-term use and long-term productivity, the irreversible and irretrievable commitment of resources, and possible mitigation measures that might be anticipated if an SNF facility were built at the NTS. Chapter 6 contains the references used to develop this part of the Environmental Impact Statement. Chapter 7 contains the abbreviations and acronyms used in this Part.

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2. NEVADA TEST SITE BACKGROUND

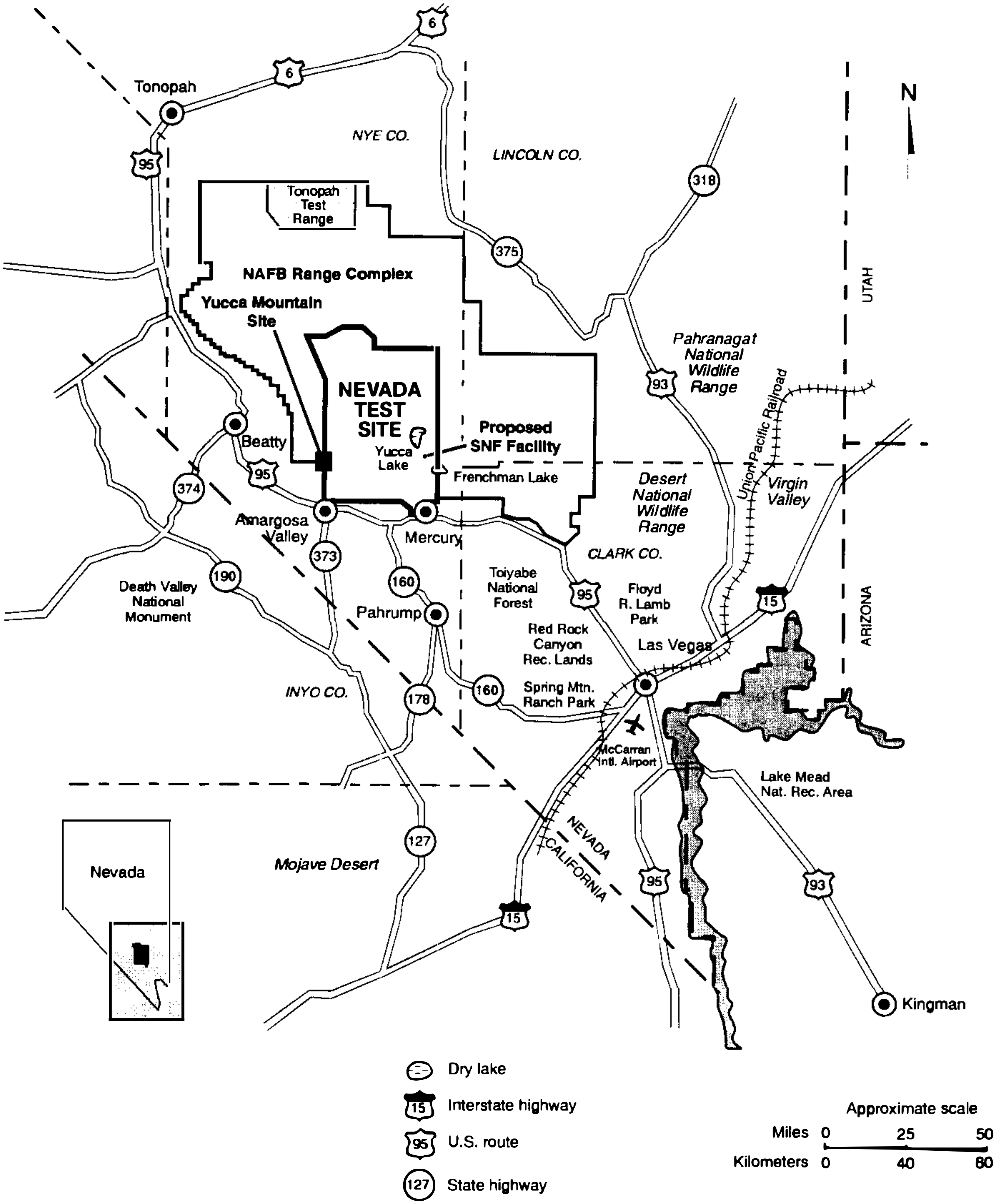
2.1 Overview

2.1.1 Site Description

The Nevada Test Site (NTS), located in the southeastern portion of Nevada, is operated by the U.S. Department of Energy (DOE) as the on-continent test site for nuclear weapons testing. The site encompasses approximately 1,350 square miles (3,500 square kilometers). The NTS is surrounded on the north, east, and west by the Nellis Air Force Base (NAFB) Bombing and Gunnery Range. Together with the Tonopah Test Range, these three properties provide a 15- to 65-mile (24- to 104-kilometer) buffer zone between the test areas and public lands. The Bureau of Land Management owns land on the southern and southwestern borders of the NTS. Las Vegas is approximately 65 miles (104 kilometers) from the southeast corner of the site (Figure 2.1-1) (DOE/NV 1991a; USAF et al. 1991).

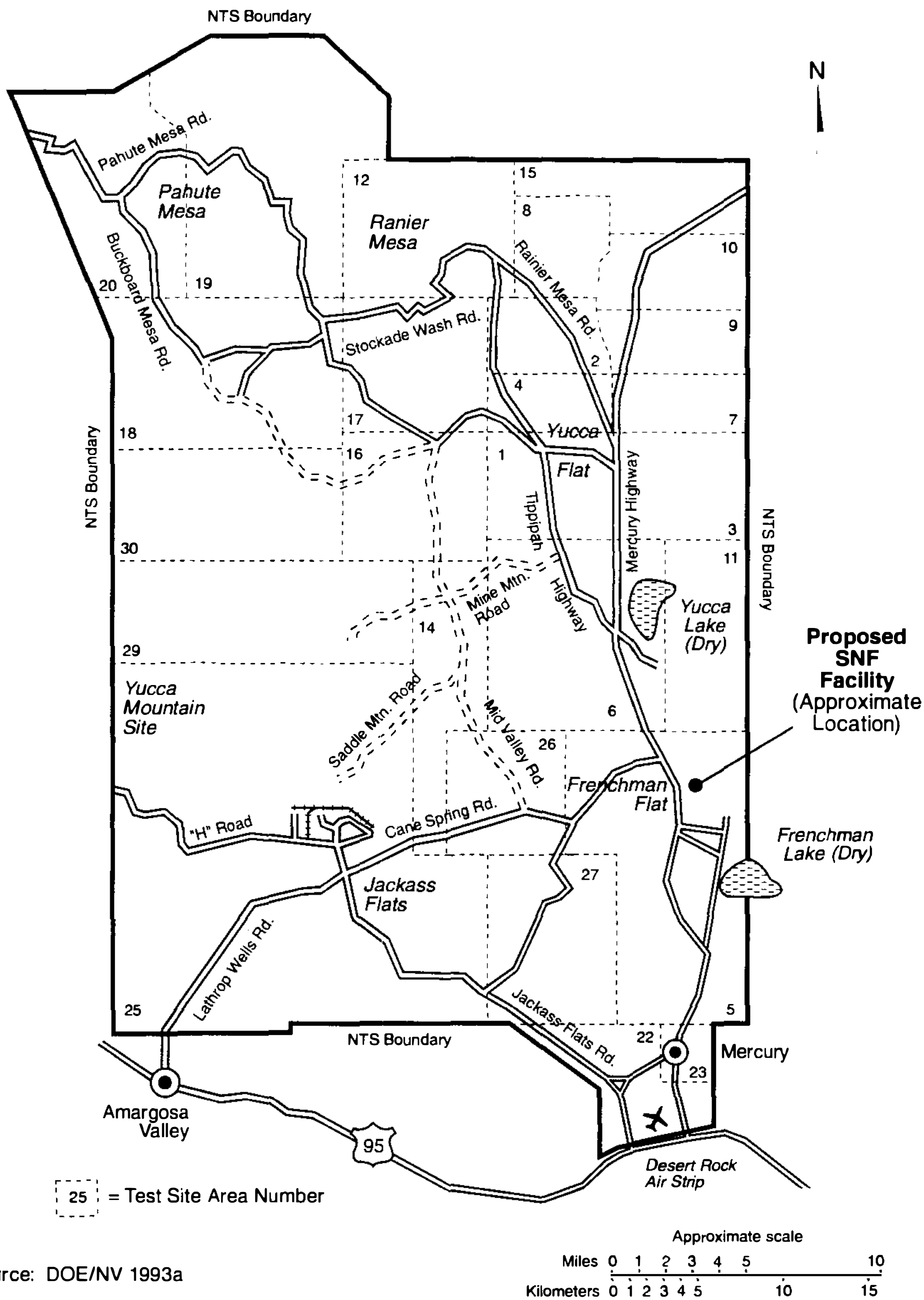
The NTS is a large, open area, tightly controlled, with the infrastructure to conduct tests with hazardous and radioactive materials. Security at the NTS consists of security guards, often using four-wheel drives, patrolling the site. The perimeter of the site is not fenced. Armed guards and electronic security measures are in place for secure areas. Approximately 25 percent of the site is unused or is used as a buffer zone for ongoing programs or projects (DOE/NV 1991a; USAF et al. 1991).

The NTS is broken into numbered test areas to simplify the distribution, use, and control of resources (Figure 2.1-2). Area 22, the site's main entrance, is located on the southeast corner of the site and contains the Desert Rock airstrip. Area 23, adjacent to Area 22, contains the Mercury base camp, which houses administrative operation and general support activities. Offices for the DOE, the U.S. Department of Defense (DoD), Defense Nuclear Agency, Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Sandia National Laboratories (SNL), and all supporting contractors of these organizations are located in this area. Other facilities in this area include the cafeteria, recreation, transportation, and housing. Area 5 (Frenchman Flat) was used in the past for nuclear testing. Area 6, north of



Source: BLM 1990

Figure 2.1-1. Nevada Test Site regional map.



Source: DOE/NV 1993a

Figure 2.1-2. Nevada Test Site map.

Area 5, contains the Control Point One facility which overlooks Yucca Flat, where a large portion of the testing occurs. This facility provides control over and execution of nuclear detonations at the NTS. Also in Area 6 there is a new work camp which is used for construction and craft support. Other areas located on the NTS are the valley of the Yucca Flat (Areas 3, 7, and 9), the Rainier Mesa (Area 12), which is the center of DoD/Defense Nuclear Agency activities, and the Pahute Mesa (Areas 19 and 20) (DOE/NV 1991a; ERDA 1977; USAF et al. 1991). Area 5 will be housing the proposed spent nuclear fuel (SNF) facilities. Figure 2.1-2 shows the approximate location of the proposed SNF facility. The actual location will be determined for site-specific environmental documentation.

2.1.2 Site History

Prior to 1951, the land which is now occupied by the NTS was used for mining and grazing. Primarily, mining was for low grades of copper, lead, silver, gold, mercury, and tungsten. Although there were short periods of mining success at the site, the area was abandoned over time. Grazing ended in 1955 when the Federal government acquired the water and grazing rights of two ranches which were operating on what is now the NTS (ERDA 1977).

Since January 1951, the land now occupied by the NTS has been the primary location for nuclear weapons testing in the United States. Land was withdrawn from the NAFB Bombing and Gunnery Range in 1952 to form the NTS. Subsequent withdrawals occurred in 1958, 1961, and 1962. A Memorandum of Understanding between NAFB and the NTS in 1967 allowed the use of Pahute Mesa by the NTS (DOE/NV 1991a; USAF et al. 1991).

Most of the tests performed at the NTS in the 1950s were atmospheric tests. After 1951, nuclear tests were carried out intermittently until a voluntary moratorium ended testing in October 1958. The first full-scale nuclear detonation occurred in 1957 in a sealed tunnel. Testing resumed in September 1961 following the ending of the moratorium. Atmospheric testing ended in the summer of 1963 following the signing of the Limited Test Ban Treaty. Since 1962, all testing has occurred underground. Two methods have been used for underground testing since 1963: vertical shafts (from the valley of Yucca Flat to the top of Pahute Mesa) and horizontal tunnels (Rainer Mesa) (DOE/NV 1991a; ERDA 1977; USAF et al. 1991).

In addition to underground testing, between 1962 and 1968, earth-cratering tests were conducted as part of the Plowshare Program. This program explored peaceful means of using nuclear explosives. Other tests which have occurred on the NTS have included the Bare Reactor Experiment (1960s) and the open air nuclear reactor, nuclear engine, and nuclear furnace tests (1959-1973). Much of the nuclear testing has been conducted on the NTS by the LANL, LLNL, SNL and, through the Defense Nuclear Agency, the DoD. Non-nuclear testing has included hazardous material spills. Other activities which occur on the NTS are the storage and disposal of low-level radioactive wastes and mixed wastes (DOE/NV 1991a; ERDA 1977; USAF et al. 1991).

As part of DOE's program to establish a national repository for high-level radioactive waste, Lawrence Livermore National Laboratory conducted an evaluation of the effects of radiation and heat from radioactive decay on granite rock formations. The project, known as Spent Fuel Test - Climax, stored 11 spent fuel elements from the Florida Power & Light Company and 6 electric heat simulators in specially designed and constructed holes in the Climax tunnel, located in the northeastern corner of the NTS in Area 15. The SNF, in hermetically sealed canisters, was emplaced in the granite formation, stored for approximately 3 years, retrieved, and then transferred, in 1986, to INEL for further testing (DOE/NV 1983, 1986a).

2.1.3 Nevada Operations Office Mission

The missions of the NTS and/or the DOE Nevada Operations Office include:

- Maintaining the capability to conduct underground nuclear weapons tests.
- Conducting all programs related to nuclear emergencies and threats.
- Supporting arms control, treaty verification, and non/counter proliferation of nuclear weapons technology.
- Supporting research activities as part of being designated a National Environmental Research Park.

- Conducting tests for the Liquefied Gaseous Fuels Spill Testing Program.
- Supporting studies in alternate energy sources and environmental management, research and development, and testing.
- Ensuring that all operations are conducted in compliance with all environmental, safety, and health laws, regulations, standards, agreements, and DOE Orders (DOE/NV 1993b, 1992a, 1991a; ERDA 1977).

2.1.4 Nevada Test Site Management

The DOE Nevada Operations Office is currently administering NTS operations. The NTS has multiple contractor support. The major support contractors are Reynolds Electrical & Engineering Co., Inc., the prime contractor; EG&G Energy Measurements, Inc., the electronic and instrumentation support contractor; Raytheon Services Nevada, the architect-engineering support contractor; and Wackenhut Services, Inc., the site security contractor.

2.1.5 Yucca Mountain Project

The DOE Office of Civilian Waste Management is conducting a program for siting the nation's first geologic repository for spent nuclear fuel and other high-level radioactive wastes. The Yucca Mountain Site has been designated by the U.S. Congress as a candidate site. Although Yucca Mountain is located outside the western boundary of the NTS, a contiguous portion of the NTS has been assigned as part of the potential repository site. Access to the site is accomplished through the NTS and Yucca Mountain Project field offices and support facilities are located in Area 25 (DOE/NV 1993b). Currently, Yucca Mountain is being characterized to study its suitability as a geological repository. The characterization study includes exploratory borings and analyses of meteorological, geological, hydrological, geochemical, erosion, tectonics, and socioeconomics conditions. Upon completion of the characterization study, the Secretary may recommend Yucca Mountain to the U.S. President as viable site for a repository (DOE 1988b).

2.2 Regulatory Framework

The National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321-4347, as amended) provides Federal agency decision makers with a process to systematically consider the potential environmental consequences of agency decisions. The DOE has prepared this environmental impact statement (EIS) in conformance with the requirements of this Act to evaluate the potential impacts of programmatic decisions on the management of SNF. This EIS will provide the necessary background, data, and analyses to help decision makers understand the potential environmental consequences of each alternative.

On October 22, 1990, the DOE published a Notice of Intent in the *Federal Register* (FR 1990a) announcing its intent to prepare a programmatic EIS addressing environmental restoration and waste management (including SNF management) activities across the entire DOE Complex. On October 5, 1992, the DOE published a Notice of Intent in the *Federal Register* (FR 1992) announcing its intent to prepare an EIS addressing environmental restoration and waste management and SNF activities at the Idaho National Engineering Laboratory. For further programmatic discussion of this topic, see Volume 1.

Significant Federal and state environmental and nuclear materials management laws are applicable to the NTS. The Federal laws are listed in Volume 1, Section 7.3. The State of Nevada laws are listed alphabetically below:

- Air Pollution Control Law (Title 40 Chapter 445)
- Air Quality Regulations (Title 40 Chapter 445)
- Disposal of Hazardous Waste (Title 40 Chapter 444)
- Disposal of Radioactive Material (Title 40 Chapter 459)
- Facilities for the Management of Hazardous Waste (Title 40 Chapter 444)
- Regulation of Highly Hazardous Substances (Title 40 Chapter 459)
- Solid Waste Disposal Act (Title 40 Chapter 444)
- Storage Tanks (Title 40 Chapter 459)
- Underground Injection Control (Title 40 Chapter 445)

- Water Pollution Control Law (Title 40 Chapter 445)
- Water Pollution Regulations (Title 40 Chapter 445)

2.3 Spent Nuclear Fuel Management Program

Currently, spent nuclear fuel is not generated, received, reprocessed, or stored at the NTS; therefore, a SNF management program does not currently exist for activities at the NTS (DOE 1993). There are no current or foreseeable environmental, safety, or health vulnerabilities at the NTS associated with SNF (DOE 1993). Selection of the No-Action Alternative would not adversely affect the operations or any planned facility modifications at the NTS.

3. SPENT NUCLEAR FUEL ALTERNATIVES

3.1 Description of Management Alternatives

This chapter describes the spent nuclear fuel (SNF) management alternatives evaluated by the U.S. Department of Energy (DOE) for Appendix F that are applicable to the Nevada Test Site (NTS). 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. For the purposes of conducting a thorough NEPA analysis, the NTS provides a contrast to other potential sites because it represents a site that has no existing SNF management infrastructure. The NTS does not currently generate or store any SNF. Hence, of the five alternatives discussed in this Programmatic Environmental Impact Statement (EIS), only two, Regionalization and Centralization, are applicable to the NTS. The other three alternatives -- No Action, Decentralization, and the 1992/1993 Planning Basis -- are not applicable to the NTS since they affect or involve only sites which currently generate or store SNF.

3.1.1 Alternative 1 - No Action

The No Action Alternative is restricted to the minimum actions necessary for the continued safe and secure management of SNF. As defined, this alternative stipulates no SNF shipments to or from DOE facilities. The NTS does not currently generate or store any SNF and would not receive any SNF under this alternative. Therefore, this alternative is not applicable to the NTS and is not analyzed or discussed further in this or subsequent chapters for the NTS.

3.1.2 Alternative 2 - Decentralization

Decentralization involves storage of SNF at or close to generation sites, with limited shipments to the Idaho National Engineering Laboratory (INEL) and Savannah River Site (SRS) as necessary to permit continued operation. Since the NTS does not generate or store any SNF and would not receive any SNF under this alternative, it is not applicable to the NTS and is not analyzed or discussed further in this or subsequent chapters for the NTS.

3.1.3 Alternative 3 - 1992/1993 Planning Basis

The 1992/1993 Planning Basis Alternative is DOE's documented 1992/1993 plan for the management of DOE and Naval SNF. Since the NTS does not generate or store any SNF and would not receive any SNF under this alternative, it is not applicable to the NTS and is not analyzed or discussed further in this or subsequent chapters for the NTS.

3.1.4 Alternative 4 - Regionalization

3.1.4.1 Overview. The Regionalization Alternative consists of two subalternatives. Subalternative A would distribute existing and new SNF between the Hanford Site, INEL, and SRS by SNF type. Under Subalternative B, SNF would be distributed to either an eastern or western regional site based on geographical location. SNF east of the Mississippi River would be shipped to the eastern region site (i.e., SRS or Oak Ridge Reservation (ORR)). SNF west of the Mississippi River would be shipped to the western regional site (i.e., Hanford, INEL, or NTS). Additionally, all Naval SNF would be shipped to only one of the sites, but not both. The ORR would be the alternative to the SRS as the eastern regional site, and the NTS would be the alternative to both the Hanford Site and INEL as the western regional site.

3.1.4.2 Regionalization Subalternative B. The following fuels would be transported to the NTS for storage under the Regionalization Subalternative B:

- Naval-type SNF (if selected)
  - All, including from the INEL, shipyards, and prototypes
- Hanford Production SNF
  - From western sites including the Hanford Site
- Graphite SNF
  - From western sites including the INEL and Public Service of Colorado

- DOE-Owned Commercial SNF
  - From western sites including the Hanford and INEL
- Experimental - Stainless steel SNF
  - From western sites including the Hanford, INEL, Foreign Research Reactors, and non-DOE domestic research reactors
- Experimental - Zirconium SNF
  - From western sites including the INEL
- Experimental - Other
  - From western sites.
- SRS Production and Aluminum SNF
  - From western sites including INEL, Los Alamos National Laboratory (LANL), Foreign Research Reactors, and non-DOE domestic research reactors

All SNF presently in storage at DOE facilities would arrive at the NTS stabilized and canned to the extent necessary for safe transportation. However, this SNF might need to be uncanned, stabilized, prepared, and recanned at the NTS to ensure safe interim storage. New non-DOE domestic, Foreign Research Reactors, and Naval SNF would be shipped in the state necessary for safe transportation but not necessarily canned. This fuel would be stabilized, prepared, and canned at the NTS to ensure safe interim storage. All fuel would be cooled for a minimum of 120 days prior to shipping and 5 years before being placed in dry storage. Additionally, if the NTS is selected for the Expended Core Facility, Naval SNF would be examined at the NTS before being turned over for interim storage management.

The NTS currently has no facilities that are suitable for receiving, canning, storing, or supporting the research activities necessary for the safe management of SNF. As a result, a new SNF management complex would be built at the NTS under the Regionalization Subalternative B. The SNF management complex would include the following:

- SNF receiving and canning facility
- Technology development facility
- Interim dry storage area

- Expended Core Facility similar to the one at the INEL (if selected for Naval Fuel Receipt).

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 technology development facility would 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. If NTS is selected for Naval fuel receipt, Naval SNF would be examined at the Expended Core Facility prior to being turned over for interim storage management.

The SNF management complex which would be built at the NTS under the Regionalization Alternative would have the same components as that built under the Centralization Alternative. However, the dry storage component would be somewhat smaller due to the smaller SNF inventory that would be transported to the NTS under the Regionalization Alternative. The other components of the SNF management complex would be the same general size as those built under the Centralization Alternative. This is because the inventories of new uncanned fuel which would be sent to the NTS under the Regionalization and Centralization Alternatives would be very similar. Additionally, since the major portion of the potential radiological and chemical releases and waste generation rates are associated with these components, the Regionalization Alternative will not be analyzed separately. This alternative will be compared to the Centralization Alternative in a semiquantitative manner.

If the NTS is not chosen as the western regional site, the Regionalization Alternative would not be applicable to the NTS.

3.1.5 Alternative 5 - Centralization

3.1.5.1 Overview. Under Centralization, all existing and new SNF would be shipped to one site. There are five Centralization options considered in this PEIS; Option A - Hanford Site, Option B - INEL, Option C - SRS, Option D - ORR, Option E - NTS. If the NTS was chosen as the centralization site, all SNF currently stored at the HS, INEL, SRS, ORR, and other sites currently storing DOE fuel would be transferred to the NTS.

3.1.5.2 Centralization Alternative Option E. The following fuels would be transported to the NTS for storage under the Centralization Alternative Option E:

- Naval-type SNF
  - From the INEL and shipyards
- Hanford Production SNF
  - From the Hanford Site
- Graphite SNF
  - From the INEL and Public Service of Colorado
- DOE-Owned Commercial SNF
  - From Hanford, INEL, West Valley Demonstration Project, and B&W Lynchburg
- Experimental - Stainless Steel SNF
  - From Hanford, INEL, SRS, FRR, and non-DOE domestic research reactors
- Experimental - Zirconium SNF
  - From the INEL and SRS
- Experimental - Other
  - From the Oak Ridge National Laboratory (ORNL)
- SRS Production and Aluminum SNF
  - From the INEL, SRS, ORNL, LANL, Brookhaven National Laboratory, Foreign Research Reactors, and non-DOE domestic research reactors.

All SNF presently in storage at DOE facilities would arrive at the NTS stabilized and canned to the extent necessary for safe transportation. However, this SNF may need to be uncanned, stabilized, prepared, and recanned at the NTS to ensure safe interim storage. New non-DOE domestic research reactor, Foreign Research Reactor, and Naval SNF would be shipped in a state necessary for safe transportation but not necessarily canned. This fuel would be stabilized, prepared, and canned at the NTS to ensure safe interim storage. All fuel would be cooled for a minimum of 120 days prior to shipping and 5 years before being placed in dry storage. Additionally, Naval SNF would be examined at the NTS before being turned over for interim storage management.

The NTS currently has no facilities that are suitable for receiving, canning, storing, or supporting the research activities necessary for the safe management of SNF. As a result, a new SNF management complex would be built at the NTS under the Centralization Alternative Option E. The SNF management complex would include the following:

- SNF receiving and canning facility
- Technology development facility
- Interim dry storage area
- Expended Core Facility similar to the one at the INEL.

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 technology development facility would 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 SNF would be examined at a new Expended Core Facility constructed at the NTS prior to being turned over for interim storage management.

The SNF management complex which would be built at the NTS under the Centralization Alternative would have the same components as those built under the Regionalization Alternative. However, the dry storage component would be somewhat larger under the Centralization Alternative due to the somewhat greater SNF inventory that would be transported to the NTS under this alternative. The other components of the SNF management complex would be the same general size as those built under the Regionalization Alternative. This is because the inventories of new uncanned fuel which would be sent to the NTS under the Regionalization and Centralization Alternatives would be very similar. Additionally, the major portion of the potential radiological and chemical releases and waste generation rates are associated with these components, and would not be significantly different for the two alternatives. Therefore, this alternative will be used as the basis for a semiquantitative comparison with the Regionalization Alternative.

If the NTS is not chosen as the centralization site, the Centralization Alternative would not be applicable to the NTS.

3.2 Comparison of Alternatives

Table 3.2-1 shows a comparison of the alternatives. The Regionalization Alternative column does not include the requirements of the Naval Expended Core Facility, although this facility may be constructed at the site under this alternative. The Centralization Alternative column does include the requirements of the Naval Expended Core Facility, which are presented in Volume 1, Appendix D, since this facility will be built at the site under this alternative.

Table 3.2-1. Comparison of alternatives for the NTS.

Parameter	Regionalization Subalternative B at NTS	Centralization Option E[a]
Land for new facilities (acres)	90	120
Site area (acres)	864,000	864,000
Percent of site area	0.01	0.01
SNF-related employment[b]	556	1,118
Baseline site employment	8,563	8,563
Percent of baseline site employment	6.5	13.1
Estimated cancer fatalities in 80-km population per year, SNF management operations[c]	4.1×10^{-5}	4.1×10^{-5}
Estimated cancer fatalities in 80-km population per year, other site operations	2.6×10^{-6}	2.6×10^{-6}
Estimated probability of cancer fatalities in a maximally exposed individual per year, SNF management operations[c]	5.9×10^{-8}	5.9×10^{-8}
Estimated probability of cancer fatalities in a maximally exposed individual per year, other site operations	5.5×10^{-9}	5.5×10^{-9}
Estimated probability of cancer fatality in average worker per year, SNF management operations[c]	1.6×10^{-5}	1.6×10^{-5}
Estimated maximum probability of cancer fatality in average worker per year, other site operations	2.0×10^{-6}	2.0×10^{-6}
Water use (million gallons) per year, SNF management	3.6	6.1
Baseline water use (million gallons) per year, site operations	1,120	1,120
Percent of baseline site water use	0.32	0.54
Electricity use (megawatt-hours) per year, SNF management	23,000	33,000
Baseline electricity use (megawatt-hours) per year, site operations	183,100	183,100
Percent of baseline site electricity use	12.56	18.02
Sewage discharge (million gallons) per year, SNF management	3.6	6.1
Baseline sewage discharge (million gallons) per year, site operations	0	0

Table 3.2-1. (continued).

Parameter	Regionalization Subalternative B at NTS	Centralization Option E[a]
Percent of baseline site sewage discharge	NA	NA
High-level waste (cubic meters) per year, SNF management	0	0
Transuranic waste (cubic meters), SNF management	16	16
Mixed waste (cubic meters), SNF management	0	0
Low-level waste (cubic meters), SNF management	203	628
Estimated maximum cancer fatalities in 80-km population from maximum risk accident[d]	6.6×10^{-4}	
Frequency of occurrence (number per year)[d]	1.6×10^{-1}	
Estimated maximum risk of cancer fatalities in 80-km population from maximum risk accident (cancer fatalities per year)[d]	1.1×10^{-4}	
Estimated maximum worker cancer fatalities from maximum risk accident[d]	1.9×10^{-3}	
Frequency of occurrence (number per year)[d]	1.0×10^{-4}	
Estimated maximum risk of worker cancer fatalities from maximum risk accident (cancer fatalities per year)[d]	1.9×10^{-7}	

a. Centralization Option includes the Naval Expended Core Facility results from Volume 1, Appendix D.
b. Annual Average SNF direct construction and operation jobs over the 10-year period 1995 to 2005.
c. Excludes baseline site operations.
d. Centralization Option is the same as the Regionalization Option for the SNF Management Facility and does not include the Naval Expended Core Facility accident analyses results from Volume 1, Appendix D.

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4. AFFECTED ENVIRONMENT

4.1 Overview

This chapter describes the existing environmental conditions in areas potentially affected by a programmatic decision to site spent nuclear fuel (SNF) facilities at the Nevada Test Site (NTS) under the Centralization and Regionalization Alternatives. Topics were selected for analysis based upon their potential to be affected by the alternatives. Each topic is addressed in the detail necessary to serve as a baseline for assessment of potential environmental consequences in Chapter 5.

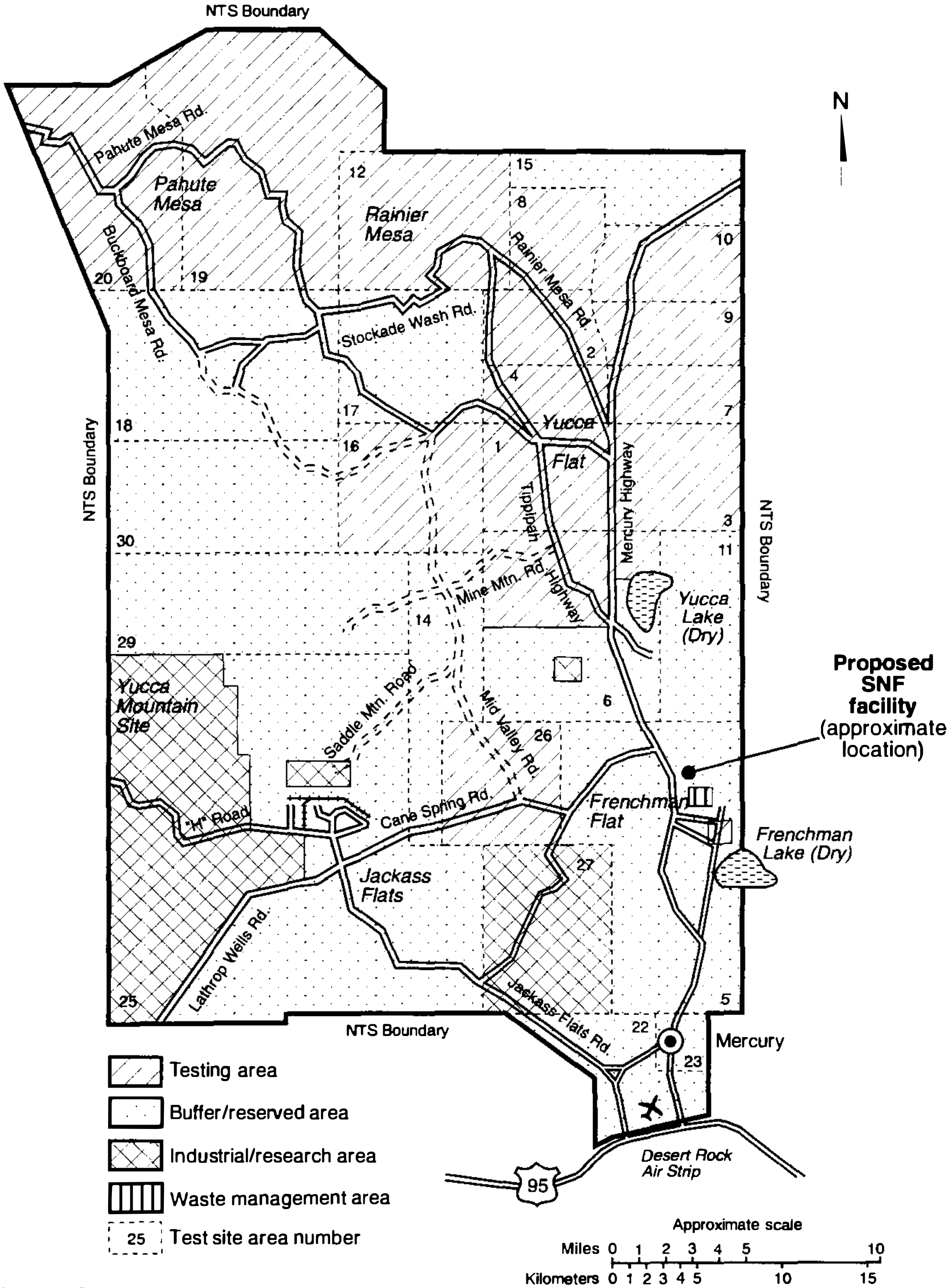
4.2 Land Use

The NTS occupies an area of approximately 1,350 square miles (3,500 square kilometers) in southern Nevada, in a sparsely populated desert area approximately 65 miles (104 kilometers) northwest of Las Vegas. The NTS is almost entirely surrounded by other federally owned lands which buffer it from lands open to the public. The NTS is bordered by the Nellis Air Force Base (NAFB) Bombing and Gunnery Range on the north, east, and west, and by Bureau of Land Management (BLM) lands on the south and southwest (DOE/NV 1993a,b).

Existing land use on the NTS falls into four general categories: Testing Areas; Buffer/Reserved Areas; Industrial/Research Areas; and Waste Management Areas. According to the latest NTS land use map (Figure 4.2-1), approximately 50 percent of the land on the NTS is buffer/reserved area for ongoing programs or projects (DOE/NV 1993a).

Land bordering the site to the north, east, and west is located on the NAFB Bombing and Gunnery Range and is primarily vacant, unused, or used for a buffer zone. Land bordering the site to the south and southwest is owned by the BLM and is used for recreation, grazing, forest management, or wildlife management (DOE/NV 1993a,b).

The NTS is located in an area of sparsely vegetated desert. Beyond the federally owned lands which surround the NTS, principal land uses in Nye County in the vicinity of the NTS



Source: DOE/NV 1993a.

Figure 4.2-1. Land use at the Nevada Test Site.

include mining, grazing, agriculture, and recreation (DOE/NV 1993a). Urban and residential land uses occur beyond the immediate vicinity of the NTS, in fertile valley regions such as the Owens and San Joaquin to the west of the site, the Virgin River to the east of the site, the Pahrump to the south of the site, the Moapa River to the southeast of the site, and the Hiko and Alamo to the northeast of the site (DOE/NV 1993b).

Clark County, to the southeast of the NTS, consists of approximately 7900 square miles (20,220 square kilometers) of which about 95 percent is owned by the federal government (ULI 1992). Primary land uses on these federal lands include grazing, mining, and recreation. The remaining 5 percent of the county supports residential, state and local government, industrial, and retail land uses (Clark County Regional Transportation Commission 1992).

Currently, Nye County does not have a zoning ordinance; therefore, no zoning classification exists for NTS lands. The NTS is required to comply with State of Nevada regulations for air pollution, safety, and transportation, and with Nye County traffic regulations and safety codes (DOE/NV 1993b). Of the total area within Nye County, only a small number of isolated areas are under private ownership and therefore subject to general plan guidelines (NEEDA 1993).

Numerous national, state, and local public recreation areas exist within the NTS region (Figure 2.1-1). Outdoor recreational areas include the Death Valley National Monument, located 12 miles (19 kilometers) to the west/southwest, and the Desert National Wildlife Range, approximately 25 miles (40 kilometers) east. (Portions of the Desert National Wildlife Range are located within NAFB Bombing and Gunnery Range and are as close as 2 miles (3 kilometers) to the NTS). State parks near the site include; the Red Rock Canyon Recreation Lands, approximately 40 miles (64 kilometers) to the southeast; Spring Mountain Ranch State Park, approximately 50 miles (80 kilometers) southeast; and the Floyd R. Lamb State Park, approximately 45 miles (72 kilometers) southeast (BLM 1990).

Other recreational areas include numerous campsites, picnic areas, and sports grounds south of the site in the Toiyabe National Forest, approximately 25 miles (40 kilometers) southeast, and numerous camping and fishing sites north of the site which are used during the spring, summer, and fall months (DOE/NV 1993a,b,c).

The NTS is a controlled area with public access limited to through traffic on U.S. Route 95 and on Lathrop Wells Road (DOE/NV 1993b).

The proposed SNF site is in the northeast portion of Area 5, located in the southeastern part of the NTS. This area is currently designated as the Low-Level Waste Facility Management Area and Buffer/Reserved Area land use categories. This area was also designated as a Non-Nuclear Test Area in the latest NTS Future Land Use Plan (DOE/NV 1993a).

To the east of Area 5, the NTS is bordered by the NAFB Bombing and Gunnery Range, which provides a buffer zone of approximately 50 miles (80 kilometers) between the NTS and lands open to the public. Beyond the NAFB Bombing and Gunnery range land, land uses to the east of the NTS are primarily mining, grazing, and agriculture (BLM 1990; DOE/NV 1993a).

There are no onsite areas that are subject to Native American Treaty rights or contain any prime or unique farmland.

4.3 Socioeconomics

4.3.1 Region of Influence

The socioeconomic information presented in this Programmatic Environmental Impact Statement (PEIS) discusses the baseline conditions in a Region of Influence comprising of Nye and Clark Counties, Nevada. This is the region potentially affected by the principal direct and indirect socioeconomic effects of actions on the NTS. This Region of Influence includes the current residential distribution of the U.S. Department of Energy (DOE) and contractor personnel employed by the NTS, the probable location of offsite contractor operations, and the probable location of labor and capital supporting indirect economic activity linked to the NTS.

The residential distribution of most of the DOE and contractor personnel employed by the NTS reflects existing commuting patterns and attractiveness of area communities. A survey of NTS worker residential distributions in 1988 revealed that 86 percent lived in Clark County and

10 percent in Nye County (DOE 1988a). In Clark County, most NTS employees reside in the Las Vegas vicinity.

The two-county Region of Influence includes several communities located within a driving time of approximately 1 hour from the NTS, including Boulder City and the Las Vegas Valley (includes the "incorporated places" of Henderson, Las Vegas, and North Las Vegas; and the "census-designated places" of East Las Vegas, Enterprise, NAFB Bombing and Gunnery Range, Paradise, Spring Valley, Sunrise Manor and Winchester) in Clark County, and Pahrump and Beatty in Nye County (DOE/NV 1993a,b).

4.3.2 Regional Economic Activity and Population

Regional economic linkage supporting production activity at the NTS occurs primarily with Clark County, where most of the offsite supporting contractors and the labor and capital supporting indirect economic activity linked to the NTS are located.

4.3.2.1 Clark County (Las Vegas Metropolitan Statistical Area[1]). Clark County is composed of five incorporated cities (Las Vegas, Henderson, North Las Vegas, Boulder City, and Mesquite) and large expanses of unincorporated land, some of which are experiencing strong growth. The area experiencing the majority of the county's development is the Las Vegas Valley (ULI 1992). In addition, 95 percent of the total area within the county is owned by the Federal government and includes several state parks, vast stretches of desert, and military installations.

Economic conditions in southern Nevada since the mid-1980s have grown continuously. Economic growth has accelerated relative to national trends due to an expansion in hotel and gaming markets, relocation of retirees to southern Nevada, expansion of local infrastructure, and additional unplanned investment to house new families in the region. The overall long-term growth pattern is forecasted to gradually change the current robust expansion to more stable

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[1] At the time of the 1990 census, Clark County and the Las Vegas Metropolitan Statistical Area were synonymous. The Census Bureau subsequently redefined the Las Vegas Metropolitan Statistical Area to include Mohave County, Arizona. However, the numbers provided here reflect the 1990 census definition.

growth conditions, as seen in the United States (The Center for Business and Economic Research 1992).

The economy in the Las Vegas Metropolitan Statistical Area is driven by growth in the hotel and gaming industry. Because of its orientation toward tourism and conventions, the economy is highly service oriented. Service employment in the Las Vegas area is substantially higher than the relative national share, accounting for nearly 45 percent of total employment, with hotels and gaming accounting for approximately 30 percent of the service factor. Trade employment accounts for 21 percent, and government and construction each account for an additional 10 percent (ULI 1992). Construction employment has increased over 130 percent since 1980, with 32,000 jobs in that sector in 1993 particularly due to the building and expansion of a number of casinos in Clark County (DOE/NV 1993a). The industrial market has also induced growth in the construction sector, causing a 50 percent increase in new construction activity between 1990 and 1992. Growth in the industrial market is expected to continue, with demand outpacing new construction (ULI 1992). Manufacturing employment is increasing steadily (7 percent from 1992 to 1993); however, this sector comprises only a 2.8 percent share of total employment (DOE/NV 1993a), still well below the national average.

Between 1980 and 1990, Clark County added an average of 15,000 jobs per year. By year-end 1991 another 19,000 jobs had been added to the employment base for 1990, for a total of 388,000 jobs (ULI 1992). In September 1992, employment in the Las Vegas area reached 399,900. Despite the national recession during 1990-1992, the number of existing jobs in the Las Vegas area increased rapidly, averaging an 8.1 percent gain during that period (DOE/NV 1993a).

The number of existing jobs in the Las Vegas area is projected to continue increasing for the next several years. The State of Nevada Employment Security Research Department estimated there would be a total of 125,190 new jobs in the Las Vegas area between 1991 and 1996, an increase of approximately 6 percent annually (DOE/NV 1993a).

The unemployment rate reached a low of 4.9 percent in 1990 and increased to 7.5 percent as of June 1993 (DOE/NV 1993a). The increase in unemployment reflected the fact that the in-migration of labor exceeded the growth in employment opportunities. However, the unemployment level is expected to decrease with new hotel, gaming, and amusement properties opening at the end of 1993 (DOE/NV 1993a).

Most of the population in the Las Vegas Metropolitan Statistical Area is centered in the Las Vegas Valley, with six population groupings in the area: the Las Vegas Valley, Boulder City, Indian Springs, Laughlin, Mesquite, and the Moapa Valley (DOE/NV 1993b). In 1990, the population of the metropolitan statistical area totaled 735,000, growing at a rate of 4.7 percent annually from 1980 (ULI 1992). This rate of growth, however, is lower than that near the end of the 1980s. The population of the metropolitan statistical area was estimated at over 900,000 as of August 1993, an increase of nearly 8 percent annually since 1990 (DOE/NV 1993b).

4.3.2.2 Nye County. The employment level in Nye County (11,310 jobs) is low relative to Clark County, and includes opportunities in the services, mining, and government sectors (DOE/NV 1993b).

Nye County is sparsely populated, with the two largest population groupings being in the unincorporated communities of Pahrump and Tonopah. The populations of Pahrump and Tonopah in 1990 were 7,424 and 3,616 (62 percent and 20 percent of the county total), respectively (DOE/NV 1993b).

Tourist (and business traveller) activity is an important part of the Nye County economy in communities along U.S. Route 95; however, in each community, mining is the major, even dominant, economic force.

In the 1970s and 1980s, nuclear weapons testing at the NTS dominated the Nye County economy when described in terms of employment by place of work. Most of the NTS work force commutes to Mercury or forward areas from the Las Vegas Valley, and most food and other services are provided at federally subsidized facilities onsite. However, some Nye County businesses do provide NTS support services. In the context of the Yucca Mountain repository oversight program, Nye County and DOE have engaged in efforts that could lead to greater employment and procurement opportunities for Nye County residents and businesses (NEEDA 1993).

4.3.2.3 Nevada Test Site. The NTS work force supports engineering design, construction, and operation of the site and includes people employed by DOE and people employed by DOE contractors. The total NTS work force in 1993 included nearly 4,000 jobs located at the NTS and an additional 5,000 jobs in the Nevada Operations Office (DOE/NV 1993a). As of January 1994, the work force totaled 8,563 (3,286 on NTS, 3,805 in Las Vegas, and 1,472 in the rest of Nevada or other areas). There is currently no SNF-related employment at NTS (DOE/NV 1994a).

4.3.2.4 Aggregate Regional Economic and Demographic Baseline. For the purposes of establishing a regional baseline to assess potential impacts for the programmatic analyses in Section 5.3, regional economic and demographic data for Clark and Nye counties were aggregated to form one region (Table 4.3-1).

The total population of this Region of Influence is projected to be 998,093 persons in 1995 and to grow at an annual average rate of 2.7 percent, reaching 1,281,666 persons in 2004. The labor force of the Region of Influence is projected to grow at an annual average rate of 3.1 percent, reaching 792,309 persons in 2004. The total employment in the Region of Influence is projected to grow at an annual average rate of approximately 3.1 percent from 552,439 jobs in 1995 to 734,589 jobs in 2004.

4.3.3 Public Service, Education and Training, and Housing Infrastructure

4.3.3.1 Police and Fire. The NTS's fire protection capacity is structured to accommodate current mission requirements, with a self-contained firefighting department responsible for suppression and prevention. Other services include rescue, hazardous material response, training of fire personnel, fire prevention inspections, installation of all fire extinguishers at the NTS, and fire prevention awareness programs. In addition, the DOE has signed an agreement whereby the Nye County Fire Department will assist the Clark County Fire Department in case of an emergency at the NTS (DOE/NV 1993a).

The Las Vegas Fire Department is spending $9.7 million to build three new fire stations in the northwest area of the city to support growing public service demand in this area. The Clark

Table 4.3-1. Aggregate regional economic and demographic indicators for the NTS.[a]

Years	Regional employment	Regional labor force	Regional population
1995	552,439	595,851	998,093
1996	573,279	618,329	1,033,234
1997	594,916	691,666	1,069,422
1998	617,450	665,968	1,107,037
1999	640,822	691,175	1,145,711
2000	665,060	717,317	1,185,766
2001	681,956	735,538	1,209,316
2002	699,258	754,197	1,233,372
2003	716,971	773,299	1,257,672
2004	734,589	792,309	1,281,666
2005	752,356	811,483	1,305,461
Average Annual Growth Rate	3.1%	3.1%	2.7%

a. Sources: Nye County Board of Commissioners (1993); The Center for Business and Economic Research (1992).

Note: Aggregate region includes Clark and Nye Counties. Labor force projection developed for this study.

County Fire Department plans to add two new fire departments within the next 5 years. There is a mutual agreement between the Clark County Fire Department and all surrounding area departments to assist in any fire emergency when necessary (DOE/NV 1993a).

Law enforcement at the NTS is provided by the Nye County Sheriff. Security enforcement, established to accommodate the requirements of NTS's mission, is the responsibility of a private contractor. Regional law enforcement services are provided principally by the Las Vegas Metropolitan Police Department. Las Vegas ranks fourth nationally in metropolitan statistical areas in police per capita, with 1 per 277 population (DOE/NV 1993a).

4.3.3.2 Health Care. The NTS has a self-contained medical center that provides limited emergency treatment. Health care in the Las Vegas metropolitan area is provided through 13 full-service hospitals, with 3.44 hospital beds per 1,000 population. A major proposed health care facility is scheduled to open in 1994 to accommodate demand (DOE/NV 1993a).

4.3.3.3 Education and Training. The Clark County School District provides education services for the families of the majority of the employees who work at the NTS. Enrollment in the Clark County School District was approximately 122,000 student in 1992 and was projected to be 136,000 students in 1993. An average student/teacher ratio of 22.32 is reported for elementary school grades K-6; the student/teacher ratio is not reported for other grades (DOE/NV 1993a).

Higher education and training resources provided by the NTS include the support provided by the DOE Contractor Education and Training Departments, with technical training in areas such as Radiation Protection Training, Radiological Response Training, Environmental and Health Training (which includes Hazardous Waste, Site Operation, and Emergency Response) to support NTS's mission. In addition, there are a number of vocational, training, and higher education institutions in the Las Vegas metropolitan area (DOE/NV 1993a).

Since 1990, southern Nevada has experienced tremendous growth in school enrollment. To accommodate the influx of students, the school district was able to negotiate the largest bond sale in Nevada history along with regular allocations from the Nevada legislature (DOE/NV 1993a).

4.3.3.4 Housing. Between 1980 and 1990, the number of housing units in Clark County increased by 84 percent, from approximately 174,000 to approximately 320,500. The housing market continues to flourish, as the demand for new housing has consistently exceeded the supply (ULI 1992). The increase in demand is attributable to the influx of retirees and other in-migrant population.

Residential building permits, which peaked in 1988 at 26,400 units, declined to 13,500 units in 1991. Between 1991 and 1995, the number of permits issued is expected to average 15,000 units per year (ULI 1992). Demand is projected to outpace supply over the next 5 years, given the strong projections for population and employment (ULI 1992).

4.4 Cultural Resources

4.4.1 Archaeological Sites and Historic Structures

For approximately 12,000 years, people have inhabited the lands now comprising the NTS site. The availability of surface water was the primary determinant governing the location of past human occupation on these lands. On what is now the NTS, access to surface water was through springs located in canyons and at the bases of mountains and mesas. Therefore, there is very little evidence of human occupation in valleys or playas where surface water sources were unavailable, including the Frenchman Flat area where the proposed SNF site would be located (DOE/NV 1993b).

Three cultural resource surveys were conducted in the vicinity of the proposed site. Two archaeological sites were recorded but neither was considered potentially eligible for listing on the National Register of Historic Places (DRI 1991, 1989, 1987). As a result, no prehistoric or historic resources are expected to be located on the proposed SNF site.

4.4.2 Native American Resources

The Southern Paiute and Shoshone Native American tribes are known to have inhabited southern Nevada including parts of what is now the NTS. These tribes are known to be affiliated with sites located in the northern portions of NTS including the Pahute and Rainier Mesas. However, no known Native American resources are located within the proposed SNF site (DRI 1986a).

4.4.3 Paleontological Resources

The NTS is characterized by alluvium-filled, topographically closed valleys surrounded by ranges composed of Paleozoic sedimentary rocks and Tertiary volcanic tuffs and lavas. Although igneous rocks do not contain fossils, the deposits might contain late Pleistocene terrestrial vertebrate fossils (Sandia National Laboratories 1982).

4.5 Aesthetics and Scenic Resources

Visual or scenic resources comprise the natural and manmade features that give a particular environment its aesthetic qualities. These features form the overall impression that a viewer receives of an area or its landscape character.

Scenic resources at the NTS are set in a landscape which is a transition area between the Mojave Desert and the Great Basin, with vegetation ranging from grasses and creosote bush in the lower elevations to juniper, pinyon pine and sagebrush in elevations above 5,000 feet (1,524 meters) (DOE/NV 1993b). The topography of the NTS consists of a series of mountain ranges arranged in a north-south orientation separated by broad valleys (DOE/NV 1993b). The topography is also characterized by the presence of numerous craters produced by past nuclear testing at the NTS. Of the three principal valleys located within the NTS, Frenchman Flat surrounds the proposed location of the SNF site (BLM 1990). Access to the NTS is from U.S. Route 95, which runs in an east-west direction along the south side of the NTS at Mercury Valley (BLM 1990). The Mercury Highway, which runs north from the Mercury Base Camp, is a restricted access road that is not available for public access (Figure 2.1-2).

The proposed SNF site at the NTS is set along the east side of the Mercury Highway in Area 5, within the Frenchman Flat. The proposed SNF site is located in the vicinity of the existing Radioactive Waste Management Site. The land cover in this area is typical desert vegetation.

The viewshed surrounding the NTS consists of unpopulated to sparsely populated desert and rural lands. Since the NTS is surrounded to the east, north and west by the NAFB Bombing and Gunnery Range and to the south by lands controlled by the BLM, the only public views into the interior of the NTS are from U.S. Route 95. Since the southern boundary of the NTS is ringed by various mountain ranges, including the Spector Range, Striped Hills, Red Mountain, and the Spotted Range, views to the interior of the site are generally limited to the Mercury Valley and the Mercury Base Camp (BLM 1990).

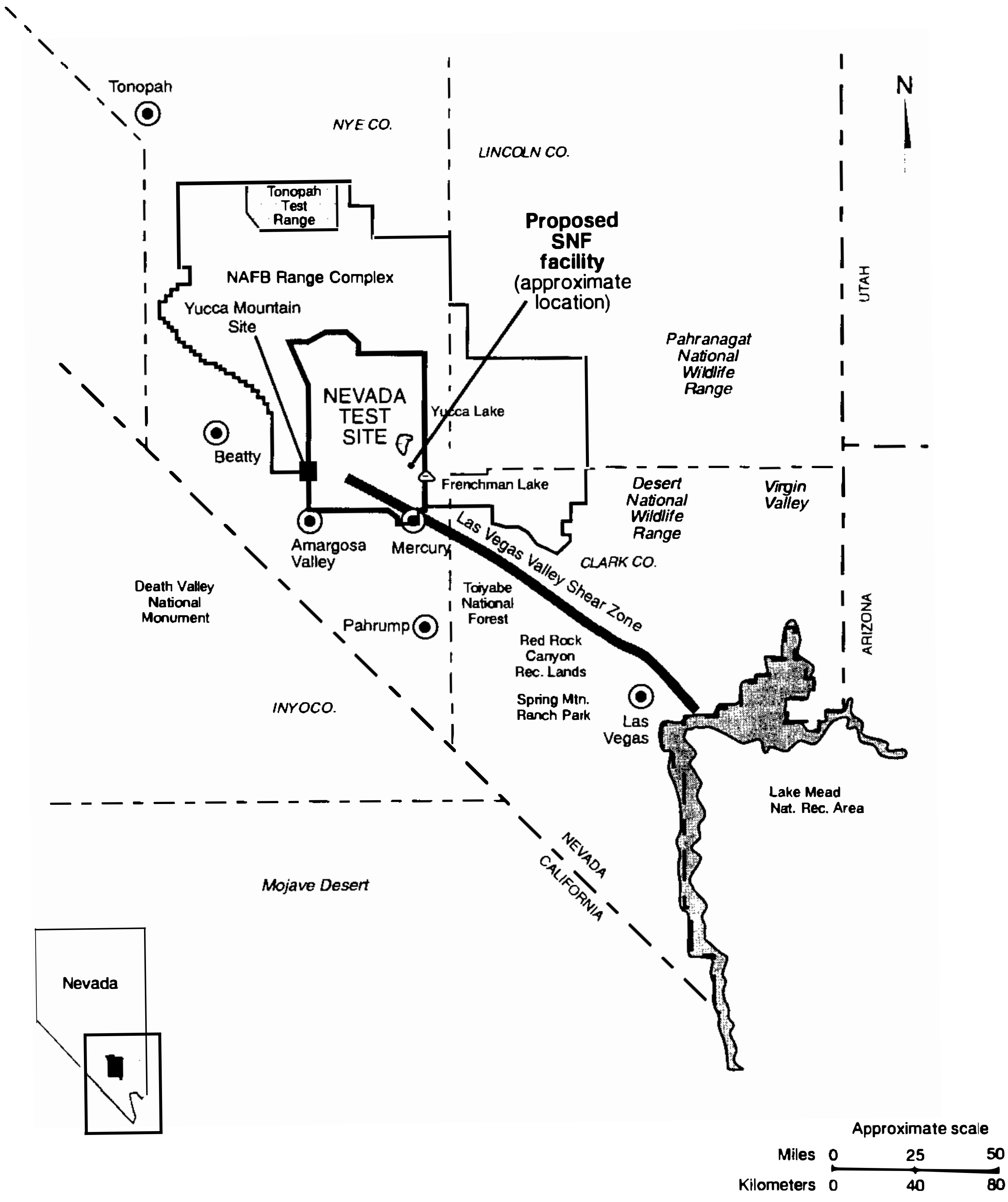
Low sensitivity exists when the public can be expected to have little or no concern about changes in the landscape. Little value may be ascribed to the views, or they may be similar to others in the area. In general, due to the mixture of industrial uses, open desert, and restricted access, the NTS could be classified as having low visual sensitivity.

4.6 Geologic Resources

This section provides a description of the general geology, geologic resources, and seismic and volcanic hazards at the NTS and surrounding area. This section also describes any existing impacts to the geology and geologic resources that have resulted from past and present activities conducted at the NTS.

4.6.1 General Geology

As shown on Figure 4.6-1, the NTS is located east and north of the Walker Lane–Las Vegas Valley Shear Zone (Eckel 1968). Walker Lane is a northwest-trending belt of right-lateral faults that disrupts the regional structural grain in the southwestern part of the Great Basin along the California-Nevada border. The Las Vegas Valley shear zone is a concealed zone of right-lateral faulting along the north side of the Las Vegas Valley (DOE 1988b). Whether the Walker Lane-Las Vegas Valley Shear Zone comprises a continuous single fault or two faults is debatable. Most geologists consider it to be a single fault system, which in the NTS area is buried beneath



Sources: Eckel 1968; DOE 1988b.

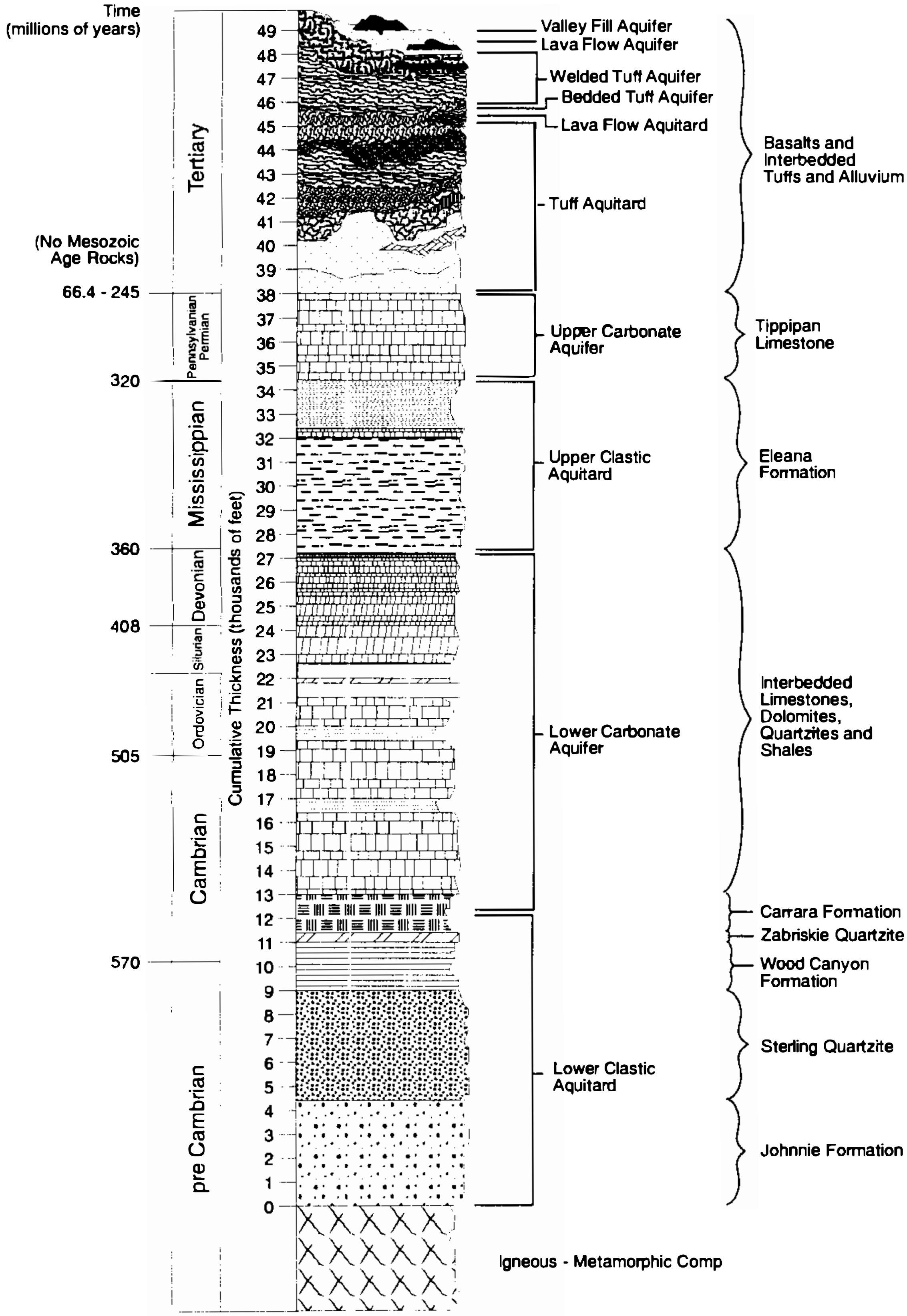
Figure 4.6-1. Location of Nevada Test Site in relation to regional fault zones.

thick Tertiary strata (Eckel 1968). The NTS also lies in the southern part of the Great Basin Section of the Basin and Range Physiographic Province. The local geology of the NTS is characterized by mountain ranges composed of Precambrian and Paleozoic sedimentary rocks and Tertiary volcanic tuffs and lavas that surround alluvium-filled, topographically closed valleys. A generalized stratigraphic column of the area is shown on Figure 4.6-2 (Sandia National Laboratory 1982). Figure 4.6-2 also shows the six aquifers and four aquitards of the NTS area (see Section 4.8). A schematic cross section illustrating NTS geology is shown on Figure 4.6-3 (DOE 1986). A geologic map of the NTS is shown as Figure 4.6-4 (DOE/NV 1993b).

The sedimentary rocks are complexly folded and faulted and are comprised mainly of carbonates (dolomite and limestone) in the upper and lower parts of the column and clastics (shale and sandstone) in the middle section. Above the approximately 4,000 meters (13,000 feet) of Precambrian to Cambrian clastic deposits are approximately 4,300 meters (14,000 feet) of Cambrian through Devonian carbonates, 2,400 meters (8,000 feet) of Mississippian shales and sandstones, and 900 meters (3,000 feet) of Pennsylvanian to Permian limestones (Sandia National Laboratory 1982).

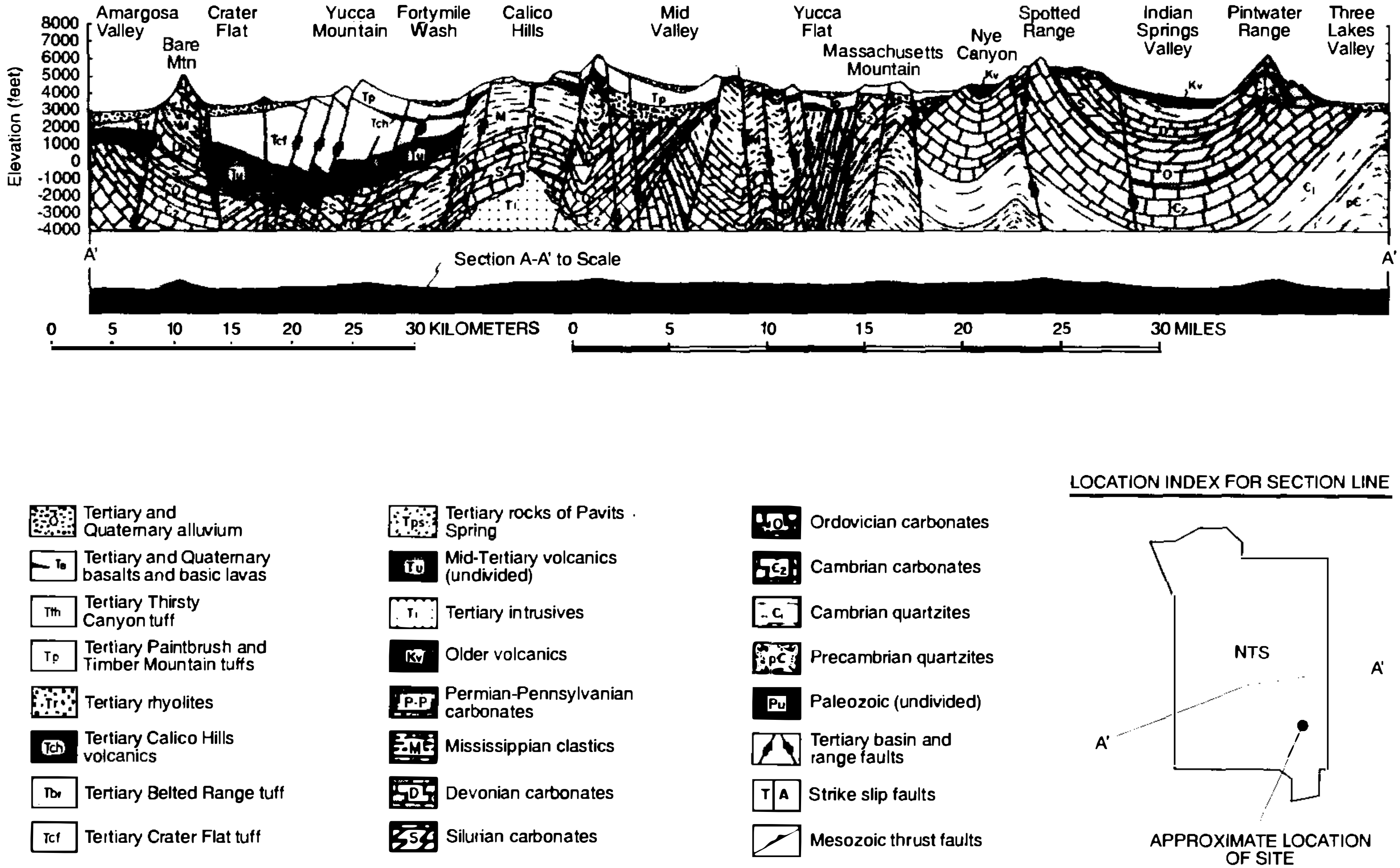
The volcanic rocks in the NTS area are predominantly Tertiary tuffs that are high in silica. Although there are minor amounts of Tertiary basalts and a few scattered Mesozoic granitic plutons in the area (Sandia National Laboratory 1982), the Tertiary tuffs comprise approximately 70 percent of the rocks exposed at the surface (Eckel 1968).

The valleys formed between steeply dipping faults that have become filled with alluvium and comprise approximately 30 percent of the area (Eckel 1968). This generally unconsolidated alluvium is derived from erosion of nearby hills composed of Tertiary and Paleozoic rocks and ranges in thickness from 600 to 900 meters (2,000 to 3,000 feet) (DOE/NV 1992c). Some layers are cemented by calcium carbonate (caliche) and/or clays. The alluvial materials are better sorted and finer grained toward the center of the basins. The sediments in the playas (flat-floored undrained desert basins tbat, at times, become shallow lakes) consist of very fine-grained lacustrine deposits up to several tens of meters (feet) thick. Near the range fronts, alluvium is generally composed of angular rubble, with individual clasts commonly a foot or more in diameter surrounded by a matrix of silt, sand, and gravel (Sandia National Laboratory 1982).



Source: Sandia National Laboratory 1982.

Figure 4.6-2. Stratigraphic column of the Nevada Test Site.



Source: DOE 1986.

Figure 4.6-3. Schematic cross section portraying the geologic complexity of NTS.

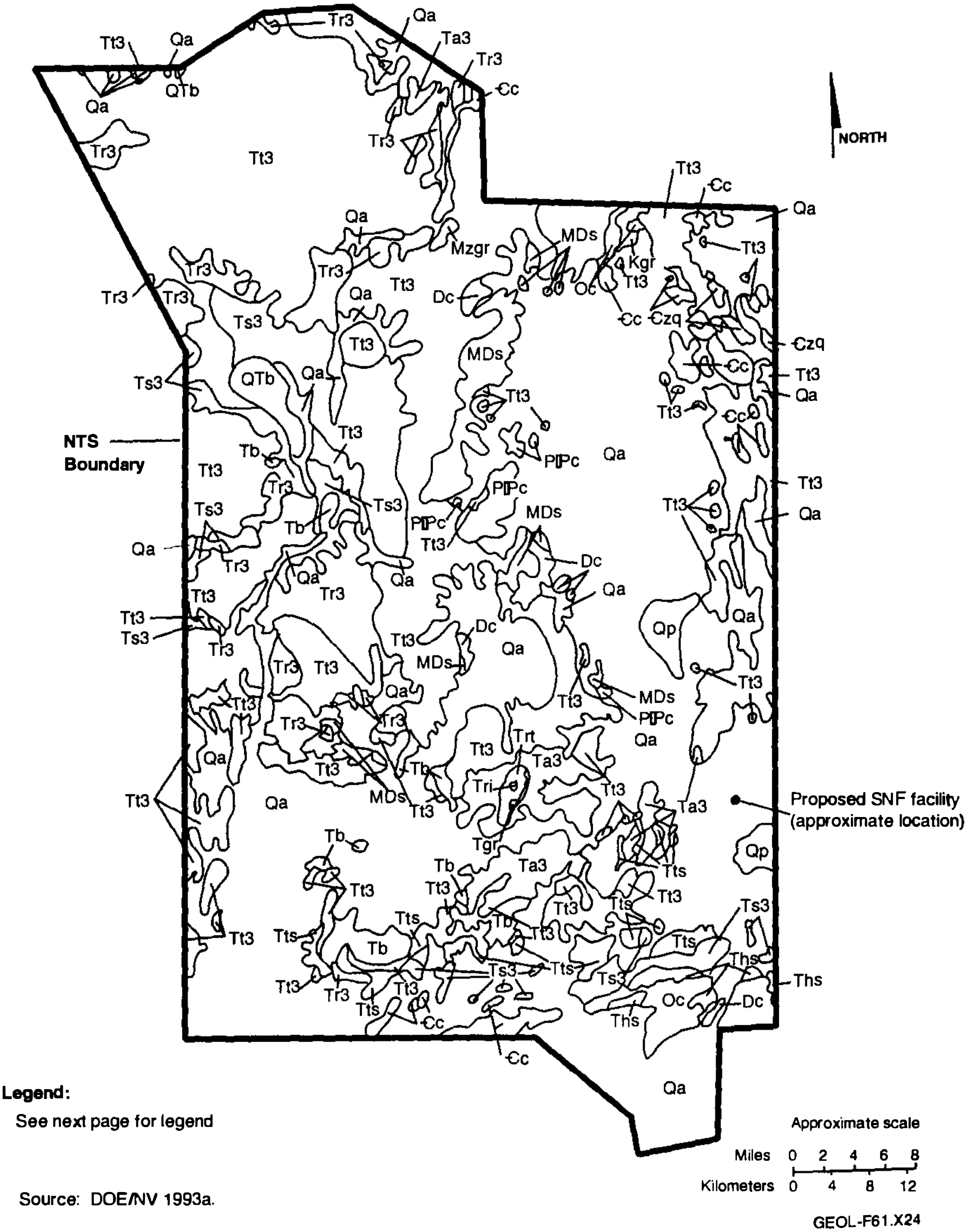


Figure 4.6-4. Geologic map of the NTS.

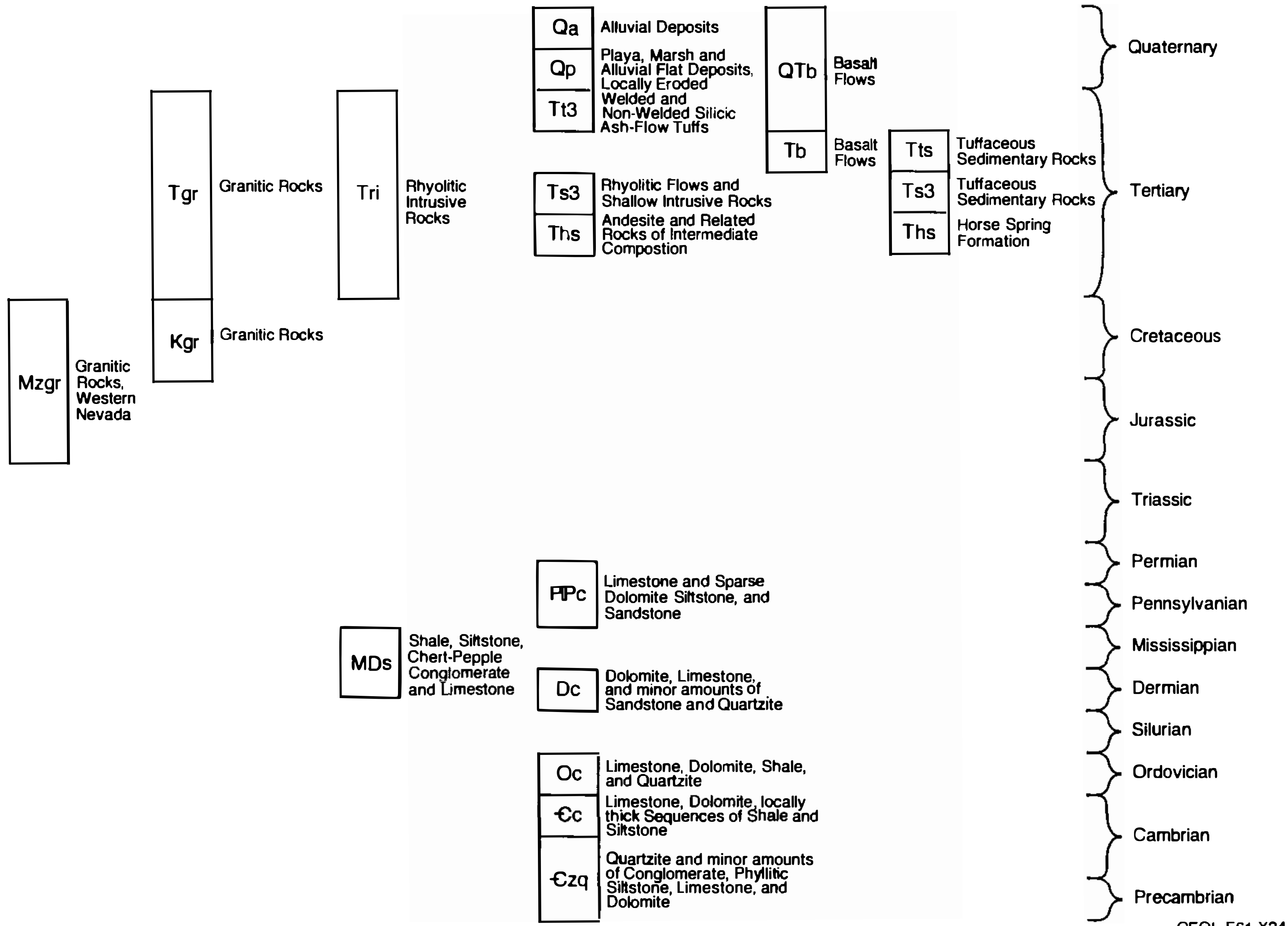


Figure 4.6-4. Geologic map of the NTS (continued).

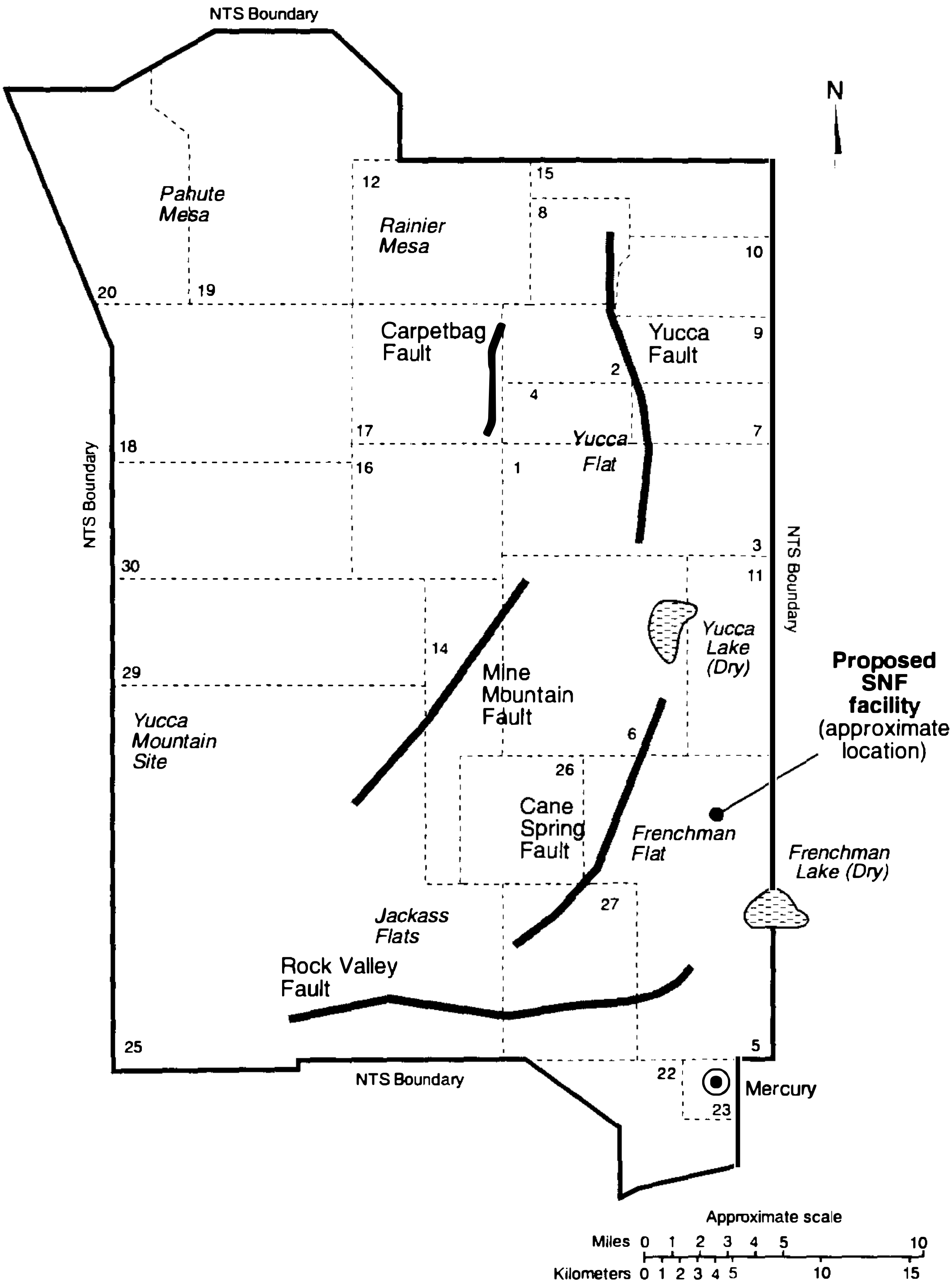
Faulting in the NTS area generally occurs as thrust faults (faults having shallow inclinations, mostly between 10 and 20 degrees), normal faults (faults with downward displacement of the face of the rock that lies above the fault), and strike-slip faults (nearly vertical faults characterized by shear zones) (DOE/NV 1992c). The faults located at NTS are shown on Figure 4.6-5 (DOE/NV 1993b). Thrust faulting in the NTS area occurs as three major thrust faults, with the total displacement along this fault system ranging from 40 to 48 kilometers (25 to 30 miles). Normal faults in the NTS area exist in both ranges and valleys and generally strike northeast and northwest, while a set of younger and potentially active faults strike north. The nearest strike-slip structure to the NTS is the Walker Lane-Las Vegas Valley Shear Zone (see Figure 4.6-1). Estimates of horizontal displacement along this shear zone range from 40 to 160 kilometers (25 to 100 miles) (Sandia National Laboratory 1982).

At the NTS, recent displacement has occurred along several faults as a consequence of underground nuclear explosions. This displacement is not attributable to naturally occurring seismic activity. Fault displacements are thought to have occurred as a result of the added stress produced by the explosion, the vibrations produced by the explosions, or a combination of both (Eckel 1968).

Faults are designated as capable if they have exhibited movement at or near the ground surface at least once within the past 35,000 years or movement of a recurring nature within the past 500,000 years (CFR 1993a). Almost all of the natural fault movement in the NTS area occurred several million years ago. However, movement along Yucca Fault, a north-south striking fault known in the northeast portion of the NTS (see Figure 4.6-5), is believed to have occurred sometime during the last tens of thousands to 250,000 years (Leedom 1994; Sandia National Laboratory 1982). Given the broad range of time during which displacement along Yucca Fault is believed to have occurred, Yucca Fault may or may not be an NRC capable fault (Leedom 1994).

4.6.2 Geologic Resources

Gold, tungsten, and molybdenum may exist in carbonate rocks near igneous intrusions, regional thrust faults, or other faults at the NTS. In other areas, these deposits have been found



Source: DOE/NV 1993b.

Figure 4.6-5. Approximate location of proposed facility in relation to major faults at NTS.

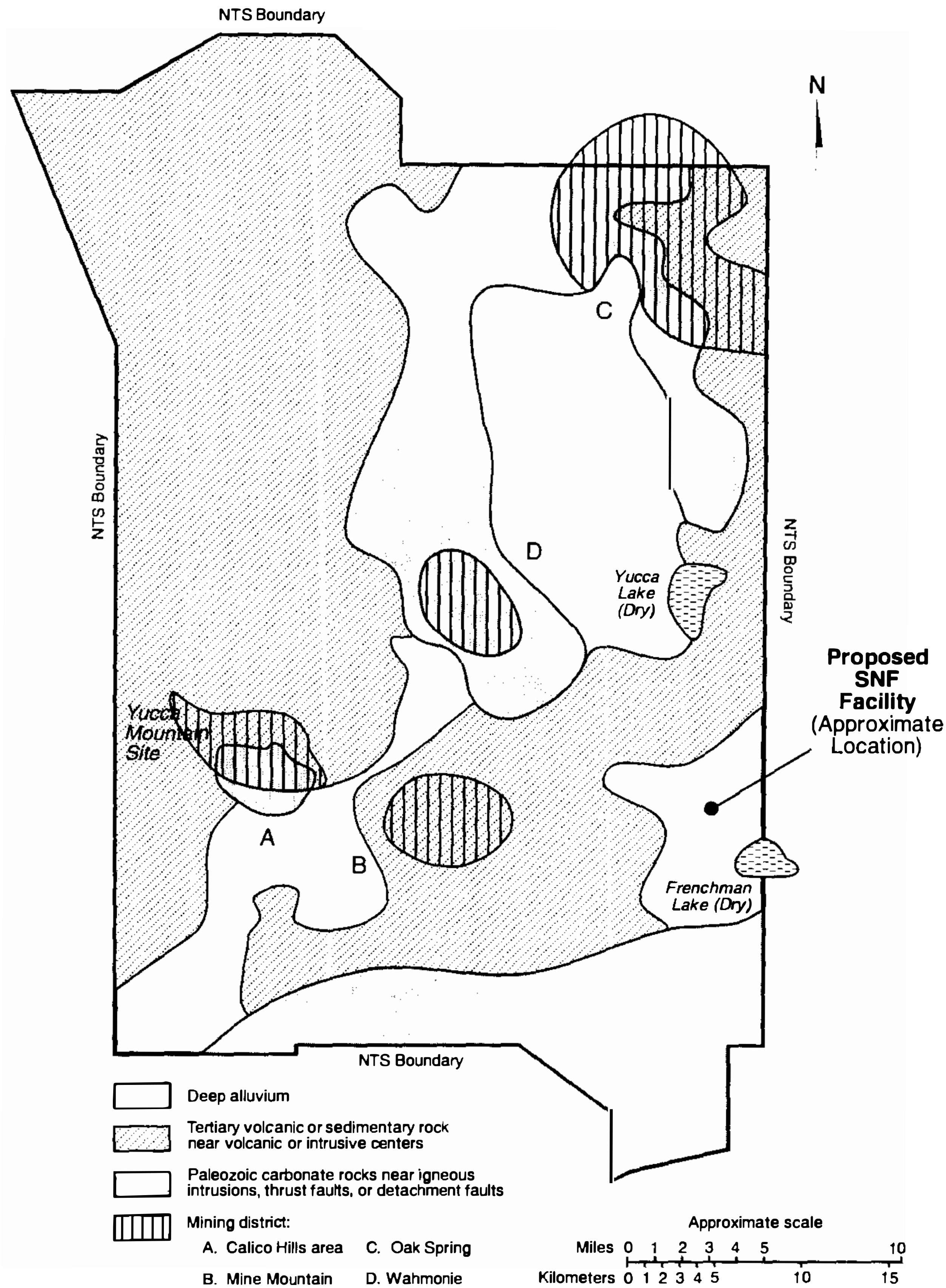
in carbonate rocks associated with this type of terrane. However, based on available information, the NTS is assessed as having only a low to moderate potential for the occurrence of tungsten skarn (contact metamorphic rock rich in iron) deposits and/or polymetallic replacement deposits, and very low potential for the discovery of gold in these types of rocks. Magnetite deposits exist in rocks at the NTS, but they are not extensive and have very low resource potential. Figure 4.6-6 shows the possible location of the SNF storage facility in relation to the types of terrains associated with geologic resources as well as to locations of mining districts (USAF et al. 1991).

Gold and silver may exist at NTS in Tertiary volcanic rocks or in sedimentary rocks near volcanic or intrusive centers. Based on limited information, however, NTS is assessed as having a low to moderate potential for the development of precious metal deposits in these rocks. It is estimated that one small to medium-sized precious metals deposit might have been developed within the NTS had the area remained open to mineral development (USAF et al. 1991).

Much of the alluvial areas along the lower flanks of the ranges within the NTS contain sand and gravel reserves. These materials, however, do not have any unique value over similar material occurring in other areas throughout southern Nevada (USAF et al. 1991).

Zeolitized rocks (various hydrous silicates occurring as secondary minerals in cavities of lavas) underlie most of the volcanic rocks and the alluvial basins at the NTS. Clinoptilolite and mordenite, either alone or in mixtures, are the most common zeolites in these deposits, but ferrierite, chabazite, and analcime also occur. Zeolite deposits in Nevada that have been developed for exploitation are lakebed deposits that have been altered to zeolites under saline water-saturated conditions. Zeolites are used in water softeners, detergent builders, and cracking catalysts. Very little information is available on the tonnage and grade of these deposits. The widespread occurrence of zeolite deposits, however, requires that the deposits at NTS be assigned a low to moderate potential for development (USAF et al. 1991).

Barite is also known to occur at the NTS. The barite occurs in veins associated with quartz and mercury, antimony, and lead mineralization. These veins cut Devonian carbonate rocks. However, the barite veins at the NTS are small and impure, and do not represent a potential barite resource (USAF et al. 1991).



Source: USAF et al. 1991.

Figure 4.6-6. Geologic terrains and mining districts of the Nevada Test Site.

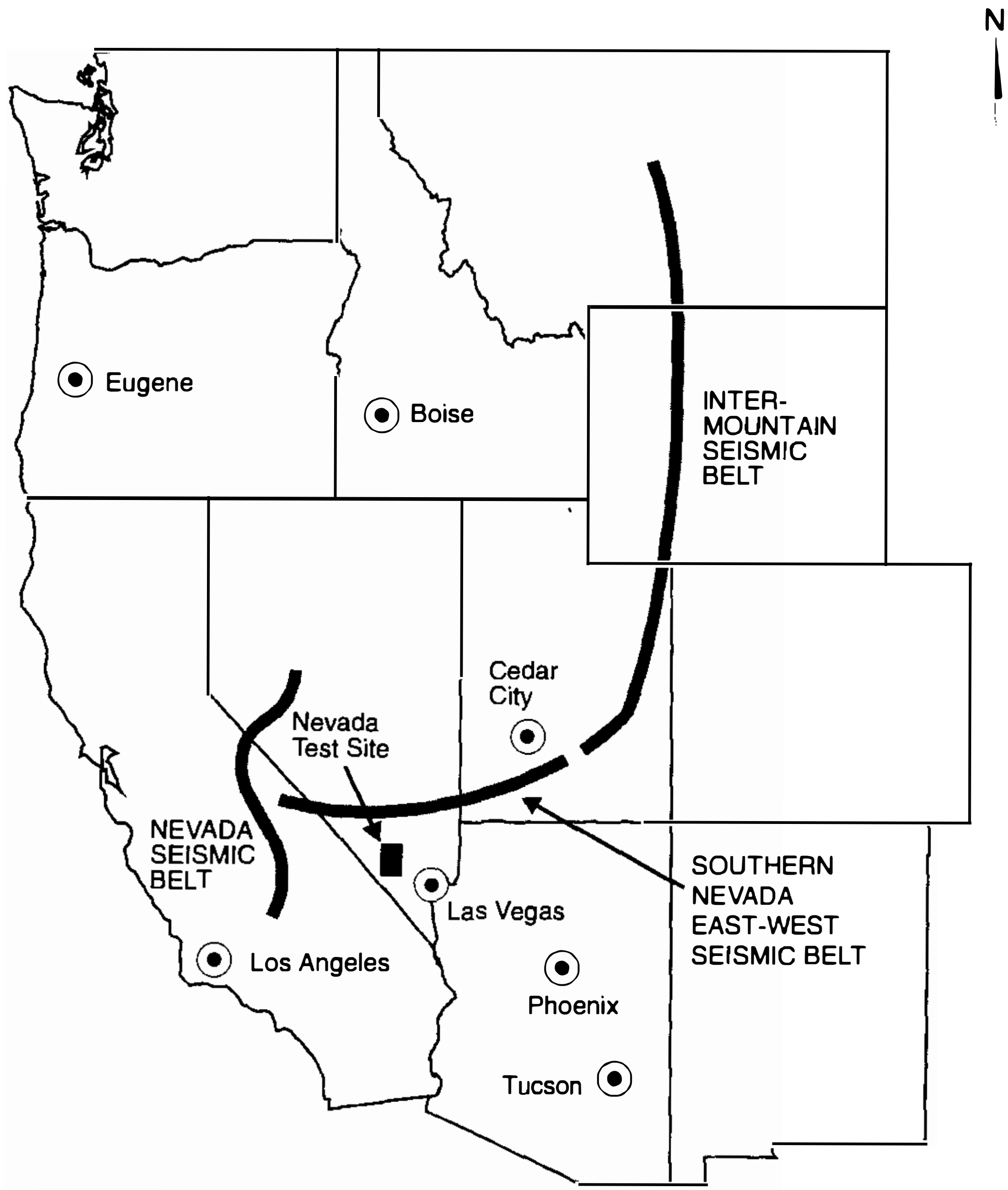
Fluorite is also reported to be present at the NTS, occurring in veins and replacement bodies within Paleozoic sedimentary rock. However, little is known about this occurrence; therefore, the NTS is assumed to have a very low to moderate potential for the development of fluorite resources (USAF et al. 1991).

4.6.3 Seismic and Volcanic Hazards

The NTS lies on the southern margin of the Southern Nevada East-West Seismic Belt. This belt connects the north-trending Nevada Seismic Belt, about 160 kilometers (100 miles) west of the site with the north-trending Intermountain Seismic Belt about 240 kilometers (150 miles) to the east. The location of these seismic belts are shown on Figure 4.6-7. The pattern of historic earthquakes in the western United States is marked by relatively brief episodes of intense activity in areas that may have been relatively inactive for hundreds and perhaps thousands of years (DOE 1986).

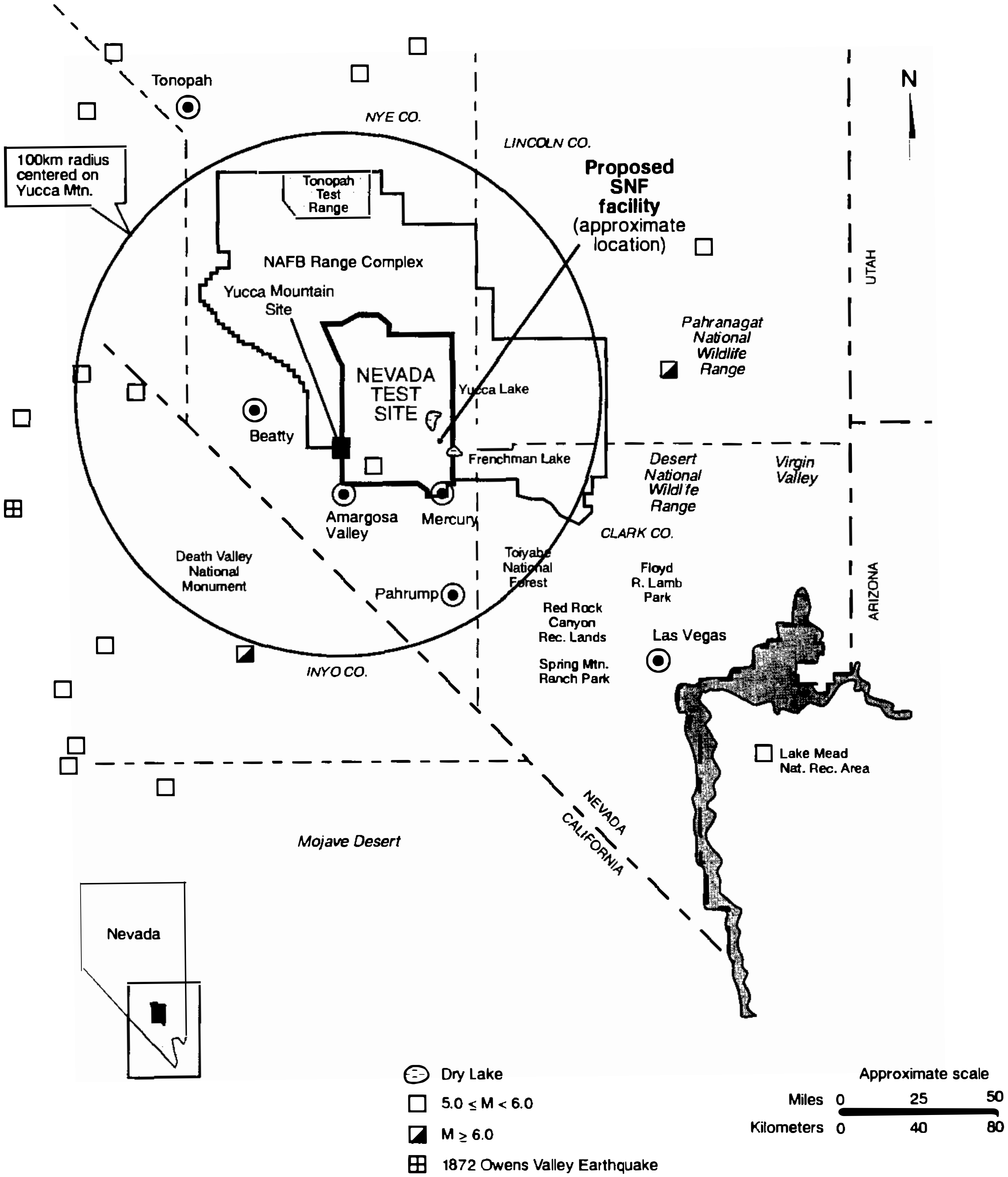
The southern Nevada region is generally characterized as an area of moderate seismic activity (DOE/NV 1993b). The proposed SNF management site is located on the eastern NTS in a region considered to have a moderate seismic-activity level. Earthquakes in southern California and the California desert have registered on the NTS seismic network.

Prior to the installation of a seismic network within a 160-kilometer (100-mile) radius of the site in 1978 and 1979, 12 earthquakes (including one series of earthquakes) with Richter magnitudes (M) of equal to or greater than 6.5 were reported within a 400-kilometer (250-mile) radius of the site (DOE/NV 1994b). One of the largest and nearest of the earthquakes relative to NTS was the 1872 Owens Valley shock (M = 8.25), located approximately 150 kilometers (100 miles) from the site. Figure 4.6-8 shows the location of the pre-network earthquakes with M greater than or equal to 5 that have occurred near the NTS (DOE 1988b). Recorded seismic activity prior to 1978 in the vicinity of the NTS also includes two earthquakes with M equals 4.3 and M equals 4.5 near Massachusetts Mountain (located just north of the proposed SNF storage site) and in Frenchman Flat (located in the southeast corner of the NTS, an area that includes the proposed SNF storage site) (DOE/NV 1994b).



Sources: DOE 1986 and DOE/NV 1993b.

Figure 4.6-7. Location of the NTS in relation to the Nevada Seismic Belt, the Intermountain Seismic Belt, and the Southern Nevada East-West Seismic Belt.



Source: DOE 1988b; DOE/NV 1994b.

Figure 4.6-8. Historical Seismicity of the Southern Great Basin from 1868 through 1993 for M>5.

Between 1978 and 1981, no earthquakes with magnitudes greater than 4.3 were recorded. Since 1981, a magnitude 5.6 earthquake was recorded near Little Skull Mountain (located near the southwest corner of the NTS) in 1992 at a depth of 12 kilometers (7.5 miles). In 1993, a magnitude 3.5 earthquake was recorded southeast of the town of Mercury on the NTS (DOE/NV 1994b). However, there is some uncertainty in the seismic sources for many signals recorded by the seismic monitoring network in the area, because underground nuclear explosions, surface drilling, and explosions to support geophysical investigations may produce earthquake-like signals (DOE 1986).

The most probable source for seismic activity within the area where the SNF storage facility would be located is the Cane Spring Fault (see Figure 4.6-5). This fault is thought to be the source of the magnitude 4.3 Massachusetts Mountain earthquake discussed above. The maximum credible earthquake associated with the Cane Springs Fault is expected to be a magnitude earthquake of 6.7. The recurrence interval for this magnitude earthquake is estimated at 10,000 to 30,000 years (DOE/NV 1993a).

Predictions of future seismicity and faulting, however, are complicated by a number of factors. Because the recurrence interval for large earthquakes on a Basin and Range fault may be thousands of years, epicenter maps of historic earthquakes or evidence of Holocene faulting alone may not be reliable indicators of future or long-term seismicity. Another complication is that when long fault zones in normal fault regimes fail, they may break along segments rather than along the entire length. Large (M greater than 7) earthquakes in the western Great Basin tend to be followed by aftershocks lasting about a century and then seismic activity stabilizes at a low level for centuries or thousands of years. Based on this concept, recurrence estimates based on historic or current earthquake distributions may not be directly applicable to the problem of identifying the most likely locations of future large earthquakes (DOE 1986).

From the historical seismicity of the southern Great Basin (two earthquakes of M equals 6) and length of active faults, a maximum magnitude of M equals 7 to 8 is inferred for earthquakes in the Yucca Mountain region. Estimates of recurrence intervals for major earthquakes in the region (M is greater than or equal to 7) are on the order of 25,000 years; for magnitudes of greater than or equal to 6, recurrence intervals are on the order of 2,500 years; and for magnitudes of greater than or equal to 5, recurrence intervals are on the order of 250 years (DOE 1986).

Ground motion acceleration resulting from earthquakes may cause damage to buildings and other structures. Ground motion acceleration is represented by the unit (g), which is the acceleration due to the force of the earth's gravitational field and is approximately equal to 986 centimeters per square second (DOE/NV 1993a). A maximum horizontal ground surface acceleration of 0.34g at the NTS is estimated to result from an earthquake that could occur once every 2,000 years (DOE 1994). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities should be evaluated on a facility specific basis consistent with DOE orders and standards and site specific procedures.

The Massachusetts Mountain earthquake associated with the Cane Spring Fault (the most probable source for seismic activity in the area of the proposed SNF storage facility) discussed above occurred on August 5, 1971 and produced a peak ground motion acceleration of 0.05 g. The maximum credible earthquake associated with the Cane Spring Fault is expected to produce a peak acceleration of 0.67 g (DOE/NV 1993a).

Volcanic activity in the area is evident in the geologic record by the presence of widespread tuffs and scattered granitic plutons deposited during the Tertiary period and basalts deposited during the late Pliocene and Pleistocene epochs (DOE 1988b).

The potential for renewed silicic volcanism is suggested by the youngest (7- to 8-million year old) major silicic volcanic center in the area, the Black mountain center, located just west of the northwest corner of the NTS. However, the occurrence of silicic volcanism near the NTS during the next 10,000 years is considered unlikely due to: no silicic volcanism in the south-central Great Basin during at least the past 6 million years, the decrease of silicic volcanism throughout the central and southern parts of the Great Basin during the past 10 million years, and the restriction of silicic volcanism to the margins of the Great Basin during the Quaternary (the past 2 million years). If silicic volcanism were to occur, the most likely effect at NTS would be the deposition of air-fall tuff from eruptions of silicic centers near the western margin of the Great Basin, as happened at least twice during the Pleistocene. Such volcanism could result in the deposition of fine-grained volcanic ash in layers ranging from a few millimeters to tens of centimeters thick (DOE 1988b).

The possibility of future basaltic volcanism near the NTS is suggested by Quaternary basaltic volcanism, notably in the Crater Flat basalt field, just west of the southwest corner of the NTS. However, future basaltic eruptions would likely be small and short-lived judging from the Quaternary record of basaltic volcanism due to: magma volumes for eruptions in the vicinity of the NTS during the past 8 million years being generally less than 1.0 x 10^8 cubic meters (3.5 x 10^9 cubic feet), and of short duration; a low rate of magma generation in the south-central Great Basin during the late Cenozoic as reflected by the small-volume, basalt eruptive cycles in the region; and the lack of geologic or geochemical patterns indicating that the rates of volcanism in the southern Great Basin are increasing, that such rates might increase in the future, or that basaltic activity could evolve into more voluminous types of basalt fields. The probability for the penetration of a repository at Yucca Mountain by basaltic volcanism was calculated based upon studies of volcanic deposits in the vicinity. According to these calculations, the annual probability is estimated as 3.3 x 10^{-10} to 4.7 x 10^{-8} (DOE 1988b).

4.7 Air Resources

Because the transport of airborne effluents is affected by meteorological conditions, the climatology at the NTS is discussed in this section. A summary of air monitoring networks is then included. Finally, the most recent air quality data available are presented.

4.7.1 Climatology

The climate at the NTS and the surrounding region is characterized by high solar radiation, limited precipitation, low relative humidity, and large diurnal temperature ranges. The lower elevations have a climate typical of the Great Basin.

NTS is situated at the edge of the Mojave Desert, and the arid climate is typical of the Great Basin. The Sierra Nevada Mountains of California and the series of mountains exceeding 1,830 meters (6,000 feet) in height immediately west and north of the NTS have a marked influence on the climate. The prevailing upper level winds are from the west; most of the moisture associated with Pacific Ocean storms falls on the western slopes of the Sierra Nevada. East of the Sierra Nevada, at locations such as the NTS, very little precipitation occurs.

The Weather Services Office at the NTS monitors meteorological data from numerous observation sites within and in the vicinity of the NTS. The nearest National Weather Service full-time meteorological monitoring station is at McCarran International Airport, Las Vegas.

At Area 6 of the NTS, the average daily maximum/minimum temperatures during the month of January are 10.6°C/-6.1°C (51°F/21°F). The average daily maximum/minimum temperatures are 35.6°C/13.9°C (96°F/57°F) in July. At Las Vegas, the coldest temperature on record is -13.3°C (8°F) and the warmest temperature on record is 46.7°C (116°F).

The average annual precipitation at Area 6 is 15 centimeters (6 inches). Precipitation amounts for each month are generally less than 1.3 centimeters (0.5 inch). At Las Vegas, the greatest precipitation recorded in a 24-hour period is 6.6 centimeters (2.59 inches). An average of 14 thunderstorm days occur each year, with maximum occurrence in July and August. Thunderstorms occasionally become severe. Tornadoes are extremely rare in Nevada. The average relative humidity at 4 AM in Las Vegas is 40 percent. The average relative humidity at 4 PM is 20 percent.

Low-level surface winds at the NTS are influenced by the large-scale weather patterns interacting with the mountain ranges, which generally run from north to south. Predominant winds are from the south during the summer and north during the winter. The general downward slope in the terrain from north to south across the NTS results in a diurnal wind reversal from the south during the day to the north during the night. At Area 6, the average annual wind speed is 11 kilometers per hour (7 miles per hour). Occasionally, strong winds associated with storms will exceed 82 kilometers per hour (50 miles per hour). These events are most common in the spring. At Las Vegas, the peak wind gust on record is 145 kilometers per hour (90 miles per hour). Strong winds interacting with dry soil conditions are responsible for occasional duststorms or sandstorms.

Wind direction and speed are major factors in planning and conducting nuclear tests, where atmospheric transport is the primary potential route of contamination to onsite workers and offsite populations. Figure 4.7-1 presents 10-meter (33-feet) wind roses for the NTS in 1990. A wind rose presents the frequency distribution of wind directions at a particular location. The wind roses indicate that there are differences in prevailing wind directions across the NTS. Mountain slopes and valleys are major determinants in these localized variations (DOE/NV 1993c; National Climatic Data Center 1991).

Atmospheric dispersion improves as the wind speed increases, conditions become more unstable, and the depth of the mixing height increases. The transport and dispersion of airborne material are direct functions of air movement. Transport directions and speeds are governed by the general patterns of air flow (and by the nature of the terrain), whereas the diffusion of airborne material is governed by small-scale, random eddying of the atmosphere (i.e., turbulence). Turbulence is indicated by atmospheric stability classification. Data collected at Desert Rock for calendar year 1990 indicated that atmospheric conditions were unstable (i.e., Stability Classes A through C) approximately 25 percent of the time, neutral (Class D) approximately 37 percent of the time, and stable (Classes E through G) approximately 37 percent of the time for that year.

4.7.2 Air Monitoring Networks

4.7.2.1 Radiological Monitoring Network. DOE Order 5400.1, General Environmental Protection Program, established the onsite environmental protection program requirements, authorities, and responsibilities for DOE operations. At the NTS, radiological effluents may originate from tunnels, underground test sites, and facilities where materials are used, processed, stored, or discharged. Airborne radiological effluents at the NTS have the greatest potential for reaching the public. There are two radiological monitoring programs for potential airborne radioactive effluents associated with the NTS, one onsite and the other offsite (DOE/NV 1993c).

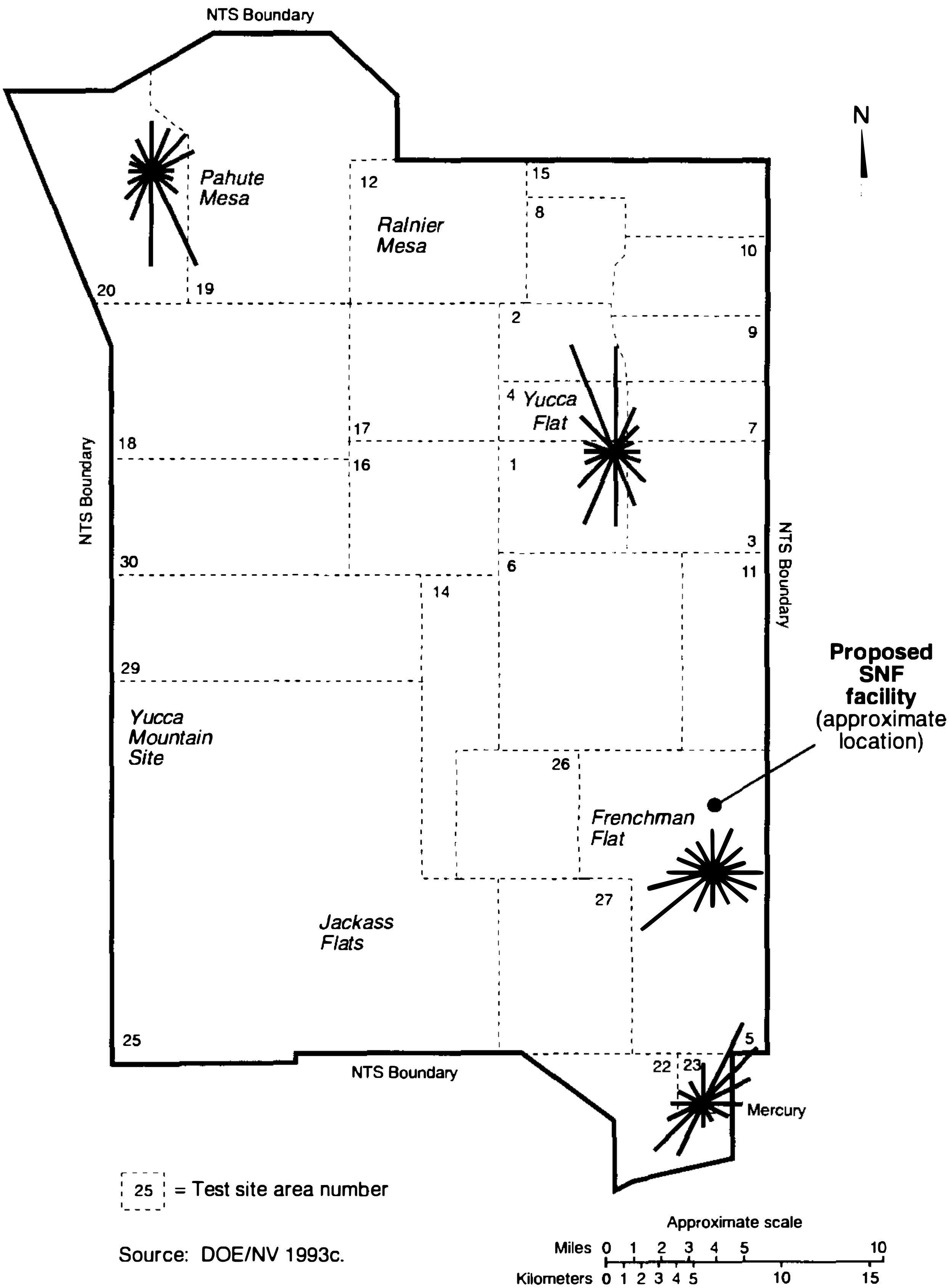


Figure 4.7-1. 1990 10-meter (33-foot) wind rose patterns for the NTS.

The onsite environmental surveillance program consists of 52 air sampling stations collecting particulates and reactive gases; 17 samplers collecting atmospheric moisture for tritium analysis; 10 samplers collecting air samples for noble gas analysis; 63 water sampling locations that include wells, springs, reservoirs, and ponds onsite; and 187 locations where thermoluminescent dosimeters are positioned for measurement of external gamma exposures (DOE/NV 1993c).

The offsite radiological monitoring program is conducted around the NTS by the U.S. Environmental Protection Agency's (EPA's) Environmental Monitoring Systems Laboratory, Las Vegas, under an interagency agreement. This program consists of several extensive environmental sampling, radiation detection, and dosimetry networks. In 1992, the Air Surveillance Network was made up of 30 continuously operating sampling locations surrounding the NTS and 77 standby stations (operating one week each quarter) in all states west of the Mississippi River. During 1992, no airborne radioactivity related to current nuclear testing at the NTS was detected on any sample from this network (DOE/NV 1993c).

4.7.2.2 Nonradiological Monitoring Network. Nonradiological environmental monitoring of NTS operations involved only onsite monitoring because there were no nonradiological hazardous material discharges offsite.

4.7.3 Air Releases

4.7.3.1 Radiological. The majority of radioactive effluents at NTS in 1992 originated from underground nuclear tests designed and conducted by two national laboratories and the Defense Nuclear Agency. The Los Alamos National Laboratory of Los Alamos, New Mexico and the Lawrence Livermore National Laboratory of Livermore, California conducted tests in support of DOE nuclear testing program objectives. Sandia National Laboratories of Albuquerque, New Mexico supported tests conducted by the Defense Nuclear Agency, which uses the NTS as a nuclear testing facility under an agreement with DOE (DOE/NV 1993c).

The presence of plutonium as an airborne, radioactive effluent at NTS in 1992 is primarily due to previous atmospheric tests and tests in which nuclear devices were detonated with high explosives (called "safety shots"). These latter tests spread low-fired plutonium in the eastern and northeastern areas of the NTS. Three decades after the conclusion of the atmospheric test program, higher than normal levels of plutonium in the air are still detected in several areas. Because of operational activities and vehicular traffic in Area 3 some of the plutonium becomes airborne and elevated levels of plutonium have been detected in Area 3 for several years (DOE/NV 1993c).

Six underground nuclear tests were conducted at the NTS during 1992. A list of these tests and a summary of environmental monitoring observations for each of these are provided in Table 4.7-1.

Air emissions from nuclear testing operations consisted primarily of radioactive noble gases and tritium released during posttest drillback, mineback, or sampling operations following each of the 1992 underground nuclear tests. None of the tests resulted in a prompt release or venting (release of radioactive materials within 60 minutes of the nuclear test). Onsite radiological safety support included monitoring emissions during the six nuclear tests. Testing included detecting, recording, evaluating, and reporting radiological conditions prior to, during, and for an extended period after each test with provisions for aerial monitoring teams to detect airborne releases (DOE/NV 1993c).

Following each test, when control of the test area was released by the DOE Controller, survey personnel obtained radiation measurements using portable detection instruments. During the postevent drillback and mining activities, continuous environmental surveillance was maintained in the work area. For containment of radioactive releases to the atmosphere during drillback, systems were employed to trap radioactive particles.

Radioactive waste management sites are located in Areas 3 and 5. These sites serve as DOE defense waste disposal sites (DOE/NV 1993c).

NTS airborne radionuclide emissions for 1992 are presented in Table 4.7-2.

4.7.3.2 Nonradiological. Air emissions from the NTS originate from concrete batch plants, aggregate crushing and processing, surface disturbance, fire training exercises, motor

Table 4.7-1. Nuclear test release summary - 1992 at the NTS Site.[a]

Event name	Test org.	Hole/ area no.	Location	Date/ time of event	Prompt release?	Telemetry measurement: Start	Telemetry measurement: Stop	Initial radiation survey: Began	Initial radiation survey: Ended	Maximum exposure rate	Release information
Junction	LANL	U19bg Area 19	Pahute Mesa	03/26/92 0830 hrs	No	03/26/92 0830 hrs	03/27/92 0830 hrs	03/26/92 1029 hrs	03/26/92 1108 hrs	0.05 mR/h	None detected
Diamond Fortune	DNA	U12p.05 Area 12	Rainier Mesa	04/30/92 0930 hrs	No	04/30/92 0930 hrs	05/11/92 1400 hrs	04/30/92 1109 hrs	04/30/92 1143 hrs	0.05 mR/h	Release included 0.242 Ci Xenon-133 and 6.05μCi Iodine-131 (5/4/92 to 7/2/92) from low level seepage until cavity gases were transferred to Distant Zenith chimney
Victoria	LANL	U3kv Area 3	Yucca Basin	06/19/92 0945 hrs	No	06/19/92 0945 hrs	06/24/92 1500 hrs	06/91/92 1014 hrs	06/19/92 1040 hrs	0.05 mR/h	None detected
Galena	LLNL	U9cv Area 9	Yucca Basin	06/23/92 0800 hrs	No	06/23/92 0800 hrs	06/24/92 2200 hrs	06/23/92 0914 hrs	06/23/92 0923 hrs	0.05 mR/h	None detected
Hunters Trophy	DNA	U12n.24 Area 12	Rainier Mesa	09/18/92 1000 hrs	No	09/18/92 1001 hrs	09/22/92 1300 hrs	09/18/92 1116 hrs	09/18/92 1151 hrs	3.0 mR/h	Release of 0.9 Ci of noble gases and tritium (11/18/92 to 1/5/93) from diagnostic studies
Divider	LANL	U3ml Area 3	Yucca Basin	09/23/92 0804 hrs	No	09/23/92 0804 hrs	09/24/92 0941 hrs	09/23/92 0856 hrs	09/23/92 0915 hrs	0.05 mR/h	Release of 0.11 Ci Xenon-133 on 10/14/92 during post shot operations
Distant Zenith	DNA	U12p.04 Area 12	Rainier Mesa	09/19/91 0930 hrs	No	1992 releases associated with ventilation of LOS pipe and drilling in the Chimney region and included: 1.33 Ci^{85}Kr, 2.07 Ci^{37}Ar, and 0.1 μCi^{39}Ar					

a. Source: DOE/NV 1993c.

Table 4.7-2. Airborne radionuclide emissions for 1992 at the NTS.[a]

Event or facility name (airborne releases)	Curies									
	Tritium[b]	Argon-37[c]	Argon-39	Krypton-85	Xenon-127[d]	Xenon-129m[e]	Xenon-131m	Xenon-133m	Iodine-131	Plutonium-239,240
Area 3, DIVIDER								1.1×10^{-1}		
Area 3[f]										2.5×10^{-3}
Area 5, RWMS[f]	6×10^{-1}									
Area 6[g]									1.3×10^{-5}	
Area 12,										
N Tunnel	4.9×10^{2}	7.9×10^{-1}	8.1×10^{-5}	1.3×10^{-2}	5.7×10^{-6}	2.4×10^{-5}	1.5×10^{-2}	3.9×10^{-2}		
P Tunnel	3.6×10^{-1}	2.1×10^{-0}		1.3×10^{0}				2.4×10^{1}	6.0×10^{-6}	
Area 19 and 20, Pahute Mesa[d]				$2.8 \times 10^{+2}$						
Total	1.0×10^{0}	2.9×10^{-0}	8.1×10^{-5}	$2.8 \times 10^{+2}$	5.7×10^{-6}	2.4×10^{-5}	1.5×10^{-2}	3.9×10^{-1}	1.9×10^{-5}	2.5×10^{-3}

a. Source: DOE/NV 1993c.

b. Total includes 4.9×10^{-2} Ci of molecular HT from Hunter's Trophy. Remainder is in the form of tritiated water vapor, primarily HTO.

c. Ar-37 with 35 day half-life not in GENII. Decays to stable Cℓ-37.

d. Xe-127 with 36.4 day half-life not in GENII. Decays to stable I-127.

e. Xe-127m with 8 day half-life not in GENII. Decays to stable Xe-129.

f. Calculated from air sampler data.

g. Assumes all radioactivity on Anti-C clothing is I-131 and all becomes airborne during drying.

vehicle operations, boilers, and fuel storage. The concrete batch plants, aggregate crushing and processing facilities, and surface disturbance activities are sources of particulate matter. These activities are largely intermittent and occur in support of specific testing programs on the NTS. Fire training exercises consist of periodic open burning in designated areas with approved fuel materials conducted by fire and emergency personnel several times per year. Motor vehicle operations and boilers are the largest sources of air pollutants at the NTS; motor vehicles consume gasoline, while boilers, construction equipment, and other diesel engines consume diesel fuel. A continuous, nonradiological air monitoring network is not in place at the NTS (USAF et al. 1991). Table 4.7-3 presents the maximum allowable nonradiological emission rates for those NTS sources which require permits.

4.7.4 Air Quality

4.7.4.1 Radiological. Onsite surveillance of airborne particulates, noble gases, and tritiated water vapor indicated onsite concentrations that were generally not statistically different from background concentrations. External gamma exposure monitoring in 1992 indicated that the gamma environment within the NTS remained consistent with that of previous years. All gamma monitoring stations displayed expected results, ranging from the background levels predominant throughout the NTS to the types of exposure rates associated with known contaminated zones and radiological material storage facilities. Results of 1992 offsite environmental surveillance indicated no NTS-related radioactivity was detected at any air sampling station, and there were no apparent net exposures detectable by the offsite dosimetry network (DOE/NV 1993c).

The GENII environmental transport and dose assessment model (PNL 1988) was used to calculate the effective dose equivalents (EDE) resulting from the airborne radionuclide emissions presented in Table 4.7-2. These results are summarized in Table 4.7-4. The maximum EDE at the NTS boundary is 1.1×10^{-2} millirem. This is 1.1×10^{-1} percent of the corresponding National Emissions Standard for Hazardous Air Pollutants. The collective EDEs to the estimated population of 15,100 persons within 80 kilometers (50 miles) of the proposed SNF facility is 5.2×10^{-3} person-rem, which is 1.2×10^{-4} percent of the natural background radiation dose affecting this population. Background radiation doses are presented in Figure 4.7-2.

Table 4.7-3. Total nonradiological emission rates at NTS for permitted sources.[a]

Pollutant	Emission rate (g/s)
Carbon monoxide	b
Nitrogen dioxide	b
Particulate matter (PM_{10})	2.8
Sulfur dioxide	4.5
Lead	b

a. Source: Engineering Science, Inc. (1990).

b. No pollutant sources indicated.

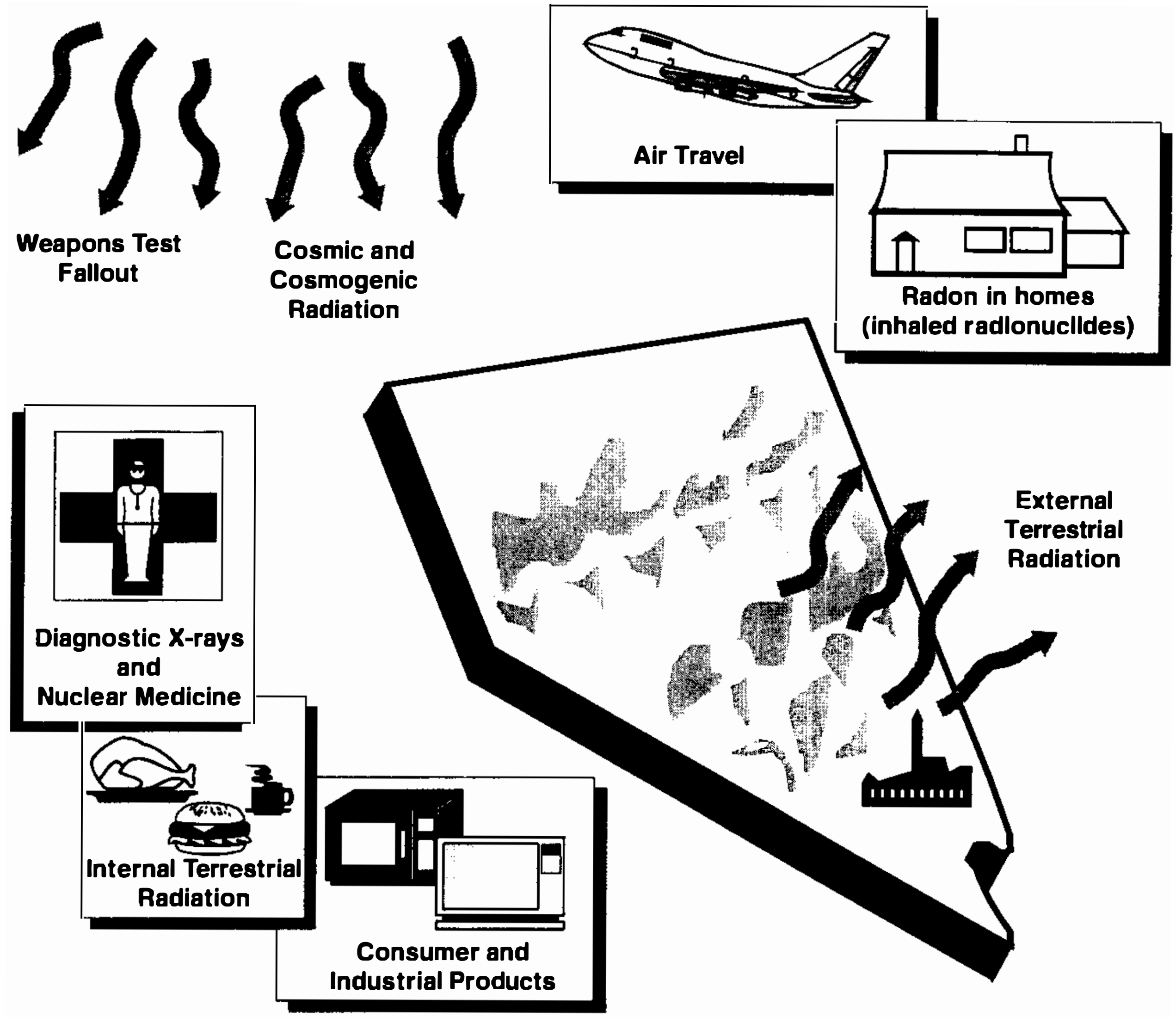
Table 4.7-4. Summary of effective dose equivalents to the public from NTS operations during 1992.[a]

	Maximally exposed individual dose[b]	Collective dose to the population within 80 km of NTS sources[c]
Dose	1.1×10^{-2} mrem	5.2×10^{-3} person-rem
NESHAP standard	10 mrem per year	--
Percentage of NESHAP	1.1×10^{-1}	--
Natural background dose	278 mrem per year	4190 person-rem per year
Percentage of natural background dose	4.0×10^{-3}	1.2×10^{-4}

a. Sources: 1992 Radionuclide emissions from DOE/NV 1993c GENII Model (PNL 1988) used to predict EDE. Natural background dose from DOE/NV 1993c.

b. The maximum boundary dose is to the hypothetical individual who remains in the open continuously during the year at the NTS boundary.

c. Based on an estimated population of 15,100 persons within 80 km of the proposed SNF facility in 1995.



Natural Background Radiation	millirem per years[a]
External penetrating radiation and Internal terrestrial radiation	78
Radon in homes (inhaled)	200
Other Background Radiation	
Diagnostic X-rays and nuclear medicine	53
Weapons test fallout	<1
Air travel	1
Consumer and industrial products	10
Total	343

[a]Committed effective dose equivalent to a hypothetical resident of Indian Springs, NV.

Sources: DOE/NV 1993c; NCRP 1987; Value for radon is an average for the United States.

Figure 4.7-2. Sources of radiation exposure, unrelated to NTS operations, to individuals in the vicinity of NTS.

4.7.4.2 Nonradiological. Air quality rules and regulations applicable to the NTS are governed by the Clean Air Act, the Nevada Revised Statutes, and the Nevada Administrative Code. The EPA administers the Federal regulations developed to implement the Clean Air Act, and the Nevada Department of Conservation and Natural Resources is responsible for enforcing the Federal and state regulations. Air quality in a given location is described as the concentration of various pollutants in the atmosphere, generally expressed in units of micrograms per cubic meter ($\mu g/m^3$).

The Clean Air Act directed the EPA to set National Ambient Air Quality Standards (NAAQS) for those pollutants, termed criteria pollutants, that pose the greatest threat to air quality in the United States. The six criteria pollutants are ozone, carbon monoxide, sulfur dioxide, lead, nitrogen dioxide, and particulate matter with an aerodynamic particle diameter less than or equal to 10 microns, referred to as PM_{10}. The Clean Air Act Amendments authorized the EPA to designate geographic regions not in compliance with NAAQS as nonattainment areas. The NTS is located within the Nevada Air Quality Control Region 147, which is in attainment with respect to the NAAQS for the criteria pollutants (CFR 1993b; Engineering Science, Inc. 1990). The nearest nonattainment areas to the Nevada Test Site Spent Nuclear Fuel site are in Clark County, which includes an area in the Las Vegas planning area that is designated serious for PM_{10} and an area in Las Vegas that is designated moderate for carbon monoxide (CFR 1993b).

Under the Clean Air Act, clean air areas are divided into classes. National parks and wilderness areas receive mandatory Class I protection. Very little pollution increase is allowed in Class I areas. The only Class I area in Nevada, the Jarbridge Wilderness Area, is located approximately 480 kilometers (300 miles) from the NTS, in the northwest corner of Nevada. The nearest Class I areas to the NTS are the Grand Canyon National Park, approximately 275 kilometers (171 miles) to the southeast, and Sequoia National Park approximately 175 kilometers (109 miles) to the west-southwest. The NTS is located in a Class II area, as are most areas across the country.

In addition to the criteria pollutants which are regulated under the National Ambient Air Quality Standards and under various emission standards, hazardous air pollutants are regulated.

Title III of the Clean Air Act Amendments of 1990 directed the EPA to determine maximum available control technologies which would be used as the basis for emission limits for the hazardous air pollutants.

Engineering Science, Inc. of Pasadena, California conducted an air quality study at the NTS in 1990. The study examined air quality compliance of the NTS with applicable Federal and state air quality standards. The study encompassed an air emissions inventory, ambient air monitoring, and air pollution source testing at various sources. Based on the data collected at the ambient air monitoring stations established for the study, air quality at the NTS is within applicable Federal and state standards. The results of background monitoring performed by Engineering Science, Inc. are summarized in Table 4.7-5. This is the most recent comprehensive analysis of NTS ambient air quality.

Air dispersion modeling was performed to determine the maximum concentrations of the criteria pollutants. These results are also summarized in Table 4.7-5. The "total existing maximum concentrations" in Table 4.7-5 would result if all permitted sources at the NTS operated at the maximum allowable capacity. All pollutant concentrations from this worst-case scenario of existing emissions at the NTS are below applicable regulations.

4.8 Water Resources

This section provides a description of the surface water and groundwater at the NTS and surrounding area. The section also describes the existing impacts to surface water and groundwater that have resulted from past and present operations at the NTS.

4.8.1 Surface Water

The drainage basins and the generalized directions of surface water flow near the NTS are shown in Figure 4.8-1 (USAF et al. 1991). The boundary lines of the drainage basins occur principally along topographic divides (DOE 1988b). Figure 4.8-1 also shows other surface water features.

Table 4.7-5. Comparison of baseline concentrations with most stringent applicable regulations and guidelines at the NTS.[a]

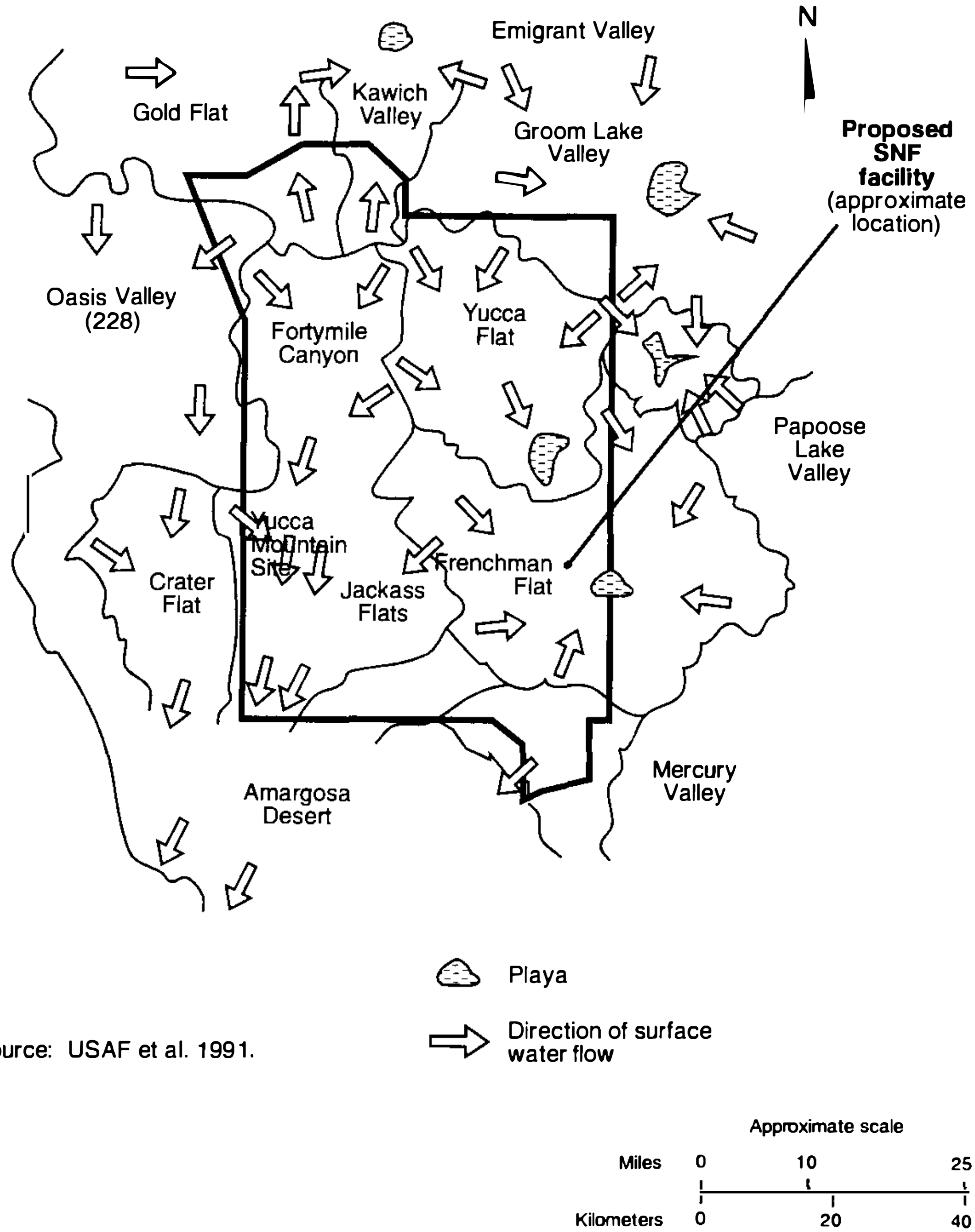
Criteria pollutant	Averaging time	Most stringent regulation or guideline ($\mu g/m^3$)	Maximum background concentration ($\mu g/m^3$)	Maximum existing DOE site contribution ($\mu g/m^3$)	Total existing maximum concentration ($\mu g/m^3$)
Carbon monoxide	8-hour	10,000	2,290	b	2,290
	1-hour	40,000	2,748	b	2,748
Nitrogen dioxide	Annual	100	c	b	b
Lead	Calendar quarter	1.5	c	b	b
Particulate matter (PM_{10})[d]	Annual	50	c	0.43	0.43
	24-hour	150	78.3	6.6	84.9
Sulfur dioxide	Annual	80	c	1.07	1.07
	24-hour	365	39.3	15.9	55.2
	3-hour	1,300	65.4	104.9	170.3
Hazardous air pollutants					
b	b	b	b		

a. Sources: Maximum background concentration provided by Engineering Science, Inc. (1990). Maximum existing DOE site contribution computed by Halliburton NUS.

b. No sources indicated.

c. Not measured.

d. All suspended particulate matter is assumed to be PM^{10}.



Source: USAF et al. 1991.

Figure 4.8-1. NTS hydrologic basins and surface drainage direction.

Almost all stream flow in the NTS area is ephemeral, and therefore almost no streamflow data have been collected. The average annual runoff within the hydrographic areas in the Death Valley Basin in Nye County was estimated at less than 164 million gallons (620,000 cubic meters) per area (DOE 1988b).

The ephemeral character of streamflow has also limited the onsite monitoring of surface water quality. Water samples were, however, collected from the main channel of Fortymile Wash and two of its principal tributaries (Drill Hole Wash and Busted Butte Wash) during periods of runoff and flooding in 1984. Due to unknown factors such as compositional variability of storms, any quantitative interpretation is unwarranted (DOE 1988b).

Throughout the NTS, perennial surface water originates solely from springs, and it is restricted to source pools at some large springs. Because of the extreme aridity of this region, most of the spring discharge travels a short distance before evaporating or infiltrating back into the ground (DOE 1986). Thus, dry washes may be the principal sources of potential groundwater recharge inputs in the area (DOE 1988b). In addition. playas on NTS, including Frenchman Lake located in Area 5 and Yucca Lake to the northwest of Area 5, may retain standing water for hours to weeks following intense precipitation events. These playas represent the only natural surface water features in the vicinity of Frenchman and Yucca Flats. The direction of movement of water accumulated in playas is generally upward due to high evapotranspiration (DOE/OFE 1994). However, accumulated runoff in Frenchman Lake and Yucca Lake reportedly serves to recharge the valley fill aquifer (DOE 1988b).

Despite the arid climate, which includes high annual average potential evaporation, low average annual precipitation, and infrequent storms, surface runoff does occur. Runoff results from storms that occur most commonly in winter and occasionally in autumn and spring, and from localized thunderstorms that occur mostly during the summer (DOE 1988b). The ephemeral streams resulting from heavy precipitation fill the normally dry washes. Local flooding may occur where the water exceeds the capacity of the channels. In contrast to the washes, the terminal playas may retain standing water for days or weeks after severe storms (DOE 1986). Playas in Kawich Valley and Gold Flat collect and dissipate the runoff from the northern part of Pahute Mesa (ERDA 1977). Summer floods usually do not accumulate to cause regional floods, but their intensive character renders them potentially destructive over limited areas (DOE 1988b).

The western half and southernmost part of the NTS have channel systems which carry runoff beyond NTS boundaries during infrequent, very intense storms. Fortymile Canyon is the largest of these systems, originating on Pahute Mesa in the northwestern part of the NTS and draining into the normally dry Amargosa River channel about 20 miles (32 kilometers) southwest of the NTS. Within the NTS, Fortymile Canyon and its tributaries are restricted to well-incised canyons. Flood-prone areas surround Fortymile Wash, a major tributary within Fortymile Canyon. The other major NTS tributaries to the Amargosa River are Tonopah Wash, which runs southwesterly from Jackass Divide in the south-central part of the NTS into the Amargosa Desert near Amargosa Valley, and Rock Valley, which drains from the southernmost part of the NTS westward and then southward to Ash Meadows in the east-central portion of the Amargosa Desert (ERDA 1977).

The Amargosa River originates in Oasis Valley and continues southeastward through the Amargosa Desert past Death Valley Junction, then southward another 45 miles (82 kilometers), where it turns northwestward and terminates in Death Valley. The river carries floodwaters following cloudbursts or intense storms but is normally dry, except for a few short reaches that contain water from springs (DOE 1988b).

Two watersheds, Fortymile Canyon and Jackass Flats, have the potential of endangering offsite public health and safety due to flooding. Regional peak-flood flow equations for the southern Nevada area indicate that the 100-year peak flow from the Fortymile Canyon drainage is approximately 13,000 cubic feet (370 cubic meters) per second and 8,200 cubic feet (230 cubic meters) per second from the Jackass Flats drainage (USAF et al. 1991).

In summary, the potential exists for sheet flow and channelized flow through ephemeral washes from intense precipitation events to cause localized flooding throughout the NTS; however, no comprehensive floodplain analysis has been conducted on the NTS to delineate the 100- and 500-year floodplains associated with NTS drainages. No flood studies are known to have been conducted for the proposed SNF facility in Area 5; a flood assessment was conducted for the Radioactive Waste Management Site in NTS Area 5 on Frenchman Flat, located southwest of the proposed SNF Site. This study determined that the southwest corner of the Radioactive Waste Management Site is located in Federal Emergency Management Agency Zone AO (100-year flood zone with depths between 1 and 3 feet [0.3 and 0.9 meter]) of the Barren Wash Alluvial Fan. The remainder of the Radioactive Waste Management Site is located in Zone X of the Halfpint Alluvial Fan (100-year flood zone with depths less than 1 foot [0.3 meter]). Areas to the north, south, and east of the Radioactive Waste Management Site are in Zone X or Zone AO (DOE/NV 1993d). These suggest that the proposed SNF facility area may encompass areas in Zone X and/or areas in Zone AO associated with the Halfpint Alluvial Fan. Probable maximum flood analyses are known to have been performed only for areas in the vicinity of Yucca Mountain to aid in flood protection design for Yucca Mountain facilities (DOE 1988b).

Underground nuclear testing has resulted in the release of radioactive materials at the land surface. There is the potential for 100-year floods to transport these contaminants beyond the boundaries of the NTS. Quantitative estimates of this potential cannot be determined without additional studies (USAF et al. 1991).

There are no National Pollutant Discharge Elimination System (NPDES) permits for the NTS, as there are no wastewater discharges to onsite or offsite surface water. NTS sanitary wastewaters are discharged to sewage lagoons or to septic tank/leach field systems. All wastewater discharges at NTS are conducted in accordance with permits issued by the State of Nevada (DOE/NV 1993c).

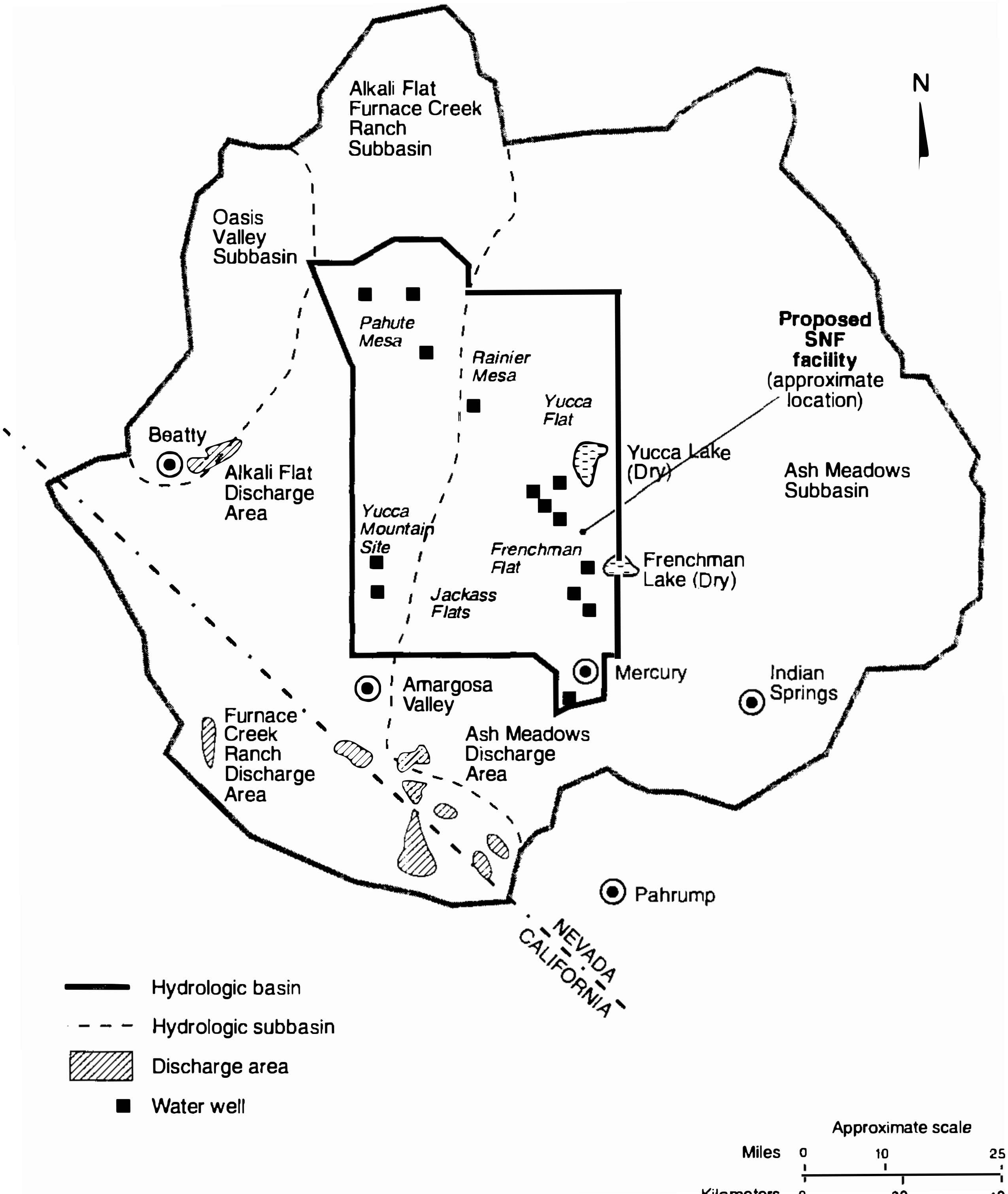
4.8.2 Groundwater

Generally, the hydrogeology at the NTS is characterized by great depths to the groundwater table and slow velocity of movement of water in the saturated and unsaturated zones (DOE/NV 1992c). Depth to groundwater varies from about 660 feet (200 meters) beneath valleys in the southern part of the NTS to more than 1,640 feet (500 meters) beneath Pahute Mesa. The depth of the water table below Area 5 is approximately 800 feet (244 meters) below land surface (DOE/NV 1993c). Locally, there are perched water tables at shallow depths (USAF et al. 1991).

Perched aquifers have been reported at depths of 70 feet (21 meters) in the southwestern part of Frenchman Flat (RSN 1993). In the eastern portions of the NTS, the water table occurs generally in the alluvium and volcanic rocks above the regional carbonate aquifer (DOE/NV 1993c).

The NTS lies within the Death Valley Groundwater System, which is a large and diverse area encompassing southern Nevada and adjacent parts of California composed of many mountain ranges and topographic basins that are hydraulically connected at depth. In general, groundwater within the system travels toward Death Valley, although much of it discharges before reaching it. Groundwater in the Death Valley system does not enter neighboring groundwater systems (DOE 1986). The Death Valley Groundwater System is divided into several groundwater subbasins. The boundaries of these subbasins have been estimated from potentiometric levels, geologic controls of subsurface flow, discharge areas, and inferred flow paths (DOE 1988b). As shown in Figure 4.8-2, the three groundwater subbasins of the system beneath the NTS are Ash Meadows, Alkali Flat Furnace Creek Ranch, and Oasis Valley. Groundwater beneath the eastern part of the NTS is in the Ash Meadows Subbasin. Most of the western NTS is in the Alkali Flat Furnace Creek Ranch Subbasin. Groundwater beneath the far northwestern corner of the NTS occurs in the Oasis Valley Subbasin (DOE/NV 1993c, 1992b).

Six major aquifers occur in the area. In decreasing order of age of the geologic units in which they are found, they are: Cambrian through Devonian lower carbonate aquifer, Pennsylvanian and Permian upper carbonate aquifer, Tertiary bedded tuff aquifer, Tertiary welded tuff aquifer, Tertiary lava flow aquifer, and Tertiary and Quaternary valley fill aquifer (Eckel 1968) (see Figure 4.6-2). The hydrologic and geologic properties of these aquifers vary (see the Yucca Mountain Site Characterization Plan [DOE 1988b] for a thorough description of the hydraulic properties of the major hydrostratigraphic units based on studies at Yucca Mountain). For example, the carbonate aquifers and the welded tuff aquifer store and transmit water chiefly along fractures. In contrast, the valley fill aquifer stores and transmits water chiefly through interstitial openings. Additionally, in places in the lower carbonate aquifer, groundwater flow is diverted laterally and vertically because of fault displacements that have juxtaposed the lower carbonate aquifer against less permeable rocks. Where the flow is blocked, intersection of the water table with the land surface causes springs (DOE 1986).



Source: DOE/NV 1992b.

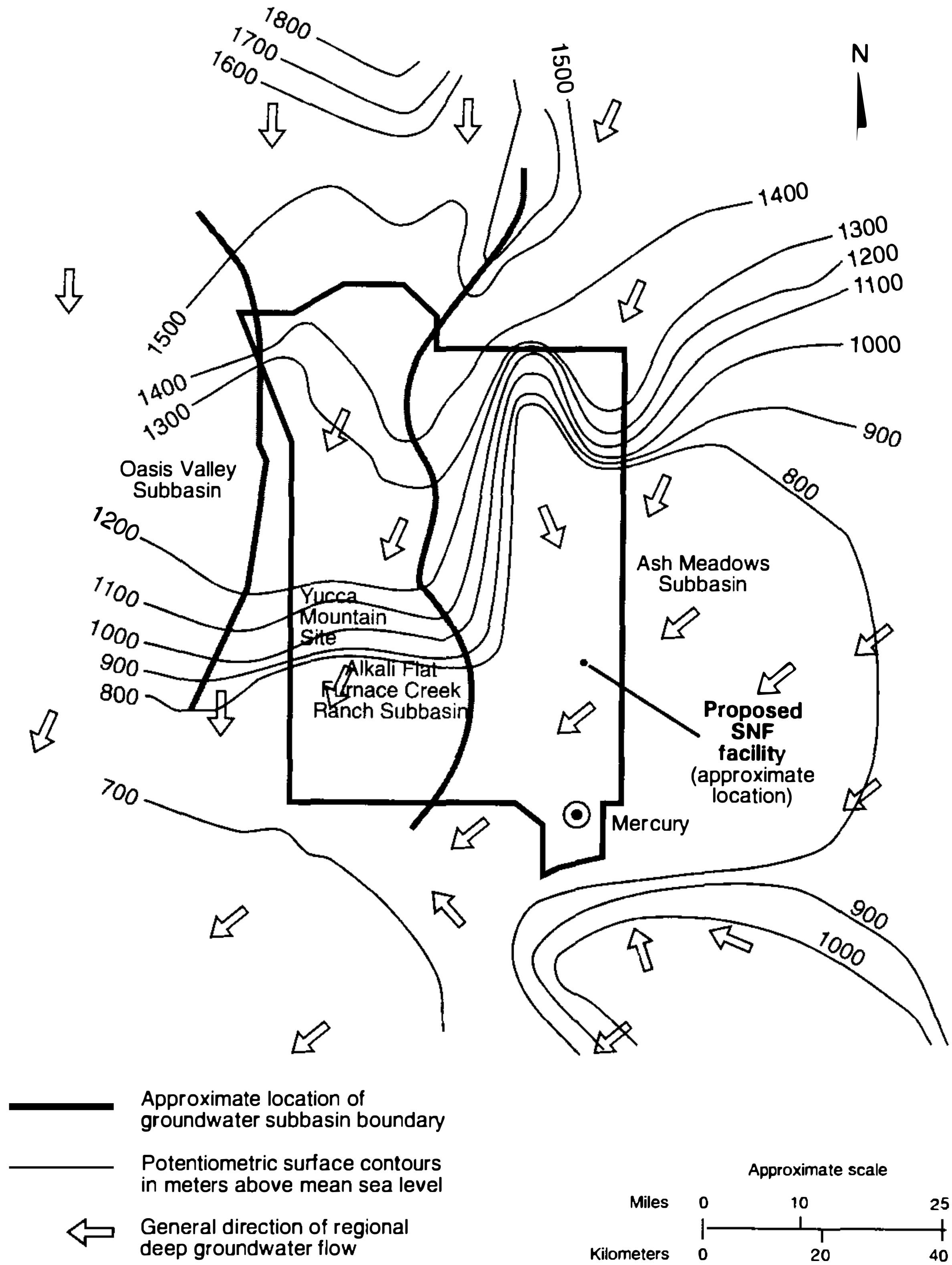
Figure 4.8-2. Groundwater hydrologic units, hydrographic areas, and well locations of the Nevada Test Site.

The lower carbonate and valley fill (alluvial) aquifers are the main sources of groundwater in the eastern part of the NTS (DOE 1986). Groundwater withdrawals in the area of the proposed SNF management facilities are principally from the valley fill aquifer of the Frenchman Flat hydrographic area (DOE 1988b). The other four units in the area have relatively low permeabilities that tend to retard the flow of groundwater. These units are called aquitards (DOE 1986). In decreasing order of age of the geologic units that form them, these aquitards are: Precambrian through lower Cambrian lower clastic aquitard, Devonian through Mississippian upper clastic aquitard, Tertiary tuff aquitard, and Tertiary lava flow aquitard (Eckel 1968) (see Figure 4.6-2).

Figure 4.8-3 is a regional groundwater potentiometric surface map of the NTS (DOE/NV 1993d). The map does not show perched groundwater. However, perched groundwater does occur at NTS, principally associated with the aquitards underlying the ridges (Eckel 1968).

In general, regional groundwater flow is from the north and northeast toward the regional discharge area near Ash Meadows in the Amargosa Desert (see Figure 4.8-2 and 4.8-3). In the western portions of the area, the regional flow is from the northwest to the south and southwest (DRI 1986b). Deep regional movement of groundwater south of the NTS occurs chiefly through the lower carbonate aquifer. Because of geologic structure, flow paths in the lower carbonate aquifer are complex and poorly defined. Groundwater from the Ash Meadow Subbasin supplies the water entering Devil's Hole, which supports the only known population of the Devil's Hole pupfish, a federally listed endangered species. The decline of the species has been attributed to low water levels caused by decreasing groundwater levels (ERDA 1977).

Groundwater recharge to the Ash Meadows Subbasin occurs primarily from precipitation over the mountainous areas in tbe northern, eastern, and southern portions of the basin (DOE 1988b). As mentioned above, this recharge generally travels vertically through the vadose zone (unsaturated zone) and the overlying aquifers to the underlying carbonate aquifers. Specifically, in the eastern half of the NTS, groundwater flows toward the major valleys before deflecting downward to join the regional flow in the carbonate aquifers. Beneath Yucca and Frenchman flats, vertical flow through the underlying volcanic rocks is impeded by bedded and



Source: DOE/NV 1993d.

Figure 4.8-3. NTS regional potentiometric surface map.

zeolitized tuffs, resulting in a downward flow rate of less than 0.2 foot (0.06 meter) per year. Vertical flow in the uppermost portions of the vadose zone in the area of Frenchman Flat is generally upward toward the surface, due to an evapotranspiration rate which is 15 times higher than precipitation (DOE/OFE 1994). Site characterization data for Area 5 indicate that the vertical flow direction in the vadose zone is upward from 0 to 250 feet (0 to 75 meters) below land surface. In the next interval (250 to 600 feet [75 to 180 meters]), a downward flow rate of 10 feet/1,000 years (3 meters/1,000 years) has been calculated. At a depth of 600 to 800 feet (180 to 250 meters), a zone of equilibrium (a zone of no vertical movement) is present above the water table (Johnejack et al. 1994).

Analyses have also been conducted in order to determine the travel time of water from the vicinity of Area 5 and Frenchman Flat to the regional water table. Modeling studies for the Radioactive Waste Management Site at Area 5 indicate that the travel time from the surface to the water table is on the order of thousands of years (DOE/NV 1993c). Specifically, the travel time from Area 5 to the regional water table is estimated to range from 19,000 to more than 113,000 years (USAF et al. 1991). The Yucca Mountain Site Characterization Plan (DOE 1988b) describes in detail the hydraulic properties of the various units comprising the unsaturated zone, based on studies at Yucca Mountain.

Three types of groundwater chemistry exist at the NTS and in its vicinity: (1) sodium and potassium bicarbonate, which generally occurs in the tuff and valley fill aquifers composed chiefly of tuff detritus; (2) calcium and magnesium bicarbonate, which generally occurs in the carbonate and the valley fill aquifers composed chiefly of carbonate detritus; and (3) mixed, which is defined as having the chemical characteristics of both type 1 and type 2 (DOE 1986).

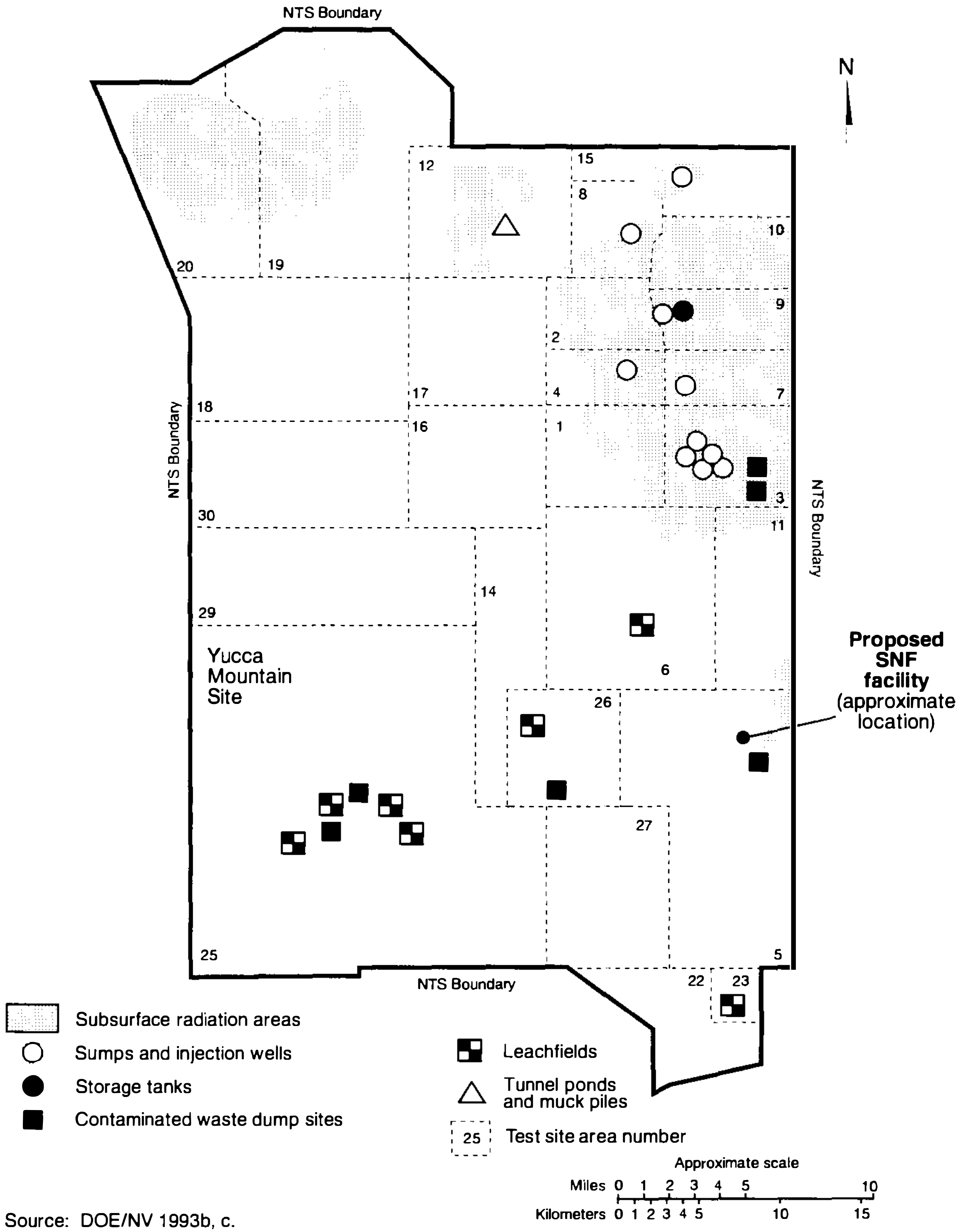
The hydrogeologic units which supply potable water to the NTS have been classified as Class IIA (currently a source of drinking water) and IIB (potentially a source of drinking water) in accordance with the EPA's guidelines for groundwater classification (DOE/NV 1993d). No aquifers at the NTS have been designated as sole source aquifers.

In general, the quality of NTS groundwater is suitable for most purposes and generally meets EPA secondary standards for major cations and anions and the primary standards for deleterious constituents. Specifically, groundwater in the Ash Meadows Subbasin has a total dissolved solids concentration ranging between 275 and 450 milligrams per liter (mg/L) (DOE/NV 1993a). Summary groundwater quality data for the period 1957 to 1990 for Well 5b, 5c, Well UE5c, and Army Well 1 which serve Area 5 reveal a pH range of 7.6 to 8.7; calcium (2.4 to 44.0 mg/L); sodium (38.1 to 129.0 mg/L); chloride (9.1 to 23.2 mg/L); sulfate (26 to 58 mg/L); and silica (0 to 55.1 mg/L) (DRI 1993).

Contamination by radionuclides occurs below the water table as well as in the unsaturated zone above it. This contamination is a result of underground nuclear testing. A preliminary environmental survey of the NTS also identified a number of potential sources of groundwater contamination. These included wastewater discharges, hazardous- or mixed-waste discharges, solid waste landfills and trenches receiving potentially hazardous waste, and over 50 inactive waste spill or release sites (USAF et al. 1991).

Underground nuclear testing has primarily occurred in the areas of Yucca Flat, Frenchman Flat, Pahute Mesa, Rainier Mesa, and Shoshone Mountain. Nuclear detonations at or near the water table have resulted in groundwater contamination. The principal confirmed or suspected contaminants from these tests include various radionuclides (primarily tritium) and heavy metals. A number of NTS waste disposal and testing facilities, including injection wells, leach fields, and various waste storage facilities or disposal sites, have caused contamination of the vadose zone. Contaminants of concern include radionuclides, organic compounds, heavy metals (primarily lead), and hydrocarbons as well as various residues from plastics, drilling muds, and epoxy (DOE/NV 1993e). Figure 4.8-4 depicts the areas with known or suspected groundwater and/or vadose zone contamination. Groundwater contamination characterization activities are in progress at NTS; at present, no contaminant plume maps are available, and available groundwater quality data are not useful for the purposes of site-wide characterization or for comparison with established criteria.

Groundwater contamination could be transported toward the NTS boundary by one of the regional groundwater flow systems. Groundwater flow velocities in these systems range between 6 and 600 feet (1.8 and 183 meters) per year. Because of sorption, however, most nuclides (other than tritium) would move at a much slower rate. The groundwater travel time from the



Source: DOE/NV 1993b, c.

Figure 4.8-4. Areas of potential groundwater contamination at the NTS.

NTS to the Ash Meadows Discharge Area of the Ash Meadows Subbasin Flow System is approximately 300 years. Radioactive decay during this time, coupled with dilution and sorption, should reduce radioactivity concentrations to well below regulatory limits (USAF et al. 1991). Thus, there are no effects on public health and safety, nor are any expected in the foreseeable future.

The NTS derives its complete water supply from the groundwater aquifers underlying the site. Water supply has been developed and is managed on the basis of five service areas that support the different NTS operating areas. Given the wastewater disposal practices on the NTS and the depth to the groundwater system, it is reasonable to assume that all of the water pumped on the NTS is consumed (USAF et al. 1991). Recent annual water use at the NTS has declined substantially from the 1980's. In 1989, NTS annual water withdrawal was 1.117 billion gallons (4.22 million cubic meters) (Leppert 1993). In 1992, NTS annual water withdrawal was 0.595 billion gallons (2.25 million cubic meters) (Leppert 1993).

In 1993, 14 wells were utilized for the NTS water supply (DOE/NV 1994c). A small portion of the NTS receives its water from 5 onsite wells drilled in the Alkali Flat-Furnace Creek Ranch Subbasin (DOE 1988b). Most of the NTS receives its water from 9 onsite wells drilled in the Ash Meadows Subbasin, which encompasses Area 5 (DOE/NV 1994c). These 9 wells have a combined production capacity of 1,813 billion gallons per year (6.86 million cubic meters per year) (DOE/NV 1993a).

Area 5, which encompasses the proposed SNF facility site, is located within NTS water service area C. Wells 5b, 5c, and UE5c serve the fire protection, construction, and potable water needs of Area 5 facilities (DOE/NV 1993b). Wells 5b and 5c are completed in alluvial materials (valley fill aquifer) with total completion depths of 900 and 1,200 feet (274 and 366 meters) below land surface, respectively. Well UE5c is completed in volcanic rock (exact aquifer unknown) with a total depth of 2,682 feet (817 meters) below land surface (DOE 1988b; DOE/NV 1993b; DRI 1993).

Groundwater for construction and operation of the SNF management facilities would likely be drawn from the Frenchman Flat hydrographic area of the Ash Meadows Subbasin. Much of the land within the Ash Meadows Subbasin is under Federal jurisdiction and has been withdrawn from the public domain (DOE 1988b). Little of the total groundwater of the subbasin is privately appropriated or used.

The perennial yield of the Ash Meadows Subbasin greatly exceeds water withdrawals by DOE and all other users. For more than thirty years water withdrawals from the Frenchman Flat hydrographic area had exceeded the estimated precipitation recharge for that area (DOE 1988b). This study also indicates that withdrawals have caused no decline in the static water level (DOE 1988b). However, it should be noted that numerous conditions on the NTS preclude the accurate measurement of static water levels (Winograd 1970). Because of hydrogeologic complexities, regional groundwater flow at the NTS is not constrained by the hydrographic basins which are defined by local topography (USAF et al. 1991). Therefore any potential groundwater overdrafts in the Frenchman Flat basin indicated by previous yield estimates are likely made up by untapped groundwater from neighboring hydrographic basins.

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 the required water is pumped from the ground, although some springs supply water to establishments in Death Valley and other areas south of the NTS. Springs in Oasis Valley near Beatty, Nevada are a significant source of water for public and domestic needs and for irrigation (DOE 1986). The City of Las Vegas obtains approximately 80 percent of its water from the Colorado River; the remaining 20 percent is withdrawn from groundwater sources. There are no plans to change the water supply sources in the near future. (Las Vegas Valley Water District 1994).

The principal water users in the area closest to the NTS are in the Amargosa Desert in and around the Town of Amargosa Valley and in the Pahrump Valley. Aquifers in the Pahrump Valley could support up to about 16,900 residents with no decline in usable storage, although local effects, such as land subsidence and well interference, could result from sustained development. The mining industry in southern Nevada also uses a small amount of water for processing. Water for this purpose is supplied from nearby shallow wells or trucked in from nearby towns. Many of the mines currently recycle process water, which reduces their water demand (DOE 1986).

The volume of groundwater underlying the NTS (as well as the estimated volume of contaminated groundwater) that has been removed from direct access to the general public is rather large. The impaired groundwater will likely remain unusable for an extended period. The significance of the loss of access to the NTS groundwater is diminished by the fact that even if access were provided, the water underlying portions of the NTS might not be usable for domestic purposes (USAF et al. 1991).

4.9 Ecological Resources

NTS lies within the transition area between the Mojave Desert and the Great Basin. As a result, flora and fauna characteristics of both occur on the NTS. The NTS covers about 3,500 square kilometers (1,350 square miles) of which only 0.55 percent is developed (DOE/NV 1988).

NTS has completed numerous studies on the effects of nuclear testing on the ecology of the area, and an extensive bibliography of these studies has been prepared (ERDA 1976). In summary, studies (including ongoing surveys) have shown that there may be a correlation between radioactive testing and the decline of vegetation present in an area. As a result, animals may not have the necessary vegetation for food and cover, thus changing the fauna diversity in those areas (USAF et al. 1991).

The following section describes the ecological resources at the NTS, including terrestrial resources, wetlands, aquatic ecology, and threatened and endangered species. Information is also presented on special status species other than threatened and endangered species such as Federal Candidate and state-listed species.

4.9.1 Terrestrial Resources

Plant communities on the NTS have been classified according to the dominant shrub. Approximately 700 taxa, representing about 70 families, have been identified on the NTS (ERDA 1976; DOE/NV 1993b, 1991b). Figure 4.9-1 presents the general plant communities identified there.

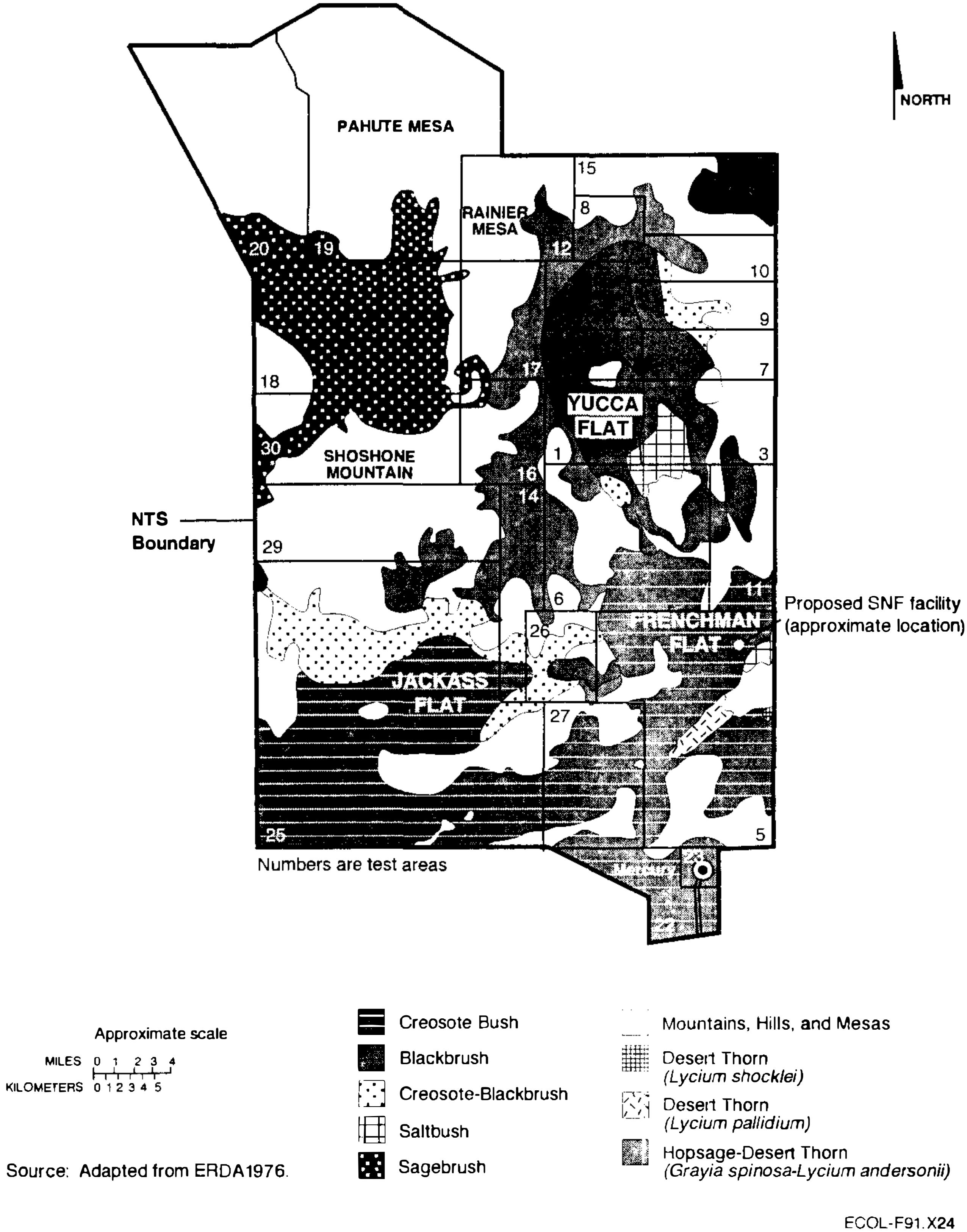


Figure 4.9-1. Plant communities on Nevada Test Site.

The Mojave Desert is located at elevations ranging up to 1,219 and 1,524 meters (4,000 and 5,000 feet). The dominant plant community is creosote bush (*Larrea tridentata*). Areas in which this community occurs are located within much of the southern portion of the NTS, including Jackass Flats and Frenchman Flat (DOE/NV 1991b, 1986b; ERDA 1976; FWS 1992).

The transitional zone between the Mojave Desert and the Great Basin occurs at elevations between 1,219 and 1,524 meters (4,000 and 5,000 feet). The dominant plant communities associated with the transition zone are: blackbrush (*Coleogyne ramosissma*), desert thorn (*Lycium pallidum*), and hopsage (*Grayia spinosa*). In general, these communities are found in upper bajadas and in closed basins within Jackass Flats and Yucca Flat (DOE/NV 1991b, 1986b; ERDA 1976).

The Great Basin is located within the northern two-thirds of NTS at elevations above 1,524 meters (5,000 feet). The dominant plant communities are big sagebrush (*Artemisia tridentata*) and black sagebrush (*Artemisia nova*), saltbush (*Atriplex canescens*), and desert thorn (*Lycium shockleyi*). In areas with elevations above 1,830 meters (6,000 feet), collectively labeled as mountains, hills, and mesas, the dominant plant communities are singleleaf pinyon (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*). In general, these communities are found at Thirsty Canyon, Yucca Playa, Rainier Mesa, and Yucca Mountain (DOE/NV 1991b, 1986b; ERDA 1976).

There is a recent trend of nonnative plant species establishing themselves in areas of disturbance at the NTS. Cheatgrass (*Bromus tectorum*), an annual grass, occurs at elevations above 1,524 meters (5,000 feet). Downey chess (*Bromus rubens*), another annual grass, is becoming established in the mid-elevations. Russian thistle (*Salsola iberica* and *S. paulsennii*) appears in areas where the native vegetation has been removed and the soil composition has changed (DOE/NV 1991b, 1988; ERDA 1976).

Like vegetation, animals on the NTS are representative of both the Mojave Desert and the Great Basin and the associated transition zone. There are over 30 species of reptiles and amphibians, 190 species of birds, and 50 species of mammals on the NTS (DOE/NV 1993b;

ERDA 1976). Many animals utilize man-made reservoirs and natural springs and seeps on the NTS. Sewage ponds have also become an important resource for wildlife.

Reptiles and amphibians on the NTS include 1 species of desert tortoise, 14 species of lizards, and 17 species of snakes. In addition, the NTS is within the range of the Great Basin spadefoot toad (*Scaphiopus intermontanus*). but this amphibian has not been identified on the NTS (DOE/NV 1993b; ERDA 1976; Medica 1990).

Birds on the NTS are often migratory and seasonal residents. The most widely distributed species include the black-throated sparrow (*Amphispiza bilineata*), house finch (*Carpodacus mexicanus*), red-tailed hawk (*Buteo jamaicensis*), common raven (*Corvus corax*), loggerhead shrike (*Lanius ludovicianus*), mockingbird (*Mimus polyglottos*), ash-throated flycatcher (*Myiarchus cinerascens*), and mourning dove (*Zenaida macroura*) (DOE/NV 1993b; ERDA 1976; Greger 1991).

The most abundant group of mammals on the NTS are rodents. Carnivores include coyote (*Canis latrans*), kit fox (*Vulpes macrotis*), badger (*Taxidea taxus*), bobcat (*Lynx rufus*), mountain lion (*Felis concolor*), and long-tailed weasel (*Mustella frenata*). Large mammals on NTS include the mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), desert big horn sheep (*Ovis canadensis*), and wild horse (*Equus caballus*). Hunting, grazing, and fishing are not allowed on the NTS (DOE/NV 1993b, 1986b; ERDA 1976; Medica and Saethre 1990).

In general, the portion of Frenchman Flat in Area 5 (i.e., north and east of Mercury Highway) within which the proposed SNF facility would be located is within the creosote bush community. This plant community is characteristic of the Mojave Desert. Pre-activity surveys completed for the Radioactive Waste Management Site, which is in the general area of the proposed SNF facility, found the dominant vegetation to include creosote bush, spiny hopsage, white bursage, desert thorn, and Nevada joint-fir (*Ephreda nevadensis*) (EG&G 1993, 1991, 1990, 1989).

The distribution of animals within the portion of Area 5 being considered for the proposed SNF facility is not as well documented as for the rest of the NTS. However, species identified within 5 kilometers (3.1 miles) of the Liquefied Gaseous Fuels Spill Test Facility include 8 reptiles, 17 bird species, and 14 mammals (Hunter et al. 1991). The Liquified Gaseous Fuels Spill Test Facility is located within similar habitat approximately 7.6 kilometers (5 miles) south of the proposed facility. There are no water sources located within the portion of Area 5 being considered for the proposed SNF facility.

4.9.2 Wetlands

There are several natural springs on the NTS that feed flowing streams (Greger and Romney nda). Some of these extend for 91 meters (300 feet) before infiltration and evaporation cause them to dry up. Vegetation along these channels consists of willow (*Salix* sp.) and tamarisk (*Tamarix* sp.). Reservoirs on the site which are fed by groundwater from wells have developed wetland vegetation such as tamarisk, cattail (*Typha* sp.), and bulrushes (*Scirpus* sp.) (Elle 1992). A wetland delineation, as defined by the 1987 U.S. Army Corps of Engineers wetlands Delineation Manual (U.S. COE 1987), has not been performed for any of these areas (DOE/NV 1993b; Elle 1992), and National Wetlands Inventory maps are not available for the NTS.

The portion of Area 5 under consideration for the SNF facility does not have any known springs, seeps, or wetland vegetation (DOE/NV 1993b; Greger and Romney nda).

4.9.3 Aquatic Resources

Potential aquatic habitat on the NTS includes surface drainages, playas, man-made reservoirs, and springs. Permanent surface water sources are limited to a few small springs.

There are two dry lake beds (playas) located in the eastern (Yucca Flat) and southeastern (Frenchman Flat) portions of the NTS. Runoff from the eastern half of the NTS flows through surface drainages to onsite playas and can collect for a few days to a few months. The remaining areas of the NTS drain offsite via arroyos and dry stream beds that carry water only during intense or persistent rainstorms. These surface drainages and playas are unable to support permanent fish populations (ERDA 1976; Greger and Romney nda).

Reservoirs resulting from discharge of well water located on the NTS support three introduced species of fish: bluegill (*Lepomis macrochirus*), goldfish (*Carassius auratus*), and golden shiner (*Notemigonus crysoleucas*). Springs located throughout the site do not support fish populations (Elle 1992). There are no springs, seeps, or other permanent water bodies on the proposed SNF Site; however Cane Spring is located in Area 5, southwest of the proposed SNF Site (Greger and Romney nda).

4.9.4 Threatened and Endangered Species

Table 4.9-1 presents a list of federally and state-listed species that may be found in the vicinity of NTS.

There are no known plants which have been listed as threatened or endangered under the Endangered Species Act (16 USC 1531-1534) on NTS. However, the U.S. Fish and Wildlife Service has identified candidate species for listing, 11 of which may occur on or in the vicinity of the NTS. Ten of these are Candidate Category 2 species, meaning that information indicates that they may be appropriate for listing as endangered or threatened but more information is needed. One species, the Beatley milk-vetch, is a Candidate Category 1 species (DOE/NV 1993b, 1991c; EG&G 1993; USAF et al. 1991). This species has been identified on Pahute Mesa (Hunter et al. 1988). A Candidate Category 1 species is one for which there is substantial information indicating that it is appropriate for listing as endangered or threatened Four Candidate Category 2 species (camissona, black wooly-pod, cymopterus, and Beatley phacelia) have been identified in Frenchman Flat, although none of these was identified during surveys conducted near the proposed SNF facility site (EG&G 1993; Tetratech 1993).

Two listed reptile species on or in the vicinity of NTS are of concern. The chuckwalla is a Federal Candidate Category 2 species which may occur on NTS. The desert tortoise is the only federally listed threatened species known to occur on NTS (DOE/NV 1993b; EG&G 1993). Both the desert tortoise and the chuckwalla are listed as reptile species of Frenchman Flat (DOE/NV 1986b).

Table 4.9-1. Federally and state-listed threatened, endangered, and other special status species that may be found in the vicinity of the Nevada Test Site.[a]

Common name	Scientific name	Status[b] Fed.	State
	Plants		
Amargosa penstemon	*Penstemon fruticiformis* ssp. *amargosae*	C2	NL
Beardtongue[c]	*Penstemon pahutensis*	C2	NL
Beatley milkvetch[c]	*Astragalus beatleyae*	C1	CE
Beatley phacelia[c]	*Phacelia beatleyae*	C2	NL
Black wooly-pod[c]	*Astragalus funerus*	C2	NL
Camissonia[c]	*Camissonia megalantha*	C2	NL
Cymopterus[c]	*Cymopterus ripleyi* var. *saniculoides*	C2	NL
Green-gentian[c]	*Frasera pahutensis*	C2	NL
Kingston bedstraw[c]	*Galium hilendiae* ssp. *kingstonense*	C2	NL
Mojave fishhook cactus[c]	*Sclerocactus polyancistrus*	NL	CY
White bear desert-poppy[c]	*Arctomecon merriamii*	C2	NL
	Birds		
Bald eagle[d]	*Haliaeetus leucoephalus*	E	E
Golden eagle[c]	*Aquila chrysaetos*	NL	P
Ferruginous hawk[c]	*Buteo regalis*	C2	NL
Loggerhead shrike[c]	*Lanius ludovicianus*	C2	NL
Mountain plover[c]	*Charadrius montanus*	C2	NL
Peregrine falcon[d,e]	*Falco peregrinus*	E	E
Western least bittern	*Ixobrychus exilis hesperis*	C2	NL
Western snowy plover[c]	*Charadrius alexandrinus nivosus*	C2	NL
White-faced ibis[c]	*Plegadis chihi*	C2	NL
	Reptiles		
Chuckwalla	*Sauromalus obesus*	C2	NL
Desert tortoise[c]	*Gopherus agassizit*	T	T
	Mammals		
Spotted bat	*Euderma maculatum*	C2	NL
Pygmy rabbit	*Branchylqus idahoensis*	C2	NL
	Fish		
Devils Hole pupfish[d,f]	*Cyprinodon diabolis*	E	E

a. Sources: CFR (1993c,d); ERDA (1976); EG&G (1993); DOE/NV (1986b); FR (1991, 1990b); FWS (1993); Hunter et al. (1988); NV DCNR (1992); Tetratech (1993).

b. Status codes:
C1 Federal candidate - Category 1 (probably appropriate to list)
C2 Federal candidate - Category 2 (possibly appropriate to list more study required)
CE State critically endangered by authority of NRS 527.270 (State Division of Forestry)
CY State protected by authority of NRS 527.60-.120 under the Nevada Cacti and Yucca Law
E Endangered
NL Not listed
T Threatened
P State protected by NAC 503.050

c. Species recorded on the NTS.

d. U.S. Fish and Wildlife Service Recovery Plan exists for this species.

e. Peregrine falcon seen on the NTS; however not identified to subspecies level.

f. Only known location of this species is outside the NTS 24 miles (39 km) southwest of Mercury. This species is included here due to potential offsite groundwater impacts.

Note: Nevada Department of Wildlife utilizes the Federal threatened and endangered species list.

The distribution and abundance of the desert tortoise have been extensively researched; the latest research for the NTS as a whole was completed in 1991 (DOE/NV 1991c). A biological opinion from the U.S. Fish and Wildlife Service was completed in 1992 for NTS activities planned for 1992 through 1995 (FWS 1992). The desert tortoise is known to exist in the southern portion of the NTS, but its abundance on the NTS is considered to be very low to low (DOE/NV 1991c). The northern extent of its range is from Massachusetts Mountain through Control Point Hills and Mid Valley to Topopah Valley and west to the NTS boundary (DOE/NV 1991c).

Two bird species which could occur on or within the vicinity of NTS are federally listed endangered species. These are the American peregrine falcon and the bald eagle. The American peregrine falcon has been sighted on the NTS in the past but not recently (DOE/NV 1991c; ERDA 1976). Bald eagles may also occur on the NTS, but sightings have not been reported in recent literature (DOE/NV 1986b; EG&G 1993; ERDA 1976; Hunter et al. 1991). Six other bird species, all of which are Federal Candidate Category 2 species, are known to occur on or within the vicinity of NTS (DOE/NV 1991c; EG&G 1993). Recent surveys of Area 5 (which contains the proposed SNF Site) have not identified any of these species (DOE/NV 1986b; EG&G 1993, 1991, 1990, 1989). However, birds listed as common to Frenchman Flat include the golden eagle and loggerhead shrike (DOE/NV 1986b; Tetratech 1993).

There are two Federal Candidate Category 2 mammal species identified as potentially occurring in the vicinity of the NTS. Neither the spotted bat nor the pygmy rabbit has been observed during recent pre-activity surveys for the area (EG&G 1993; USAF 1993). They are also not listed as mammals occurring in Frenchman Flat (DOE/NV 1986b; Tetratech 1993).

There are no known fish species indigenous to the NTS. However, it is important to note that the only known location of the Devils Hole pupfish, a federally listed endangered species, is approximately 39 kilometers (24 miles) southwest of the NTS. The decline of this species has been attributed to low water levels caused by decreasing groundwater levels (ERDA 1977; USAF et al. 1991).

Pre-activity surveys for threatened and endangered species have recently been completed for the Radioactive Waste Management Site located in Area 5 near the proposed SNF facility. The primary purpose of these surveys was to identify live tortoise, scat, burrows, and remains. Although these surveys have found few tortoise or their sign, each new activity on NTS must undergo pre-activity surveys for the desert tortoise (DOE/NV 1991c; EG&G 1993, 1991). In addition, these surveys look for other listed species. Recent surveys have not identified any other listed or candidate species in the portion of Area 5 surrounding the Radioactive Waste Management Site, which is near the proposed SNF Site (EG&G 1993, 1991).

4.10 Noise

The major noise sources at the NTS occur primarily in developed operational areas and include various facilities, equipment and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles), aircraft operations, and testing. No NTS environmental noise survey data are available. At the NTS boundary, away from most facilities, noise from most sources is barely distinguishable from background noise levels. Some disturbance of wildlife activities might occur within the NTS as a result of operational activities and construction activities.

Existing NTS-related noise sources of importance to the public are those from transportation of people and materials to and from the NTS. These sources include trucks, buses, private vehicles, helicopters, and airplanes. In addition, some air cargo and business travel via commercial air transport through the McCarren International Airport in Las Vegas can be attributed to the NTS operations.

The State of Nevada and Nye County have not established any regulations that specify acceptable community noise levels with the exception of prohibitions on nuisance noise.

During a normal week, about 3,300 employees travel to the NTS each day. Most employees commute using the contracted bus service and a small portion commute in government or private vehicles. Both government-owned and private trucks pick up and deliver materials at the site. Most of the private vehicles, buses, and trucks travel to and from the site each day using U.S.

Route 95. The contribution of the NTS operations to traffic volumes along U.S. Route 95, especially during peak traffic periods, affects noise levels at residences along this route.

4.11 Traffic and Transportation

Traffic congestion is measured by level of service. Level of Service A represents free flow of traffic. Level of Service B is in the range of stable flow, but the presence of other users in the traffic stream begins to be noticeable. Level of Service C is in the range of stable flow, but marks the beginning of the range of flow in which the operation of individual users becomes significantly affected by interactions with others in the traffic stream. Level of Service D represents high-density but stable flow. Level of Service E represents operating conditions at or near the capacity level. Level of Service F is used to define forced or breakdown of flow of traffic. The calculated Level of Service are for discrete locations along a segment. Level of Service will most likely be worse in urban areas and better in rural areas along with the segment.

The Region of Influence for the following analysis includes site roads and regional roads in Nye and Clark counties.

Vehicular access to the NTS is provided by U.S. Route 95 to the south, with off-road access to the northeast provided via Nevada State Route 375. Baseline traffic along segments providing access to the NTS contributes to differing service level conditions. Nevada State Route 375 and U.S. Route 95 are projected to remain at Level of Service A. No major improvements are presently scheduled for those segments providing immediate access to the NTS (NDOT 1992). Regional roads and local roads providing access to NTS are presented in Figures 2.1-1 and 2.1-2, respectively.

Future background traffic (defined as all future traffic not attributable to the proposed SNF facilities) is projected to contribute to differing service-level conditions for local roads in 2001. The year 2001 was selected for analysis because that is when the impacts from the proposed SNF facilities would be highest. All local and regional roads are projected to operate at Level of Service A.

The Level of Service was calculated using average daily traffic counts (NDOT 1992) and standard parameters (ITE 1991; Rand McNally 1993; TRB 1985).

The public transit serves the heavily populated regions of Clark County. Contract buses run to the NTS. There is no public transportation system serving the NTS; however, approximately 70 buses a day transport employees to and from the site. The nearest major railroad is the Union Pacific, located approximately 50 miles (80 kilometers) east of the NTS. A 9-mile (15-kilometer) standard-gauge railroad serves Area 25 of the NTS but does not connect with the Union Pacific (ERDA 1977). No navigable waterways within the Region of Influence are capable of accommodating waterborne transportation of material shipments to the NTS.

McCarran International Airport in Las Vegas provides jet air passenger and cargo service from both national and local carriers. It is outside the Region of Influence. Smaller private airports are located throughout the Region of Influence. Desert Rock Airstrip, the onsite airport, is located near Mercury.

4.12 Occupational and Public Health and Safety

Health impacts to the public from activities on the NTS are minimal as a result of administrative and design controls to minimize releases of pollutants to the environment and to achieve compliance with permit requirements, e.g., air emissions and National Pollutant Discharge Elimination System permit requirements. The effectiveness of these controls is verified through the use of monitoring and inspections. Health impacts to the public may occur during normal operations at the NTS via inhalation of air containing radioactive and chemical pollutants released to the atmosphere, immersion in this air, and ingestion of food contaminated by these pollutants. Risks to public health from other possible pathways such as exposure to contaminated soil are low relative to these pathways.

Health impacts to NTS workers during normal operations may include those from inhalation of the workplace atmosphere, consumption of potable water, direct exposure, and possible other contact with hazardous materials associated with work assignments. The potential for health impacts varies from facility to facility and from worker to worker, and available information is not sufficient to allow a meaningful estimation and summation of these impacts. However, workers are protected from hazards specific to the workplace through appropriate training, protective equipment, monitoring, and management controls. NTS workers are also protected by occupational standards that limit atmospheric and drinking water concentrations of potentially hazardous chemicals and that also limit radiation exposure. Monitoring ensures that these standards are not exceeded. Additionally, DOE requirements (DOE Order 3790.1B) ensure that conditions in the workplace are as free as possible from recognized hazards that cause or are likely to cause illness or physical harm. Therefore, worker health conditions at the NTS are expected to be substantially better than required by standards.

Health effects from radiation are presented here as the risk of fatal cancer. This risk is in the ratio of the health risk estimator (risk of fatal cancer per rem of exposure). The value of this estimator for exposures to the public is 5.0×10^{-4} for fatal cancers. The corresponding estimator for exposures to workers is 4.0×10^{-4}.

The DOE Nevada Field Office published a Waste Minimization and Pollution Prevention Awareness Plan in June 1991 to reduce the quantity and toxicity of hazardous, mixed, and radioactive wastes generated at DOE/NV facilities. The plan is designed to reduce the possible pollutant releases to the environment and thus increase the protection of employees and the public. All DOE/NV contractors and NTS users that exceed the EPA criteria for small-quantity generators are establishing their own waste minimization and pollution prevention awareness programs that are implemented by the DOE/NV plan. Contractor programs ensure that waste minimization activities are in accordance with Federal, state, and local environmental laws and regulations, and DOE Orders (DOE/NV 1993c).

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of wastes generated, and implementation of recycling programs. Goals also include incorporation of waste minimization concepts and technologies in planning and design of new processes and facilities, and in upgrades of existing facilities. A waste minimization task force composed of representatives from each contractor and NTS user has been established to coordinate DOE/NV waste minimization and pollution awareness activities (DOE/NV 1993c).

4.12.1 Doses

4.12.1.1 Radiological Doses. Every individual is affected by natural and other background radiation. The major sources of background radiation exposure to individuals in the vicinity of the NTS are shown in Figure 4.7-2. All annual doses to individuals from background radiation are expected to remain constant over time.

Releases of radionuclides to the environment from NTS operations provide another source of radiation exposure to people in the vicinity of the NTS. Table 4.7-2 summarizes the airborne radionuclides and quantities released in curies during baseline NTS operations. The annual committed doses to the public resulting from these release are given in Table 4.7-4. Compared to those from natural background radiation, these doses are very small. The doses are all less than 1 percent of the most restrictive standard given in DOE Order 5400.5.

Workers at the NTS receive the same dose as the general population from background radiation but also receive an additional dose from working in the facilities. The doses to the average and maximally exposed workers due to operation in 1991 (assumed representative of 1995 operations), were approximately 5 and 500 millirem, respectively; the total dose to all workers was about 4 person-rem (DOE/NV 1992c). The maximum dose is well within the limit of 5,000 millirem per year specified in DOE Order 5480.11 and in 10 CFR 835.

4.12.1.2 Nonradiological Doses. Every individual is also affected by background concentration of nonradiological pollutants. The maximum background concentrations for those criteria pollutants which have been measured is provided in Table 4.7-5. The maximum existing DOE site contribution concentration was then computed, as discussed in Section 4.7.

4.12.2 Health Effects

4.12.2.1 Radiological. The fatal cancer risk to the maximally exposed member of the public due to the radiological emissions from NTS baseline operations in 1995 would be 5.5×10^{-9}. The same risk estimator projects 2.6×10^{-6} excess fatal cancer to the population within

80 kilometers (50 miles) of the NTS. These values would be approximately 2.2 x 10^{-7} and 1 x 10^{-4}, respectively, during the 40 years of SNF facility operations.

Because of the different age distribution of a working population, the health risk estimators for workers are somewhat lower than for members of the general public. As a result of 1995 baseline operations at the NTS, these estimators predict a fatal cancer risk of 2.0 x 10^{-4} to the maximally exposed worker, and 1.6 x 10^{-3} excess fatal cancer among all workers. The risk faced by an average worker would be 2.0 x 10^{-6}. Over the 40-year operating life of the proposed SNF facility, and assuming a particular worker during this time, these values would be 8.0 x 10^{-3}, 6.4 x 10^{-2}, and 8.0 x 10^{-5}, respectively.

4.12.2.2 Nonradiological. As discussed in Section 4.7, the maximum existing DOE site contribution of criteria nonradiological air pollutants were computed. In Table 4.7-5 the total existing maximum concentration (which adds the maximum existing DOE site contribution to the maximum background concentration) is presented. The total existing maximum concentration values represent the highest concentrations to which members of the public would be exposed. In every case where information was available, the highest concentration was less than the applicable health-based standard.

4.12.2.3 Health Effects Studies. The epidemiologic studies concerning the NTS have concentrated on the health effects in soldiers and children associated with nuclear testing rather than on plant emissions (Beck and Krey 1983; Bross and Bross 1987; Caldwell et al. 1980; Lyon et al. 1979; Rallison et al. 1990; and others). The results regarding the observed leukemia incidence and deaths in exposed children are contradictory, with some studies reporting an excess and others reporting no excess. The validity of the analytical methods used in some of these studies are subject to various opinions. For soldiers, the results regarding leukemia and polycythemia vera differed between two studies relating to nuclear test explosions, but reanalyses showed leukemia, respiratory, and other cancers to be associated only with exposure to higher doses, e.g., more than 300 millirem for leukemia cases.

In March 1990, the Secretary of Energy announced that DOE would turn over responsibility for analytical epidemiologic research on long-term health effects on workers at DOE facilities and surrounding communities to the Department of Health and Human Services and directed that worker health and exposure data be released. A Memorandum of Agreement with the Department of Health and Human Services was signed in January 1991. The Department of Health and Human Services is now conducting the ongoing health effects research program. To develop a data base on workers, DOE has initiated an Epidemiologic Surveillance Program and a Health-Related Records Inventory.

4.13 Utilities and Energy

4.13.1 Water Consumption

There are 14 active wells which supply water to the NTS. Figure 4.8-2 in Section 4.8 shows the location of these wells. These 14 wells combined had a capacity of 387 liters per second (6,139 gallons per minute) in 1993 (DOE/NV 1993a). From 1988 to 1993, water use at the NTS 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 (DOE/NV 1994c; Leppert 1993). Water usage projections to 1995 are unavailable; however, significant changes in the water consumption level are not anticipated.

There are also a number of deactivated wells located on the NTS. These wells could add additional water supply capacity if they were reactivated (Leppert 1993). It has been estimated that the activation of these wells could increase the available water supply by 85 liters per second (1,342 gallons per minute). Other methods to increase production of water could include increasing pump sizes or installing new wells (DOE/NV 1993a).

The proposed SNF site would be located in Area 5. There are four wells located in Area 5, two of which supply potable water. These two wells have a capacity of 38 liters per second (595 gallons per minute) (DOE/NV 1994c; 1993b). A third well in the area is currently being used to supply water for construction activities. The fourth well has been deactivated (DOE/NV 1993b). In 1993, Area 5 used approximately 12 liters per second (191 gallons per minute) of water, including the well used for construction purposes. Water usage for Area 5 is not expected to change substantially from 1993 to 1995 (DOE/NV 1994c; Leppert 1994).

4.13.2 Electrical Consumption

The NTS obtains electrical power from the Nevada Power Company and Valley Electric Association. Each company provides an independent 138 kilovolt transmission line to the site. The capacity of these transmission lines, with scheduled upgrades, is approximately 40 to 45 megavolt-amperes. The local utilities' 138 kilovolt transmission grids have adequate capacity within a 80-kilometer (50-mile) radius of the NTS to serve an additional 75 megavolt-amperes of load. In addition, the local utilities' proposed expansion of their existing 230 kilovolt transmission systems would make capacity in excess of 200 megavolt-amperes available within an 80-kilometer (50-mile) radius (DOE/NV 1993a).

From 1989 to 1993, the annual consumption of electricity ranged from a high of 183,118 megawatt hours in 1989 to a low of 144,521.5 megawatt hours in 1993. The peak demand varied from a high of 38.4 megavolt-amperes in 1989 to a low of 30.9 megavolt-amperes in 1993 (Leppert 1993; Thornton 1994). In 1995, the annual consumption of electricity is projected to be 176,440 megawatt hours, with a peak demand of 39.5 megavolt-amperes. The institution of energy management practices can regulate the peak demands of various NTS activities so that the maximum peak capacity is not exceeded. The predicted increase in overall electricity usage for 1995 is attributable to the increased requirements for the Yucca Mountain Site Characterization Project; the usage for the rest of the NTS is predicted to continue its downward trend (Thornton 1994).

The Frenchman Flat Substation, located in Area 5, has a capacity of 12.5 megavolt-amperes (Thornton 1994). A 34.5 kilovolt line from this substation feeds the loads at Area 6, Well C, the Tweezer facility, and the east side of the test areas used by LANL (DOE/NV 1993b). In 1993, the peak demand on the substation was 5.2 megavolt-amperes. This demand is not anticipated to change substantially from 1993 to 1995 (Thorton 1994).

4.13.3 Fuel Consumption

The majority of the energy used at the NTS is provided by electricity, but diesel fuel and fuel oil are used to provide heat in some facilities and backup power.

4.13.4 Wastewater Disposal

Currently, there are no wastewater disposal facilities in Area 5. Septic systems are used in parts of the NTS for sanitary wastewater disposal. These septic systems discharge to percolation/evaporation stabilization ponds. These ponds, however, are only used for the disposal of wastewater not generated by any manufacturing processes.

4.14 Materials and Waste Management

The operations conducted at the NTS have resulted in generation of low-level radioactive waste, hazardous waste, mixed waste (radioactive and hazardous combined), and sanitary waste (nonhazardous, nonradioactive solid waste). In addition, the NTS stores mixed transuranic waste received from Lawrence Livermore National Laboratory. This section discusses the treatment, storage, and disposal of waste at the NTS.

DOE currently operates two disposal facilities in Areas 3 and 5 at the NTS for low-level radioactive waste generated by DOE defense facilities. The Area 5 Radioactive Waste Management Site also serves as a interim storage area for LLNL transuranic wastes which will be shipped to the Waste Isolation Pilot Plant in New Mexico for final disposal. The Area 5 facility also accepts mixed waste, which contains both low-level radioactive waste and hazardous waste only if the waste was generated on the NTS.

All hazardous wastes generated at the NTS are disposed of offsite at commercial facilities approved and permitted by the EPA. Hazardous wastes are temporarily stored at the NTS in full compliance with Federal, state, and local requirements.

Mixed waste disposal facilities are presently operating under interim status, pending completion of the Resource Conservation and Recovery Act (RCRA) permitting process. Operation of the low-level radioactive waste and mixed waste disposal sites and the temporary transuranic waste storage site are supported by an environmental monitoring program that indicates waste is being safely contained in the near-surface environment in which it is emplaced.

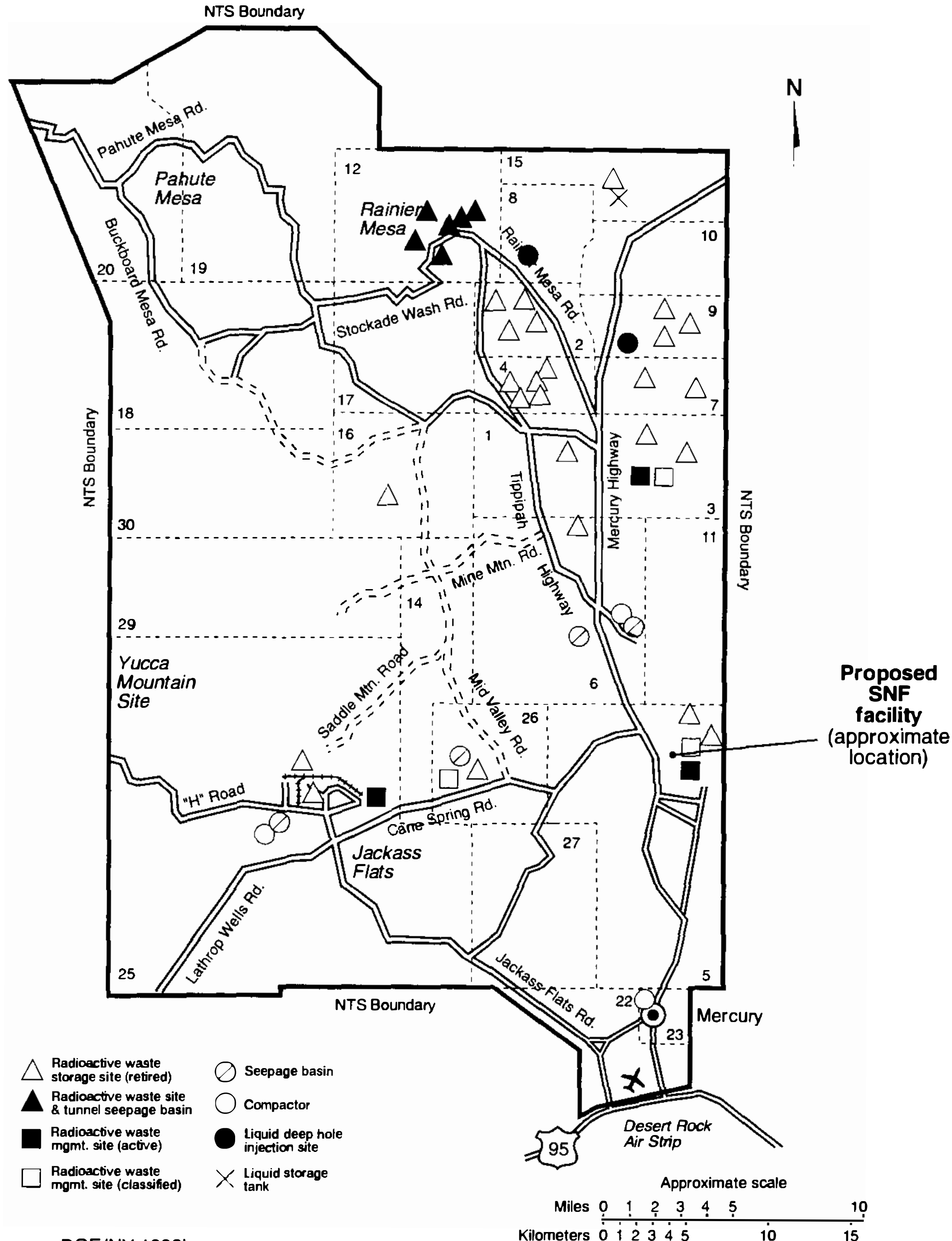
The radioactive and mixed-waste disposal facilities are mainly shallow land burial areas. Figure 4.14-1 shows the location of the waste management facilities at the NTS (DOE/NV 1993b, 1992b).

The DOE Nevada Operations Office developed and implemented a Waste Minimization and Pollution Prevention Awareness Plan to reduce the quantity and toxicity of hazardous. mixed, and radioactive wastes generated at the NTS. The plan is designed to reduce the possible pollutant releases to the environment. The objectives of the waste minimization and pollution program are to:

- Identify processes generating waste streams
- Characterize and track each waste stream
- Identify, evaluate, and implement applicable waste minimization technologies
- Set numerical goals and schedules after the initial assessment of technological and economic feasibility
- Establish an employee pollution prevention awareness and training program.

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of wastes generated, implementation of recycling programs, and incorporation of waste minimization concepts and technologies in planning and design of new processes and facilities and in upgrades of existing facilities.

The NTS manages the following waste categories: mixed transuranic waste, mixed low-level waste, low-level waste, hazardous waste, sanitary waste, and nonhazardous waste. The NTS does not currently manage high-level waste or SNF. The NTS waste management activities include onsite treatment, onsite storage, onsite disposal, and preparation for appropriate offsite disposal. Additionally, the NTS uses and manages an onsite inventory of hazardous materials, including



Source: DOE/NV 1993b.

Figure 4.14-1. Existing treatment, storage, and disposal units at the NTS.

some managed in underground storage tanks. Figures 4.14-2 and 4.14-3 present flow diagrams of onsite generated waste management and waste shipment, receipt, and disposal, respectively.

Waste generation rates presented for each of the waste categories for the NTS represent 1993 waste generation rates unless otherwise stated and are assumed representative of the 1995 baseline year. Table 4.14-1 presents the baseline waste management for 1995 for those waste categories currently managed at the NTS. In addition, the table presents available disposal/ storage capacity and waste disposition.

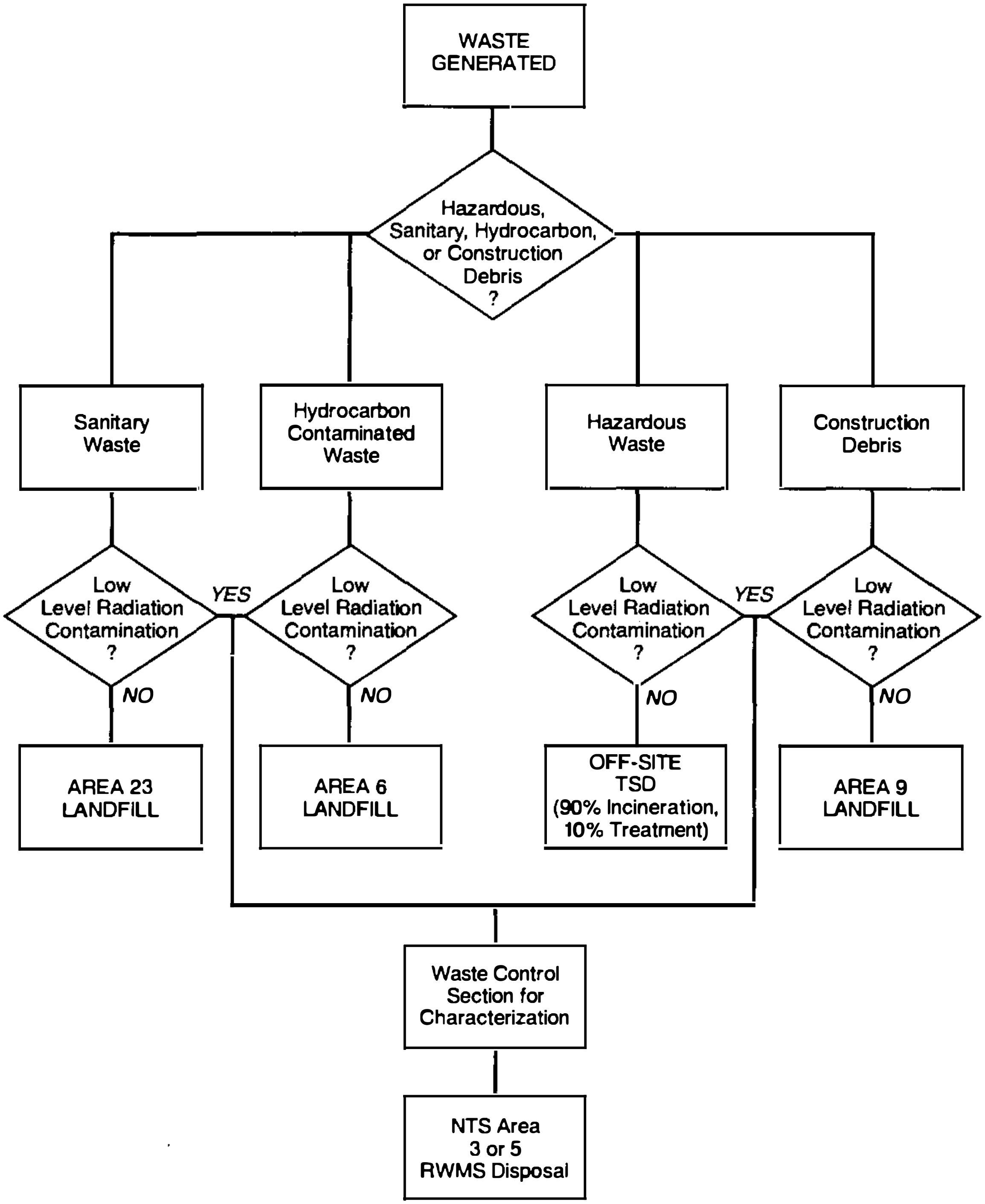
4.14.1 Transuranic Waste

Transuranic waste from the Rocky Flats Plant and mixed-transuranic waste from LLNL are stored at the NTS at the transuranic waste storage cell located in Area 5 Radioactive Waste Management Site. The transuranic waste has been characterized and repackaged, and the mixed-transuranic waste has been placed in a RCRA-permitted storage area consisting of 55-gallon drums and steel boxes stored on wooden pallets fixed upon a curbed asphalt pad. Approximately 204,663 kilograms (451,201 pounds) with a total volume of 612 cubic meters (800 cubic yards) of transuranic waste are stored at the NTS (DOE/NV 1994d). The NTS expects no additional transuranic or mixed-transuranic wastes to be stored at this unit.

4.14.2 Mixed Low-Level Wastes

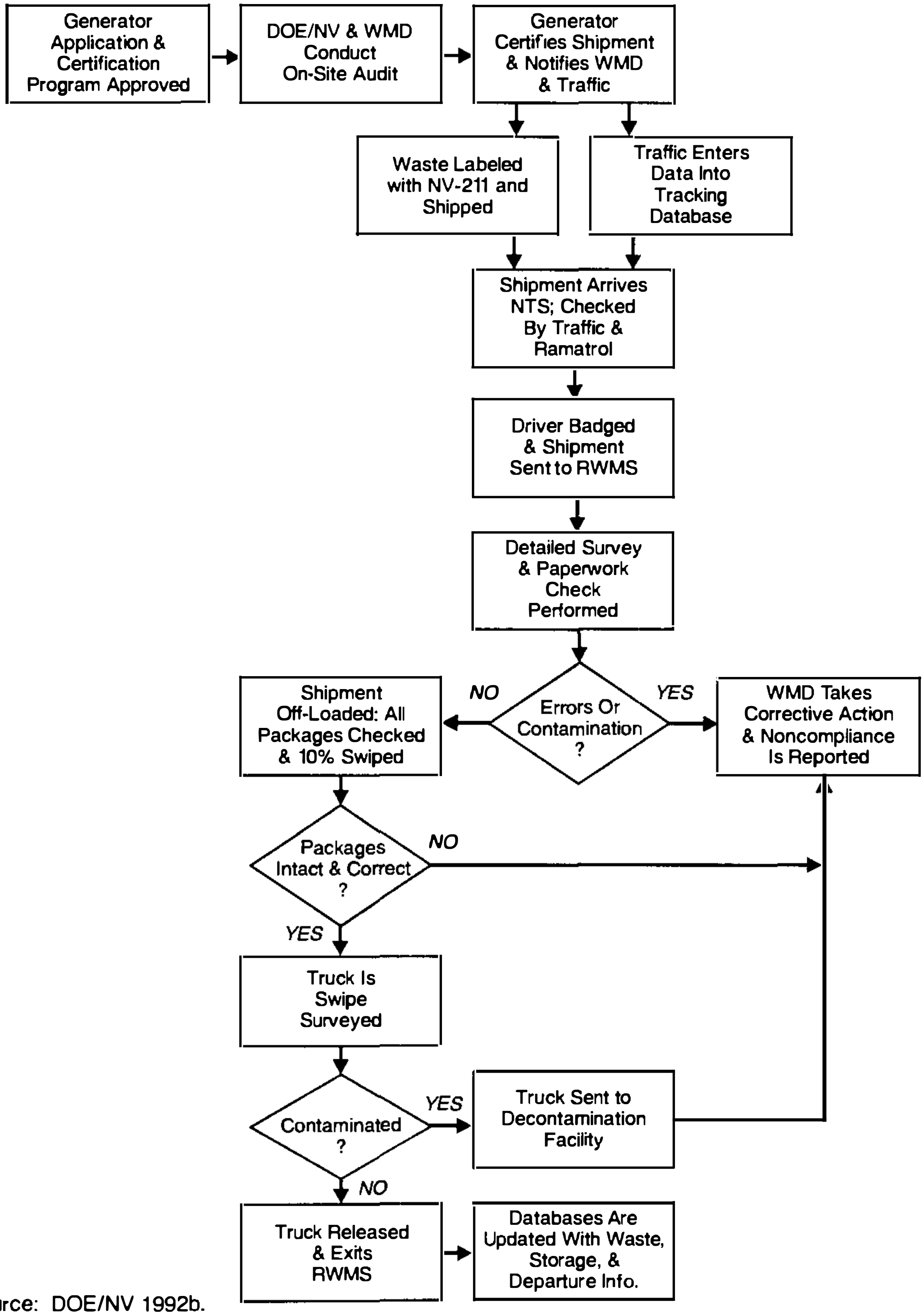
The Area 5 Radioactive Waste Management Site contains Pit 3, which is an active mixed low-level waste management unit. Pit 3 is the only active landfill cell within the Area 5 Radioactive Waste Management Site for which a RCRA permit is being sought. Pit 3 is an unlined, trapezoidal shaped pit occupying 3.42×10^4 square meters (8.46 acres) with a process capacity of 1.29×10^5 cubic meters (1.69×10^5 cubic yards). The estimated disposal space for mixed low-level waste remaining at this facility is 9.03×10^4 cubic meters (1.19×10^5 cubic yards) (DOE/NV 1992b).

A RCRA permit is being sought for a proposed Mixed Waste Disposal Unit in the area immediately north of Pit 3 in the Area 5 Radioactive Waste Management Site. This Mixed



Source: DOE/NV 1994c.

Figure 4.14-2. Flow diagram for waste generation at the NTS.



Source: DOE/NV 1992b.

Figure 4.14-3. Flow diagram for waste shipment, receipt, and disposal at the NTS.

Table 4.14-1. Baseline waste management for 1995 at the NTS.[a]

Waste type	Volume generated or disposed of (m^3)	Available disposal space (m^3)	Disposition
Transuranic waste and mixed-transuranic waste	0	8,296	Interim onsite storage
Low-level waste	10,845	438,359	Onsite disposal
Mixed low-level waste	0	90,240	Onsite disposal
Hazardous waste	252	91	90-day pad
Sanitary waste	1.1×10^4 [b]	c	Onsite disposal

a. Sources: DOE/NV (1994d, 1992c).

b. 1992 data.

c. Current disposal space adequate.

Waste Disposal Unit would occupy 2.1 x 10^5 square meters (52 acres) and consist of ten landfill cells. The estimated disposal space for mixed waste in this proposed unit is approximately 1.20 x 10^5 cubic meters (1.58 x 10^5 cubic yards) (DOE/NV 1992b).

In May 1990, mixed waste disposal operations ceased due to EPA issuance of the Land Disposal Restrictions of RCRA. Active mixed waste disposal operations will commence under interim status in Pit 3 upon completion of NEPA documentation and an approved Waste Analysis Plan (DOE/NV 1993c). No mixed low-level waste has been received, generated, or disposed of at the NTS since 1991 (DOE/NV 1994d, 1993c,f).

4.14.3 Low-Level Waste

Two low-level waste disposal facilities are in operation at the NTS: Area 5 Radioactive Waste Management Site and the Area 3 Radioactive Waste Management Site (DOE/NV 1992c). The Area 5 Radioactive Waste Management Site receives low-level waste generated at the NTS and other DOE facilities and occupies approximately 2.9 square kilometers (730 acres) of land. The waste is disposed of in large-diameter shafts, trenches, and shallow pits. The total volume of low-level waste disposed of at the Area 5 Radioactive Waste Management Site between 1961 and 1991 was 3.96 x 10^5 cubic meters (5.8 x 10^5 cubic yards). Average annual low-level waste disposal for this period was 1.3 x 10^4 cubic meters (1.7 x 10^4 cubic yards). During 1993, approximately 1.1 x 10^4 cubic meters (1.4 x 10^4 cubic yards) of low-level waste was disposed of at the NTS (DOE/NV 1994d).

4.14.4 Hazardous Waste

The primary facilities that generate or manage nonradioactive hazardous wastes and/or use or store nonradioactive hazardous materials are the Liquified Gaseous Fuels Spill Test Facility, the Hazardous Waste Accumulation Site, the tunneling facilities and operations, and various underground storage tanks.

The Liquified Gaseous Fuels Spill Test Facility is located on Frenchman Lake in Area 5. This location provides a remote, environmentally acceptable setting for atmospheric release of hazardous materials and toxic substances for investigative purposes. The facility consists of a tank farm, spill area, wind tunnel, and pads for conducting small volume spill tests. The facility also includes a control building that houses data acquisition and recording instruments, a command and control computer, and support personnel. A total of 17 spill tests were conducted at the facility in Area 5. Discharges from the test facility occur at a controlled rate and consist of a measured volume of hazardous test fluid released on a surface especially prepared to meet the test requirements. Personnel monitor and record operating data, close-in and downwind meteorological data, and downwind gaseous concentration levels. Spills involving hydrofluoric acid were conducted in 1991 and the results monitored (DOE/NV 1992c).

The Hazardous Waste Accumulation Site consists of an impervious concrete pad with 15-centimeter (6-inch) curbs to contain spillage and to protect the pad from precipitation runon and runoff; a separate curbed area is provided for noncompatible wastes. A roof protects the wastes from rain and weathering effects; there is also a fire detection system (DOE/NV 1992d). Each operating entity at NTS is a potential satellite accumulation area for hazardous waste. Each satellite accumulation area is allowed to accumulate up to 208.2 liters (55 gallons) of hazardous waste or 0.95 liter (1 quart) of acutely hazardous waste. Within 3 days of reaching these quantities, the waste is transferred to the Hazardous Waste Accumulation Site. If the material is unknown or if an offsite treatment, storage and disposal facility wishes to confirm the contents of a waste stream, samples are collected for characterization (DOE/NV 1992d).

When the waste containers are transferred to the Hazardous Waste Accumulation Site, they are checked for proper labeling and an accumulation date is assigned to each container. An EPA-permitted treatment, storage, and disposal facility is contacted prior to the 90-day storage limit to collect and remove the accumulated wastes from the NTS (DOE/NV 1992d).

Nuclear devices were tested in horizontal tunnels mined into Rainer Mesa at the NTS. The tests were conducted in zeolitized volcanic tuffs, which act as a perching layer for waters infiltrating from the mesa surface. During normal tunneling operations, fractures containing water are intercepted creating artificial springs in the tunnels. Periodically, these waters contain radionuclides from previous underground nuclear tests and are drained out of the tunnels into evaporation ponds or washes. Tunneling and related operations also may have released organic compounds and heavy metals to the tunnel effluent. Presently, sampling of the tunnel effluent is being conducted to characterize the effluent. The objectives of the project include identifying the types and concentrations of radionuclides, metals, and organic compounds in the effluent of U12t, U12e, and U12n tunnels. Variations of discharge volumes and chemical contaminants over time are also being examined (DOE/NV 1992c).

There is a site-wide inventory of 115 underground storage tanks at the NTS. These include 24 underground storage tanks containing petroleum products that were removed, closed in place, or temporarily taken out of service in 1991 in accordance with state statutes as well as 17 underground storage tanks which were temporarily closed in 1991 while awaiting upgrades (DOE/NV 1992c).

As part of the 1991 underground storage tank activities, all tanks to be upgraded had soil samples taken from the tank ends to identify any soil contamination prior to redesign and construction. To date, overfill releases from underground storage tanks located at the Areas 6, 12, and 23 gasoline stations were observed and necessitated additional soil sampling. All underground storage tanks that were planned to be upgraded (except a tank containing asphaltic material) were also pressure tested for leaks. All tanks passed the test limit of 0.76 liter per hour (0.2 gallon per hour) (DOE/NV 1992c).

Numerous underground storage tanks have been identified throughout the site as "Undetermined Activity Status." The contents of some of these underground storage tanks is classified as "H?" which indicates that the contents are presumed to be hazardous.

The types of possible wastes found on the surface of the NTS include radionuclides, organic compounds, metals, hydrocarbons, and residues from plastic, epoxy, and drilling muds (not petroleum production related and therefore considered hazardous under Subtitle C of RCRA). A wide variety of surface facilities, such as injection wells, leach fields, sumps, waste storage facilities, tunnel ponds and muck piles, and storage tanks, may have contaminated the local soil and the shallow unsaturated zone of the NTS. Because of the great depths to groundwater and the arid climate, it is assumed that the potential for mobilization of surface and shallow subsurface contamination is minimal. However, contaminants entering carbonate bedrock from

Rainier Mesa tunnel ponds, contaminated wastes injected into deep wells, and wastes disposed into subsurface craters have the potential to reach the regional water table. Pilot wells were to be installed during 1992 to support the RCRA permitting process (DOE/NV 1992c).

Annual generation or disposal of hazardous waste at the NTS was approximately 252 cubic meters (329.6 cubic yards) during 1993. Available storage space on the 90-day pad is approximately 91 cubic meters (119 cubic yards) (DOE/NV 1994d).

4.14.5 Sanitary Waste

Sanitary wastes are expected to be generated at the current rates for several years into the future, then decline assuming the present moratorium on underground weapons testing. Liquid sanitary wastes are disposed of in septic tanks/leach fields, sumps, or in ponds, and solid sanitary wastes are disposed of in landfills at various locations on the site. The NTS currently maintains 13 sewage discharge permits: Area 2, Area 6 (5), Area 22, Area 23, Area 25 (4), and Area 12 (DOE/NV 1993c). Approximately 9.1 x 10^3 cubic meters (11,902 cubic yards) of sanitary waste were generated at the NTS during 1991 and 1.1 x 10^4 cubic meters (14,388 cubic yards) during 1992 (DOE/NV 1993c). Sufficient disposal space is available at the NTS for current needs.

4.14.6 Hazardous Materials

Polychlorinated biphenyls, pesticides, and asbestos have been or currently are managed at the NTS. These wastes and materials are managed in addition to the approximately 90,000 kilograms (100 tons) of RCRA-regulated nonradioactive hazardous wastes generated annually at the NTS, the approximately 218,000 kilograms (240 tons) of non-RCRA-regulated hazardous waste generated annually at the NTS, and the wastes and materials managed at the facilities discussed previously.

By the end of 1991, all known polychlorinated biphenyl transformers and other electrical equipment had been either reclassified or appropriately disposed of, and three polychlorinated biphenyl-contaminated transformers and regulators were under the 90-day period for reclassification. Successful reclassification of these three polychlorinated biphenyl-contaminated transformers will complete the reclassification or disposal of all known polychlorinated biphenyl and polychlorinated biphenyl contaminated transformers at the NTS (DOE/NV 1992c).

No unusual environmental activities relating to the Federal Insecticide, Fungicide, and Rodenticide Act occurred in 1991 at the NTS. Pesticides are stored in an approved storage facility located in Area 23. Pesticide usage includes insecticides, herbicides, and rodenticides. Insecticides are applied twice a month at the food service areas, herbicides are applied once a year, and all other pesticides are applied on an as-requested basis. General-use pesticides are used for most applications, although restricted-use herbicides and rodenticides are used on occasion (DOE/NV 1992c).

The Area 11 Explosive Ordnance Disposal Facility is a thermal treatment unit for disposal of conventional explosives. Explosives detonated at the facility include Defense Nuclear Agency materials and waste explosives from Reynolds Electrical and Engineering Co., Inc. tunnel operations, the Wackenhut Firing Range (used by the NTS security force), and the resident national laboratories. No radioactive or radioactive-contaminated materials are accepted or detonated at the Area 11 Explosive Ordnance Disposal unit.

The unit encompasses approximately 0.08 square kilometer (20 acres) of land located between Frenchman Flat and Yucca Flat, with four graded areas. Only one of these graded areas is used for detonation. Magazines are used to store detonation materials and waste explosives. Approximately 80 to 90 percent of the explosives detonated at the Explosive Ordnance Disposal unit during the past 10 to 12 years have been water-gel explosives; earlier, the primary waste was gelatin-based dynamite. Other explosives detonated include small amounts of trinitrotoluene (TNT), RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) pellets, small arms ammunition (from past military operations at NTS), and black powder (DOE/NV 1992b).

4.14.7 Non-hazardous Waste

Solid wastes are regulated through State of Nevada regulations NAC 444 and Federal regulations 40 CFR 241, 257, and 258. Solid wastes generated include used petroleum products, uncontaminated tunnel muck, drilling fluids, cement and grout wastes, construction debris, refuse, sludge from wastewater lagoons, septic tank and chemical toilet sludge, and animal carcasses. The NTS has several sanitary landfills and construction landfills in operation; several landfills have been closed or abandoned (DOE 1990).

Some wastes not regulated under RCRA will be stored at the Hazardous Waste Accumulation Site. These nonregulated wastes are shipped offsite along with the RCRA wastes to a treatment, storage, and disposal facility. Only non-RCRA hazardous wastes that cannot be disposed of at the NTS landfill will be stored at the Hazardous Waste Accumulation Site for offsite shipment. Any drum containing nonregulated wastes will carry a label so specifying. The contents of the drum will be entered on a space provided on the label. Wastes in this category include but are not limited to epoxies, photochemicals, spent antifreeze, and oils and solvents that do not carry EPA codes.

Recycling of paper, metals, glass, plastics, and cardboard has already resulted in some decrease in quantities of waste and is expected to result in significant decreases over the next few years (DOE/NV 1992b).

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5. ENVIRONMENTAL CONSEQUENCES

5.1 Overview

This chapter describes the potential environmental consequences from the construction and operation of spent nuclear fuel (SNF) facilities at the Nevada Test Site (NTS) under the Centralization and Regionalization Alternatives. Potential environmental consequences are assessed to the extent necessary to support a programmatic decision concerning the siting of the proposed SNF facilities. More detailed considerations of potential environmental consequences would be performed as necessary prior to initiating construction or operation of the facilities.

5.2 Land Use

5.2.1 Centralization Alternative

Construction and operation of SNF facilities under this alternative would require the disturbance of approximately 90 acres (0.36 square kilometer), including buffer areas. Use of the proposed SNF site for program activities would be consistent with existing nearby land uses and land use policies and plans. The current land use designations for this area are Low-Level Waste Facility Management and Buffer/Reserved Area. Use of this area for program activities would also be consistent with future land use plans (DOE/NV 1993a).

Use of the proposed site for the construction and operation of SNF facilities could result in irreversible or irretrievable land use impacts in those areas currently under Buffer/Reserved use. However, the placement of SNF facilities at this location would be consistent with DOE's 1994 draft future land use plan, which designates this portion of Area 5 as a Non-Nuclear Test Area (DOE/NV 1993a). Therefore, no mitigation measures are proposed.

5.2.2 Regionalization Alternative

As under the Centralization Alternative, use of the proposed site for construction and operation of SNF facilities under the Regionalization Alternative would be consistent with existing land uses and with all applicable land use policies and plans. Impacts would be similar in character to those described for the Centralization Alternative, except that there could be reduced land requirements under this alternative.

5.3 Socioeconomics

Socioeconomics as addressed in this Programmatic Environmental Impact Statement (PEIS) encompasses the interaction of economic, demographic, and social conditions. Economic consequences (e.g., capital requirements to support SNF research and development activities) affect business activities, market structures, procurement methods, and dissemination of commodities within and between regions. Demographic consequences (e.g., in-migration of specialized human resources to support the SNF Management Program) affect size, distribution, and composition of the population, labor force, and the housing market in the regions. Social consequences (e.g., capacity modifications of public infrastructure to support SNF activity) affect the overall quality of life enjoyed by the residents of a community (Murdock and Leistritz 1979). These conditions are potentially affected either directly or indirectly by actions proposed under the U.S. Department of Energy (DOE) SNF Management Program.

The importance of actions is relative to the affected region. A region can be described as a dynamic socioeconomic system, where physical and human resources, technology, social and economic institutions, and natural resources interrelate to create new products, processes, and services to meet consumer demands. The measure of a region's ability to support these demands depends on its ability to respond to changing economic, demographic, and social conditions.

Potential socioeconomic effects are addressed only to the extent that they are interrelated with the natural or physical environment. Direct effects include those impacts that are caused by the action and occur at the same time and place. Indirect effects include those impacts caused by the action that are later in time or farther removed in distance but still are reasonably foreseeable (i.e., offsite) (CFR 1993e). Direct and indirect effects are presented quantitatively from 1995 through 2005, and qualitatively through 2035.

Socioeconomic effects are quantified for regional economic activity and population. Other potential socioeconomic impacts to individual communities, such as public infrastructure and housing, are discussed qualitatively to address programmatic issues.

Economic impact projections include direct and indirect jobs. Direct jobs are those jobs needed to construct or support the operation of the SNF management complex at the NTS. Indirect jobs are created throughout the regional economy within the Region of Influence as a result of procurement for materials, services, and other commodities, and induced effects from consumer spending. These direct and indirect impacts reflect both construction and operation phase demands, which may occur concurrently or independently throughout the project planning period. Indirect jobs were projected using parameters from the U.S. Bureau of Economic Analysis Regional Input-Output Modeling System.

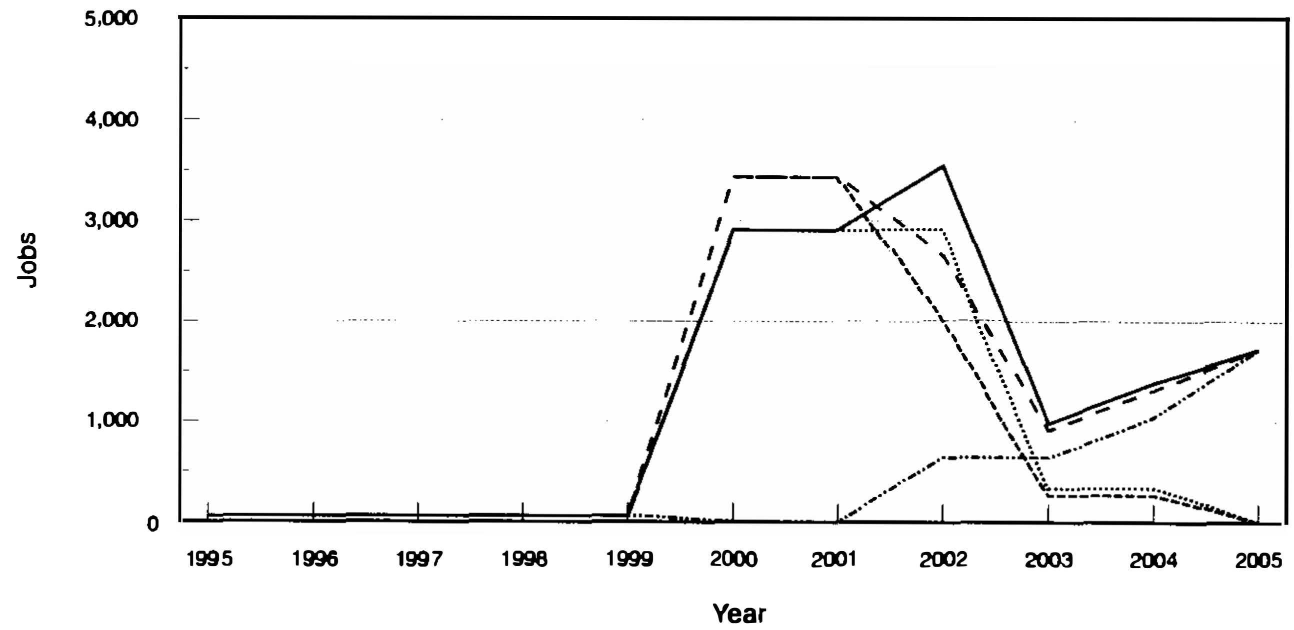
Two scenarios were analyzed to account for two potential distributions of the SNF facility construction efforts. The construction effort consists of fabricating various structures, each with its own construction labor need and a duration of either three or five years. The Peak Scenario accelerates the construction labor requirements into the first two years of construction. The Average Scenario averages the labor requirements of a structure for the duration of construction. The total construction effort for all structures, in labor years, is the same for each scenario. Therefore, for structures with a three year construction duration, the Peak Scenario has high labor needs for the first two years and then a substantial reduction for the third year, while the Average Scenario has a constant labor requirement for the three years. Likewise, for structures with a five year construction duration, the Peak Scenario has a high labor need for the first two years, then a lower need for the remaining three years, while the Average Scenario has a constant requirement for all five years. Because the total construction labor years for each structure is the same for both scenarios, the Average Scenario will have a lower requirement than the Peak Scenario in the first two years, then will have a higher requirement then the Peak Scenario in the remaining construction years.

Regional population projections reflect the potential change in population resulting from an increase in regional economic activity. Detailed assumptions regarding in-migration associated with the SNF Management Program were not developed, given the programmatic scope of this analysis. Potential in-migration effects resulting from direct job creation are presented qualitatively where appropriate.

5.3.1 Centralization Alternative

The upper and lower bounds of construction and operation-related jobs generated by SNF facilities for both scenarios under the Centralization Alternative from 1995 to 2005 are illustrated in Figure 5.3-1 and tabulated in Table 5.3-1. In its initial phase, the Centralization Alternative may create 54 jobs (25 direct, 29 indirect) over a 5-year period beginning in 1995 and continuing through the year 1999 to support project planning, engineering design, personnel operations training, and environmental permitting and compliance. Construction is expected to begin in the year 2000, requiring a total of 4,351 direct jobs (5,041 indirect jobs). In that year and 2001, the Peak Scenario requires 1,587 construction laborers, while the Average Scenario needs 1,346. There is no operational labor required for this time period. In 2002, after two years of construction, the Peak Scenario decreases its construction labor requirements to 928 workers, while the Average Scenario maintains its 1,346 laborers. Additionally, 300 operational personnel are needed, raising the total of SNF workers to 1,228 for the Peak Scenario and 1,646 for the Average Scenario. By 2003, the buildings with three year construction durations have been completed; therefore, both the Peak and Average Scenario construction labor requirements decline to 125 and 157, respectively. Operation labor requirements remain at 300 workers. Total SNF labor requirements are 425 workers for the Peak Scenario and 457 for the Average Scenario. In 2004, construction labor needs for both scenarios remains at their previous level, but operational personnel increase. Total SNF labor requirements are 612 workers in the Peak Scenario and 644 workers in the Average Scenario. By 2005, all construction has been completed and operational personnel have increased to the full staff labor requirement of 800 workers.

The Peak Scenario reaches its maximum construction labor with 1,587 direct jobs (3,426 total jobs created) over a 2-year period from years 2000 through 2001. The Average Scenario would have its maximum construction labor with 1.346 direct jobs (2,906 total jobs created) in a



1. Effects are direct and indirect.
2. Peak scenario assumes construction labor peaks in the initial years of construction activity.
3. Average Scenario assumes construction labor is averaged throughout construction period.

Figure 5.3-1. Total employment effects, NTS centralization alternative

Table 5.3-1. Socioeconomic effects - centralization of SNF at Nevada Test Site.

	Time period					
Years	1995 - 1999	2000, 2001	2002	2003	2004	2005 +
Operations						
Direct jobs	25	0	300	300	487	800
Indirect jobs	29	0	344	344	559	918
Total jobs	54	0	644	644	1,046	1,718
Construction						
Direct jobs						
Peak	0	1,587	928	125	125	0
Average	0	1,346	1,346	157	157	0
Indirect jobs						
Peak	0	1,839	1,076	145	145	0
Average	0	1,560	1,560	182	182	0
Total jobs						
Peak	0	3,426	2,004	270	270	0
Average	0	2,906	2,906	339	339	0
Total						
Direct jobs						
Peak	25	1,587	1,228	425	612	800
Average	25	1,346	1,646	457	644	800
Indirect jobs						
Peak	29	1,839	1,420	489	704	918
Average	29	1,560	1,904	526	741	918
Total jobs						
Peak	54	3,426	2,648	914	1,316	1,718
Average	54	2,906	3,550	983	1,385	1,718
Population Change						
Peak	91	5,664	(1,084)	(2,379)	547	540
Average	91	4,804	896	(3,522)	547	447

3-year period from years 2000 through 2002. Operation requirements would be minor until 2002, when engineering and administrative services are assumed to be in demand to accommodate project requirements. Ancillary SNF complex operations, such as utilities and research and development activities, are assumed to begin in 2004, taper off into 2005, and remain relatively constant through 2035. The maximum total SNF management direct jobs under either construction scenario would occur in 2002 with 1,346 construction jobs for the Average Scenario and 300 operation jobs. Implementation of the Centralization Alternative would increase the projected average annual rate of growth rate for both regional population and employment from 1995 through 2005 by 0.02 percent.

Regional businesses and the work force would benefit from increased competition for contract procurement and jobs. Most of this activity is anticipated to be captured by Clark County, with a smaller share occurring in Nye County. However, the impact to the regional economy represents only a portion of the total economic activity generated by the Centralization Alternative. For instance, purchases of specialized materials and technology acquisition may occur even outside the State of Nevada. It has been estimated that about 50 percent of total NTS expenditures occur within the State of Nevada (Nye County Board of Commissioners 1992). This leakage would result in the associated economic benefits accruing outside of the regional economy.

Most of the population change in the Region of Influence above the baseline forecast would be due to in-migration of labor and households to support SNF management activity at the NTS. It is likely that most of the SNF operation work force would be supplied by SNF personnel relocating from DOE sites where SNF inventories were stored before shipment to the NTS, since they are familiar with the processes, technologies, and research. Other demands for operational jobs not related to SNF management would be accommodated by the regional labor market. The regional labor market could accommodate most of the construction requirements, with the exception of very specialized tasks. Construction employment in Clark County is twice that of the national average. As the population continues to grow, demand on public infrastructure grows as well. These projects will result in continued growth in construction activity (Las Vegas Review Journal et al. 1993).

To assess potential population and housing impacts, an in-migration rate per job was estimated using a ratio between projected employment and population figures (Table 4.3-1). This ratio was applied to the number of total (direct and indirect) jobs created by SNF management activities at the NTS, resulting in the total estimated number of persons in-migrating into the Region of Influence per job created (Table 5.3-1).

With initial operation in 1995 under the both scenarios (Table 5.3-1) a total of 91 persons could migrate into the Region of Influence. The number of persons coming in would be at its largest for the years 2000 through 2001, (5,664 in-migrants for the Peak Scenario and 4,804 for the Average Scenario) the period when construction starts. In the final phases of construction, people would migrate out of the Region of Influence. However, the number of in-migrants would increase in the years 2004 and 2005, as more of the SNF management operations start. After 2005, in-migration due to SNF management activities would cease, since SNF management activities would not create any more jobs.

Construction of the SNF complex could result in a temporary increase in housing demand in Nye County. The demand for both the rental market and short-term lodging could increase. The demands on housing would fluctuate over time, based on the various construction phases, peak employment levels, the level of local sub-contracting, and any decision by a contractor to develop temporary housing arrangements near the job site. Within Nye County, the communities of Tonopah and Beatty would probably experience the most impacts related to housing demand. Both communities support fairly large inventories of temporary housing. While such demands are favorable for local lodging operators and landlords, they could compete with tourism demands (Nye County Board of Commissioners 1992).

Overall socioeconomic impacts to Clark County could be absorbed within the projected expansion of the county's economy, local infrastructure, public service, and real estate development.

5.3.2 Regionalization Alternative

Socioeconomic impacts resulting from the Regionalization Alternative are expected to be similar to those for the Centralization Alternative. The construction and operation cycles for each alternative would be the same; therefore, the same issues identified for the Centralization Alternative would apply. Labor requirements might be reduced slightly for the Regionalization Alternative. Although the volume of SNF stored would be less for the Regionalization Alternative, an economy of scale occurs for both alternatives, so that differences in labor and capital between the two alternatives would be minimized.

5.3.3 Mitigation Measures

5.3.3.1 Coordination with Local Jurisdictions. To reduce construction- and operation-related impacts, possible coordination with local communities could address potential impacts from increased labor and capital requirements. The knowledge of the extent and effect of growth due to SNF management activities could greatly enhance the ability of affected jurisdictions to plan effectively. Effective planning would address changes in levels of service for housing, infrastructure, utilities, transportation, and public services and finances.

5.3.3.2 Enhance Labor Force Availability. To alleviate potential impacts associated with the in-migration of labor, local labor force availability could be increased through various employment training and referral systems currently provided by the NTS. The goal of these systems would be to reduce the potential for in-migration of labor to support SNF management activities.

5.4 Cultural Resources

5.4.1 Centralization Alternative

Under the Centralization Alternative, tbe construction of SNF facilities is not expected to require the disturbance of more than 90 acres (0.36 square kilometer) on the NTS. There are no known historical, archeological, paleontological, or Native American traditional sites in the proposed area or its vicinity. Therefore, no impacts to cultural resources are expected due to ground disturbance, noise, or air emissions during construction and operation of the SNF facilities. Consultation with the Nevada State Historic Preservation Office (SHPO) prior to project implementation is required under Section 106 of the National Historic Preservation Act of 1966. The SHPO may recommend that further archaeological studies be conducted throughout the construction area to verify that there are no archaeological sites subject to disturbance.

5.4.2 Regionalization Alternative

Under the Regionalization Alternative, the location of the SNF facilities would remain the same but could be reduced in area. As with the Centralization Alternative, impacts are not anticipated.

5.5 Aesthetics and Scenic Resources

5.5.1 Centralization Alternative

The proposed SNF facilities under the Centralization Alternative, when fully constructed and under operation, would consist of a series of industrial buildings set within a security fence on the proposed 90-acre (0.36 square-kilometer) site. The facility would have the appearance of industrial buildings ranging in height from one to three stories. The maximum height of the buildings contained within the site would not exceed 42 feet (13 meters) above ground level. The proposed SNF site is located within a valley over 10 miles (16 kilometers) from U.S. Route 95, separated by intervening hills and mountains, including Red Mountain, the Spotted Range, the Specter Range, Hampel Hill and Skull Mountain. The site would not be visible from areas outside the NTS or the Nellis Air Force Base Bombing and Gunnery Range. Therefore, impacts to aesthetics and scenic resources are not anticipated.

5.5.2 Regionalization Alternative

Under the Regionalization Alternative, proposed SNF facilities could be reduced in area and intensity of operations from the Centralization Alternative. Environmental effects to aesthetics and scenic resources could also be less than that of the Centralization Alternative.

5.6 Geologic Resources

This section describes any incremental or additional impacts on geology and geologic resources that would result from the construction and operation of the new facilities associated with the storage of SNF at the NTS. Seismic and volcanic hazards are discussed in Section 4.6.

5.6.1 Centralization Alternative

As discussed in Section 4.6.2, precious metal deposits may exist in certain carbonate rocks and volcanic or sedimentary rocks at the NTS. Figure 4.6-5 shows the proposed SNF site in relation to these types of geologic terranes as well as to the locations of mining districts. Although the proposed SNF facilities would not be located within a mining district, they would be situated on Tertiary volcanic or sedimentary rocks near volcanic or intrusive centers (the type of geologic terrane where small to medium-size precious metal deposits could be developed). However, because the NTS would likely remain closed to mining operations, the impact on any precious metal deposits that might exist at the NTS would not change if the proposed storage facility were to be sited there.

In addition, destruction of unique geologic features are not expected to occur as a result of construction and operation of a new SNF storage facility nor are mass movement and subsidence and sediment runoff from land disturbances.

5.6.2 Regionalization Alternative

Impacts to geology and geological resources under the Regionalization Alternative would generally be as described for the Centralization Alternative.

5.7 Air Resources

Both radiological and nonradiological air emissions impacts from the proposed SNF facilities are discussed in this section.

5.7.1 Centralization Alternative

5.7.1.1 Emissions.

5.7.1.1.1 Radiological Emissions—There would be no radiological emissions from construction of the proposed SNF facilities. The total annual airborne radionuclide releases from operation of the proposed SNF facilities are provided in Table 5.7-1.

5.7.1.1.2 Nonradiological Emissions—During construction of the proposed SNF facilities, short-term emissions, such as fugitive dust and heavy equipment exhaust emissions, would be temporary and only affect receptors close to construction areas. Fugitive dust emissions would be minimized by curtailing soil-disturbing activities during high winds. During operation of the proposed SNF facilities, criteria and hazardous air pollutants would be emitted. The total annual emissions from all modules associated with the proposed SNF facilities are listed in Table 5.7-2.

5.7.1.2 Air Quality.

5.7.1.2.1 Radiological—The GENII environmental transport and dose assessment model (PNL 1988) was used with 1990 meteorological data from Desert Rock Army Airfield to determine effective dose equivalents from the radiological emissions listed in Table 5.7-1. A population of 15,100 persons was estimated to be within 50 miles (80 kilometers) of the proposed SNF facilities. It was also assumed that 1995 operations at the NTS would result in the same baseline radiological emissions as the 1992 operations at the NTS. The most recent comprehensive radiological emissions report at the NTS was based on 1992 operations.

Table 5.7-1. Annual airborne radionuclide emission source terms for proposed NTS SNF facility operational phase.[a]

Isotope	Release rate (Ci/yr)[b,c]
Tritium	7.9×10^{-1}
Carbon-14	1.2×10^{0}
Manganese-54	2.2×10^{-8}
Cobalt-60	4.2×10^{-8}
Krypton-85	1.0×10^{4}
Strontium-90	3.3×10^{-6}
Yttrium-90	2.0×10^{-6}
Ruthenium-106	1.1×10^{-5}
Antimony-125	3.4×10^{-4}
Iodine-129	1.0×10^{-1}
Cesium-134	6.2×10^{-8}
Cesium-137	4.8×10^{-5}

a. Source: Johnson (1994).

b. 2.0×10^{-6} Ci/yr of Barium-137m, from Wet Storage, is not in GENII. Barium-137m, with a half-life of 2.55 min, decays to Barium-137, which is stable.

c. 7.5×10^{-8} Ci/yr of Thallium-208, from Wet Storage, is not in GENII. Thallium-208, with a half-life of 3.10 min, decays to Lead-208, which is stable.

Table 5.7-2. Total annual nonradioactive emissions for the SNF storage facility at NTS.[a]

Criteria pollutants	Release rate (kg/yr)
Carbon monoxide	1.7×10^{3}
Particulate matter (PM_{10})[b]	1.0×10^{-3}
Nitrogen oxides	5.5×10^{3}
Sulfur dioxide	1.3×10^{2}
Lead	5.0×10^{-9}

Hazardous air pollutants	Release rate (kg/yr)
Selenium compounds	1.6×10^{-4}
Mercury compounds	5.1×10^{-1}
Chlorine	3.5×10^{3}
Hydrogen fluoride	1.6×10^{1}
Cadmium compounds	2.9×10^{-7}
Cobalt, chrome, antimony, and nickel compounds	2.0×10^{-10}

a. Source: Johnson (1994).

b. All suspended particulate matter is assumed to be PM_{10}.

Table 5.7-3 summarizes the sum of the baseline and the incremental contribution from the proposed SNF facilities to the effective dose equivalents of the maximum site boundary individual and, collectively, to the population within 50 miles (80 kilometers) of the proposed facility. These combined effective dose equivalents for operation of the proposed SNF facilities would be less than 1 percent of the National Emissions Standards for Hazardous Air Pollutants (NESHAP) standard and less than 1 percent of the natural background radiation.

5.7.1.2.2 Nonradiological—The Industrial Source Complex Short Term air dispersion model (EPA 1992) was used with 1990 meteorological data from Desert Rock Army Airfield to determine pollutant concentrations resulting from the Centralization Alternative nonradiological emissions listed in Table 5.7-2. A maximum emissions baseline was established to characterize conditions that could result if all sources operated to the maximum extent allowed by permit conditions. It was also assumed that 1995 operations at the NTS would result in the same baseline nonradiological emissions as the 1990 operations at the NTS. The most recent comprehensive nonradiological emissions report at the NTS was based on 1990 operations. The results of modeling are in Table 5.7-4, where a comparison of the existing DOE site contribution concentration is compared to the existing DOE site contribution concentration plus the proposed SNF contribution. The increases in pollutant concentrations from operation of the proposed SNF facilities would be negligible in magnitude. The concentrations of pollutants at the NTS with the inclusion of the proposed SNF facilities would remain within regulatory guidelines.

The calculated atmospheric maximum concentrations at the site boundary and offsite for the proposed SNF facilities are presented in Table 5.7-5. The maximum concentrations at the site boundary reflect exposure to a maximally exposed individual, whereas the maximum onsite concentrations reflect exposure to a worker.

5.7.2 Regionalization Alternative

As with the Centralization Alternative, construction of the proposed SNF facilities under the Regionalization Alternative would not result in radiological air emissions, but could result in minor, temporary emissions of fugitive dust. These emissions could be slightly less than under the Centralization Alternative, since the extent of construction disturbance would be less.

Table 5.7-3. Summary of effective dose equivalents to the public from proposed SNF storage facility plus 1995 baseline operations at NTS.[a]

	Maximally exposed individual dose[b]	Collective dose to population within 80 km of NTS sources
Dose	1.3×10^{-1} mrem per year[c]	8.7×10^{-2} person-rem[d]
NESHAP standard	10 mrem per year	--
Percentage of NESHAP standard	1.3	--
Natural background dose	278 mrem per year	4190 person-rem per year
Percentage of natural background dose	4.7×10^{-2}	2.1×10^{-3}

a. Effective dose equivalents computed using GENII (PNL 1988).

b. The maximum boundary dose is to the hypothetical individual who remains in the open continuously during the year at the NTS boundary.

c. The SNF facility contributes 1.2×10^{-1} millirem to this dose.

d. The SNF facility contributes 8.2×10^{-2} person-rem to this dose.

Table 5.7-4. Comparison of baseline concentrations with most stringent applicable regulations and guidelines at NTS for proposed SNF facility plus current operations.

Criteria pollutant	Averaging time	Most stringent regulation or guideline[d] ($\mu g/m^3$)	Maximum background concentration ($\mu g/m^3$)	Total existing maximum concentration[e] ($\mu g/m^3$)	Total projected maximum concentration[f] ($\mu g/m^3$)	Increase in maximum concentration ($\mu g/m^3$)
Carbon dioxide	8-hour	10,000	2,290	2,290	2290.8	0.80
	1-hour	40,000	2,748	2,748[b]	2754.0	6.03
Nitrogen dioxide	Annual	100	a	b	0.20	0.20
Lead	Calendar quarter	1.5	a	b	3.7×10^{-12}	3.7×10^{-12}
Particulate matter (PM_{10})[c]	Annual	50	a	0.43	0.43	0
	24-hour	150	78.3	84.9	84.9	0
Sulfur dioxide	Annual	80	a	1.1	1.1	0
	24-hour	365	39.3	55.2	55.2	0
	3-hour	1,300	65.4	170.3	170.3	0
Hazardous air pollutants						
Selenium	8-hour	4.8	a	b	2.18×10^{-7}	2.18×10^{-7}
Mercury compounds	8-hour	0.2	a	b	2.18×10^{-3}	2.18×10^{-3}
Chlorine compounds	8-hour	71.4	a	b	1.52	1.52
Hydrogen fluoride	8-hour	59.5	a	b	3.70×10^{-3}	3.70×10^{-3}
Cadmium compounds	8-hour	1.2	a	b	1.81×10^{-9}	1.81×10^{-9}
Cobalt, chromium, antimony, and nickel compounds[g]	8-hour	1.2	a	b	5.5×10^{-10}	5.5×10^{-10}

a. Not measured.

b. No sources indicated.

c. All suspended particulate matter is assumed to be PM_{10}.

d. Criteria pollutant regulations are National Ambient Air Quality Standards. Hazardous air pollutant regulations are Nevada Ambient Air Quality Standards.

e. Includes background concentration plus existing DOE facilities impact concentration. This is the baseline concentration.

f. Includes background concentration plus existing DOE facilities impact concentration plus SNF facilities impact concentration.

g. Individual emission rates were not specified for each of cobalt, chrome, antimony, and nickel compounds. Only a total emission rate for all four was provided. Therefore, the most stringent standard for any of the four compounds, 1.2 $\mu g/m^3$ for cobalt, was used.

Table 5.7-5. Calculated annual maximum concentrations for hazardous air pollutants at NTS, onsite and offsite.[a]

Hazardous air pollutant	Maximum annual average concentration onsite ($\mu g/m^3$)	Maximum annual average concentration offsite
Selenium compounds	6.03×10^{-8}	1.20×10^{-8}
Mercury compounds	6.03×10^{-4}	1.20×10^{-4}
Chlorine compounds	4.2×10^{-1}	8×10^{-2}
Hydrogen fluoride	1.02×10^{-3}	2.04×10^{-4}
Cadmium compounds	5.01×10^{-10}	1.0×10^{-10}
Cobalt, chromium, antimony and nickel compounds	1.50×10^{-10}	3.00×10^{-11}
Lead	1.21×10^{-11}	2.40×10^{-12}

a. All impacts from proposed source only. No hazardous air pollutant emissions information available for existing sources.

The same types of radiological and nonradiological air emissions from operation of the proposed SNF facilities would occur under the Regionalization Alternative as under the Centralization Alternative. However, the magnitudes could be lower. As with the Centralization Alternative, the combined dose equivalents from the operation of the proposed SNF facilities would be less than 1 percent of the NESHAP and less than 1 percent of the natural background radiation. The concentrations of non-radiological air emissions from the operation of the proposed SNF facilities under this alternative would remain within all applicable regulatory guidelines (EPA 1992; PNL 1988).

5.8 Water Resources

Construction and operation of the SNF modules could affect surface and groundwater resources. Potential environmental impacts to surface water and groundwater resources during construction include depletion of groundwater supplies, floodplain encroachment, and surface water sedimentation from erosion runoff occurring after land clearing. Potential normal operational impacts could include depletion of groundwater supplies and diminished surface water and/or groundwater quality resulting from wastewater discharges from normal operations.

5.8.1 Centralization Alternative

Separate discussions are provided for surface water quantity, surface water quality, groundwater quantity and groundwater quality.

5.8.1.1 Surface Water Quantity. Existing activities on the NTS derive their water supply from groundwater sources, and the same would be true for construction and operation of the proposed SNF facilities. Therefore, construction and operation of the proposed SNF facilities would have no impact on surface water availability in the region. In addition, under normal operating conditions, there would be no wastewater discharges to Area 5 watercourses which could affect surface water flow characteristics.

Stormwater runoff associated with construction and operation of the proposed SNF facilities is expected to have a negligible impact on surface water quantity. During construction, standard stormwater management techniques would be employed to attenuate runoff. The impact of stormwater runoff on the ephemeral character of Area 5 watercourses during operation of the SNF facilities is also expected to be negligible. A site drainage and stormwater management system consisting of a perimeter drainage ditches and a retention pond would be included as part of the SNF facilities (Johnson 1994). This system would provide for control of runoff and erosion, which otherwise could affect Area 5 watercourses or the SNF facilities.

As discussed in Section 4.8.1, analyses of available data indicate that the areas encompassed by the proposed SNF facility may lie in flood Zone X (100-year flood zone with depths less than 1 foot [0.30 meter]) and/or Zone AO (100-year flood zone with depths between 1 and 3 feet [0.30 and 0.9 meter]) associated with the Halfpint Alluvial Fan. Accordingly, the SNF facilities would have to be located and constructed to minimize floodplain impacts and to avoid floodplains to the maximum extent possible, as required by Executive Order 11988 (Floodplain Management) and DOE Orders. Site-specific surveys would be performed to determine locations of flooding elevations more accurately.

5.8.1.2 Surface Water Quality. The proposed SNF facility in the northeast portion of Area 5 is not served by the NTS sanitary sewer system. A number of NTS facilities have self-contained sanitary sewer systems. The nearby Radioactive Waste Management Site does have its own septic tank and leach field system to dispose of sanitary wastewater (DOE/NV 1993a). The proposed SNF facilities would have a sanitary sewer system comprised of a sewage treatment facility equipped with a sewage treatment and ejection pump system with a programmable controller and software. A pressurized sanitary sewer line would be provided to run to a sewage lagoon at the facility (Johnson 1994). This system would be adequate to accommodate the estimated 9,863 gallons (37,335 liters) per day of sanitary wastewater generated by the SNF facilities and personnel. This system would be operated in accordance with State of Nevada permitting requirements.

The proposed SNF facilities are designed to generate no liquid releases of wastewater with hazardous chemicals or radiological characteristics related to SNF management operations. These facilities would be constructed using state-of-the art technologies including secondary containment, and leak detection and water balance monitoring equipment. The normal operation of the proposed SNF facilities is not expected to affect the quality of any surface water on or near the NTS.

During construction, 90 acres (0.36 square kilometer) would be disturbed, all of it in previously undisturbed areas. This would create the potential for increased sediment runoff into dry washes and shallow drainages or to spread out overland as a result of sheetflow. However, sediment runoff from construction activities would be controlled by implementing soil erosion control measures, which would result in negligible effects to surface water quality.

In addition, as stated in Section 4.8.1, existing onsite contaminants may be transported and dispersed beyond the facility boundary during flooding (USAF et al. 1991). Therefore, the potential exists for some incremental transportation and dispersion of any additional contaminants that might result from the construction or operation of the SNF facilities. Although this potential cannot be determined without additional studies, any additional contamination would be unlikely, due to the design of the containment structures and leak detection system of the SNF facilities.

5.8.1.3 Groundwater Quantity. Operation of the SNF facilities would require approximately 9,863 gallons (37,335 liters) per day. This translates to an additional 3,600,000 gallons (13,627 cubic meters) of water used at the NTS per year. It is assumed that the water demand of the SNF facilities would be supplied via the existing NTS Area 5 supply wells and water distribution system. If this scenario should be demonstrated to be infeasible or impractical, a water supply and distribution system consisting of two 8-inch-diameter wells supplying two 250,000-gallon (946,333-liter) aboveground storage tanks would be constructed to service the SNF facility complex (Johnson 1994).

Water withdrawals to support the proposed SNF facilities would likely be from the Frenchman Flat hydrographic area of the Ash Meadows Subbasin. In 1993, 176 million gallons (666,000 cubic meters) of groundwater was withdrawn by DOE from the Frenchman Flat hydrographic area. An additional 3.6 million gallons (14,000) cubic meters) per year would be required for SNF operations. The recharge due to precipitation in the Frenchman Flat hydrographic area was estimated to be 32.6 million gallons (123,000 cubic meters) (Rush 1970).

This recharge estimate was exceeded for more than thirty years with no decline in static water levels (DOE 1988b). Accurate measurement of static water levels are, however, precluded by numerous conditions on the NTS (Winograd 1970). More detailed analyses of perennial yield and total water withdrawal from the hydrographic area would be required if the NTS were chosen as a site for SNF management facilities, but because the estimated perennial yield has been exceeded for more than thirty years with no measurable decline in static water levels, it is likely that increased water use for the SNF Management Facility could be sustained.

Because of hydrogeologic complexities, a regional groundwater flow at the NTS is not constrained by the hydrographic basins which are defined by local topography (USAF et al. 1991). Therefore any potential groundwater overdrafts in the Frenchman Flat hydrographic area indicated by previous yield estimates are likely made up by untapped groundwater from neighboring hydrographic areas. Localized impacts could occur if the perennial yield of Frenchman Flat hydrographic area is exceeded. Potential impacts include depletion of water stored locally in the regional aquifer, removal of that groundwater from other potential uses, and the potential modification of the rate and direction of contaminant migration resulting from underground nuclear testing. The complex issues of groundwater contamination and use are being addressed in the Resource Management Plan being prepared in conjunction with the NTS site-wide EIS.

The vast majority of groundwater not withdrawn from the Frenchman Flat hydrographic area, and the Ash Meadows Subbasin as a whole, is discharged at Ash Meadows. Using 1993 water withdrawal data, NTS annual withdrawal from the Ash Meadows Subbasin would only increase by 1% or 3.6 million gallons (14,000 cubic meters) to approximately 370 million gallons (1.4 million cubic meters) if the proposed SNF facilities were sited on NTS. This increase in withdrawal would have little impact on the subbasin as a whole as its perennial yield is estimated to be 12 to 18 billion gallons (46 to 68 million cubic meters) (DOE 1988b; USAF et al. 1991). Water from the groundwater systems which pass beneath the NTS annually discharge approximately 8.8 billion gallons (33 million cubic meters) to the deserts southwest of the NTS (DOE/NV 1993b). Annual groundwater withdrawal for SNF operations would amount to 0.04 percent of this discharge. No impacts to down-gradient users and discharge areas would be expected due to the small volume of water required and the vast amount of water in the regional groundwater system.

Dewatering is not expected to be necessary to construct the SNF facility complex, due to the relatively great depth to groundwater across the NTS. Although perched water table conditions at depths of 70 feet (21 meters) have been reported for Frenchman Flat, all excavation activities are expected to occur in the vadose zone. Consequently, there would be no effect on groundwater quantity due to construction dewatering of wastewater with hazardous chemical or radiological characteristics related to SNF management activities.

5.8.1.4 Groundwater Quality. As previously mentioned, the proposed SNF facilities are designed to have no liquid release to the environment. However, for the purpose of this water resource analysis, a conservative release scenario was evaluated to identify the potential environmental consequences of a liquid release to the environment under normal operating conditions. The release scenario was evaluated for information purposes only, as no normal operating releases are planned for the proposed facility. The scenario consisted of a maximum potential liquid release to the environment under normal operating conditions such as an undetected secondary containment failure or piping leak. The scenario was evaluated using conservative estimates of the sensitivity of actual leak detection systems and operational source term data from similarly functioning facilities at the Idaho National Engineering Laboratory (INEL). The conservative estimates for the hypothetical release included a point release of 5 gallons (19 liters) per day to the environment over the course of 1 month. The release volume and durations were considerably greater than existing leak detection system sensitivities, surveillance activities, and radiological surveys. Source terms were derived at the 95 percent confidence level from 8 years of operational data at the INEL Fluorinel and Storage Facility at the Idaho Chemical Processing Plant.

The point source release as described above has been conservatively assumed to occur at a depth of 40 feet (12 meters) below land surface (the bottom of the Wet Storage Basin for the Receiving/Canning Facility). As detailed in Section 4.8.2, this is well within the vadose zone underlying Area 5 at Frenchman Flat. Vertical flow in the uppermost portions of the vadose zone at Area 5 is generally upward toward the surface, due to an extremely high evapotranspiration rate relative to precipitation. Site characterization data for Area 5 indicate that the vertical flow direction in the vadose zone is upward from 0 to 75 meters (0 to 250 feet) below land surface. In the next interval (75 to 180 meters [250 to 600 feet]), a downward flow rate of 3 meters/1,000 years (10 feet/1,000 years) has been calculated. At a depth of 180 to 250 meters (600 to 800 feet), a zone of equilibrium is present above the water table (a zone of no vertical movement). These data, combined with the relatively extensive depth to the water table (244 meters [800 feet]) and extreme travel times to the water table, indicate that the release described above would be highly unlikely to reach the saturated zone. The release would likely remain indefinitely in the vadose zone beneath the proposed SNF facilities, where it would present a persistent source of contamination but would not affect groundwater quality.

5.8.2 Regionalization Alternative

Potential impacts to surface water and groundwater from construction and operation of the proposed SNF facilities under the Regionalization Alternative would generally be as described for the Centralization Alternative. However, the quantity of groundwater withdrawn to support operation of the proposed facilities could be less.

5.9 Ecological Resources

The Centralization and Regionalization Alternatives could potentially affect ecological resources primarily through the alteration or loss of habitat. Potential impacts to terrestrial and aquatic resources and threatened and endangered species are described below for both alternatives.

Radiation doses received by terrestrial biota from waste management activities would be expected to be similar to those received by humans. Although guidelines have not been established for acceptance limits for radiation exposure to species other than humans, it is generally agreed that the limits established for humans are also conservative for other species (NRC 1979). Evidence indicates that no other living organisms have been identified that are likely to be substantially more radiosensitive than humans (Casarett 1968; National Academy of Sciences 1972). Additionally, work areas where potential radiation exposure is high and monitored site workers utilize protective equipment, have controlled access measures which limit entry by biota. Thus, so long as exposure limits protective of humans are not exceeded, no substantial radiological impact on populations of biota would be expected as a result of waste management activities at the proposed SNF facility.

5.9.1 Centralization Alternative

Under this alternative, 90 acres (0.36 square kilometer) of the creosote bush plant community would be disturbed during construction. The area disturbed would include construction laydown areas, grading, and new buildings. In addition, disturbance would be expected along access roads and other rights of way which have not been included in the 90 acres. This plant community is common to the southern portion of NTS. To obviate any impacts to this plant community, ground-disturbing activities would be kept to a minimum. This would also serve to reduce the number of non-native species, such as Russian thistle, to the area. However, non-native species would probably become established in some areas, for example, along the access road.

Impacts to wildlife would occur as a direct result of habitat loss and/or an indirect result of increased human presence. There could be a decrease in the number of small mammals and reptiles during the construction period due to ground-disturbing activities. More mobile animal species would be able to move to other areas on the NTS during construction. Depending upon the carrying capacity of these areas, there could be increased competition for food and water resources. After construction activities are complete, it is expected that species which adapt to developed areas would become established.

Impacts to birds protected under the Migratory Bird Treaty Act are expected to be minimal during construction, since there are no water sources at the proposed site. However, surveys prior to construction may be required by the U.S. Fish and Wildlife Service. During operation, there may be an increase in migratory birds utilizing the area due to the increase in water sources.

There would be no impact on wetlands or aquatic habitats due to the construction of the facility because these habitats do not exist in the area. The operation of the proposed SNF facilities would increase water sources for wildlife species due to retention ponds and a sewage lagoon area. This could bring an increase in species, especially migratory birds, seeking aquatic habitats. The addition of new species to the area would impact upon the general ecology by increasing diversity of species. Since these areas would be within fenced enclosures, it is expected that the larger mammals would be unable to directly utilize these water sources.

Noise and activity associated with construction would be expected to have short-term effects on most wildlife. Studies on the effects of noise on wildlife have shown varying responses by different species. Responses include becoming frightened and running away, altering migration or breeding patterns, changing home ranges (often decreasing them), or adapting to the noise and activity (EPA 1980). These effects would continue indefinitely during the operating life of the proposed SNF facilities.

Potential impacts to threatened and endangered species would be the direct result of increased human presence and the loss or alteration of habitat. Any Federal Candidate or state-protected species on the site would result in further consultation with the U.S. Fish and Wildlife Service and the Nevada State Forester. Mitigation plans would be developed in cooperation with the appropriate agencies if any of these species were identified on the project site.

Although positive identification of most of the species listed on Table 4.9-1 has not occurred during prior studies, the addition of water sources to the area could increase the suitability of habitat for some endangered, threatened, or candidate bird species. These might include birds of prey (bald eagle, peregrine falcon, ferruginous hawk, and golden eagle), and species which inhabit water areas such as shorebirds (mountain plover, western least bittern, western snowy plover, and white faced ibis). An increase in loggerhead shrikes may occur due to the fencing that would be erected around the facility and would serve as posts for this bird.

The project area is located within the range of the desert tortoise, a federally listed threatened species. Recent pre-activity surveys for other nearby projects have not identified the desert tortoise in the general area of the project site. However, a pre-activity survey for this project would be needed to determine the presence or absence of the desert tortoise and other species of concern. If present, the desert tortoise could be impacted during construction of the proposed SNF facilities due to increased vehicular traffic, construction of trenches for utilities, and other temporary construction excavations. Prior to and during construction activities, fencing of the areas and removal of tortoises within the fence would decrease the potential to bring harm to the desert tortoise. All activities with this species must be completed by a qualified biologist.

5.9.2 Regionalization Alternative

Impacts under this alternative are expected to be generally the same as under the Centralization Alternative. The major difference between the two is the total area to be disturbed. The Regionalization Alternative is expected to involve construction of fewer buildings and, therefore, to require disturbance of less land.

5.10 Noise

As discussed in Section 4.10, noises generated on the NTS do not propagate offsite at levels that impact the general population. Thus, the NTS noise impacts for both the Centralization and Regionalization Alternatives would be limited to those resulting from the transportation of personnel and materials to and from the site, which affect the nearby communities, and those resulting from onsite sources which may affect some wildlife near these sources. The effect of noise on wildlife near SNF management facilities under the Centralization or Regionalization Alternatives would be addressed in a project-specific environmental assessment.

The transportation noises are a function of the size of the work force (e.g., an increased work force would result in increased employee traffic and corresponding increases in deliveries by truck and rail, and a decreased work force would result in decreased employee traffic and corresponding decreases in deliveries). The analysis of traffic noise took into account noise from the major roadway which provides access to the NTS. Vehicles used to transport employees and personnel on roadways would be the principal sources of community noise impacts near the NTS from the Centralization and Regionalization Alternatives.

This analysis used the day-night average sound level to assess community noise, as suggested by the U.S. Environmental Protection Agency (EPA 1982, 1974) and the Federal Interagency Committee on Noise (FICON 1992). The change in the day-night average sound level from the baseline noise level for each alternative was estimated based on the projected change in employment and traffic levels from the baseline levels. The baseline is comparable to current activity at the NTS for 1993. The combination of construction and operation employment was considered. The traffic noise analysis considered U.S. Route 95, which employees use to access the NTS from Las Vegas. Changes in noise level below 3 decibels would not be expected to result in a change in community reaction (FICON 1992).

5.10.1 Centralization Alternative

Under the Centralization Alternative, the projected NTS work force would increase by about 48 percent of existing onsite employment in the years 2000 to 2002, the peak construction period, and decrease thereafter (Section 5.3). There would be a corresponding increase in truck, private vehicle, and bus trips. The day-night average sound level at 50 feet (15 meters) from U.S. Route 95 would be expected to increase by about 1 decibel. No change is expected in the community reaction to noise along this route. No mitigation efforts are necessary.

5.10.2 Regionalization Alternative

Under the Regionalization Alternative, traffic noise impacts would be the same as for the Centralization Alternative.

5.11 Traffic and Transportation

The proposed SNF management activities would involve a small increase in the number of employees commuting to the NTS and the transportation of SNF and hazardous chemicals on the NTS. This section summarizes potential transportation impacts due to the proposed SNF facilities on the NTS.

5.11.1 Centralization Alternative

5.11.1.1 Levels of Service. Levels of service were calculated for construction and operation of the SNF facility at the NTS. The maximum reasonably foreseeable scenario for construction and operations occurs when the combined number of employees and population are at their highest. This would occur in 2001, when there would be 3,426 employees and a projected baseline population in the Region of Influence of 1,209,316. The Region of Influence includes Nye and Clark counties. Direct employees associated with the proposed SNF facility generate direct trips in the Region of Influence. These trips are distributed to the Region of Influence road network according to percentages based on a traffic flow between the site and where employees historically have lived. Increases in baseline population and indirect site-related employees generate indirect trips in the Region of Influence. These trips are distributed based on the current average daily traffic per present population in the region of influence for a given segment. Direct and indirect average daily traffic are added and a new level of service is determined. Construction and operation employees contribute little to the future traffic because they represent such a small percentage of the Region of Influence population growth.

None of the future baseline levels of service would change due to SNF-related impacts.

5.11.1.2 Rail Transportation. The generic facility design would require rail access for Naval fuel delivery. The rail spur would most likely be built from the Union Pacific line, located approximately 50 miles (80 kilometers) east of the NTS. Impacts from construction and operation of the rail spur would be evaluated in detail if the site were selected for the SNF facility.

5.11.1.3 Transportation Impacts of Hazardous Chemicals. It is assumed that the hazardous chemicals required and hazardous waste generated by the proposed SNF facility operation would be transported by truck. The onsite transportation impacts for these hazardous chemicals and wastes shipments are calculated based on the assumptions that they do not have any incident free impacts, the material would not leak during transport, only risk is due to traffic fatalities, and the material spill of entire contents is bound by the risk evaluated for the Expended Core Facility, considered under facility accidents.

The total distance for onsite shipment of these hazardous chemicals is assumed to be the maximum site boundary distance from the proposed SNF facility to the nearest highway. Based on the unit risk factor (Cashwell et. al. 1986), occupational and non-occupational fatalities considering a rural setting the onsite transportation risks are calculated, assuming 10 annual shipments.

The maximum one-way distance from the site to the NTS gate by which trucks would deliver hazardous wastes is 20 miles (32 kilometers). Based on 1.5×10^{-8} accident occupational fatalities per kilometer per shipment, 4.0×10^{-4} accident occupational fatalities are estimated over a 40-year period. Based on 5.3×10^{-8} accident non-occupational fatalities per kilometer per shipment 1.4×10^{-3} accident non-occupational fatalities are estimated over a 40-year period.

5.11.1.4 Transportation Impacts of Radioactive SNF. The definition of offsite transportation include transportation of radioactive material from the shipping facility to the storage facility at the receiving site; therefore, local transportation does not separately address the onsite transportation impacts due to radioactive material shipment.

5.11.2 Regionalization Alternative

The impacts due to the Regionalization Alternative would be less than those described for the Centralization Alternative due to the smaller size of the facility and the smaller amount of waste expected.

5.12 Occupational and Public Health and Safety

The Waste Minimization and Pollution Prevention Awareness Plan at the NTS would be implemented within the SNF Management Program. While more chemicals per year would be used, health impacts to the public would continue to be minimal as a result of administrative and design controls to minimize releases of radioactive and chemical pollutants to the environment and to achieve compliance with permit requirements and applicable standards. Workers would continue to be protected from hazards specific to the workplace through appropriate training, protective equipment, monitoring, management controls, and occupational standards that would limit atmospheric and drinking water concentrations of potentially hazardous chemicals as well as limit radiation exposures. This would include protection from wastes generated from the increased use of the chemicals needed to accommodate spent fuel storage and from radioactivity associated with this storage. The NTS Emergency Preparedness Plan would continue to operate as designed to minimize or mitigate the impact of any emergency upon the health and safety of employees and the public.

Health effects from radiation are presented here as the risk of fatal cancer. This risk is in the ratio of their health risk estimator (risk of fatal cancer per rem of exposure). The value of this estimator for exposures to the public is 5.0×10^{-4} for fatal cancers. The corresponding estimator for exposures to workers is 4.0×10^{-4}.

5.12.1 Centralization Alternative

This section evaluates the impacts to human health resulting from both contaminated air emissions and direct exposures associated with the proposed SNF facility under the Centralization Alternative. Pathways assessed include inhalation of air, ingestion of food, submersion in plumes, and direct exposure.

5.12.1.1 Radiological Doses. Releases of additional radionuclides to the environment from operations at the proposed SNF facilities are summarized in Table 5.7-1. The annual committed doses to the public resulting from the proposed SNF facilities plus baseline operations in 1995 are provided in Table 5.7-3. The doses would be approximately 1 percent of the most restrictive health standard, and less than 0.1 percent of the natural background radiation. The dose to the maximally exposed member of the public is assumed to remain constant over the 40-year operational lifetime of the SNF; the population dose would increase slightly (less than 3 percent) due to population growth during this 40-year period.

Doses to SNF facility workers are assumed to be similar to those presently received by major DOE facility Waste Processing/Management personnel. Based on data for the years 1989 through 1991 for the Hanford Site, INEL and the Savannah River Site (SRS) (DOE 1992), it is estimated that the average dose to a worker from annual SNF operations at the NTS would be approximately 40 millirem and the maximum dose would be about 3,000 millirem. Assuming that 800 persons were involved at the peak of these operations, the total worker dose from annual SNF operations would be approximately 32 person-rem. Adding the baseline contribution, the total dose to all workers at the NTS would be about 36 person-rem.

5.12.1.2 Nonradiological Doses. Releases of additional nonradiological airborne pollutants from operations at the proposed SNF facilities are summarized in Table 5.7-2. The concentrations from these releases have been calculated and are presented in Tables 5.7-4 and 5.7-5.

5.12.1.3 Radiological Health Effects. The fatal cancer risk to the most exposed member of the public due to operation of the proposed SNF facilities would be 5.9×10^{-8}. The fatal cancer risk to the most exposed member of the public due to operation of the proposed SNF facilities plus baseline operations (1995 levels) would be 6.5 x 10, over 40 years (estimated storage duration), the risk to this individual would be approximately 2.6×10^{-6}. The estimated number of fatal cancers to the population within 80 kilometers (50 miles) of the proposed facility would be 4.4×10^{-5} for the operation of SNF facilities plus baseline operations and 4.1×10^{-5} for the operation of the SNF facilities without baseline operations. The number of increased fatal cancers from total NTS operations to the public during the estimate storage duration of the SNF would be approximately 1.8×10^{-3}. The number of fatal cancers from all causes that would normally be expected to occur during this same time period to the 80-kilometer population is 1,500.

The calculation of the number of health effects to SNF workers from annual operations is based on somewhat lower risk estimators than for the general public. The estimators are lower as the result of different age distributions among workers and members of the public. The risks of fatal cancer to the average worker is estimated to be 1.6×10^{-5}. The corresponding risk to the maximally exposed worker is estimated to be 1.2×10^{-3}. An excess of 0.013 fatal cancer among all SNF facility workers is projected from peak annual operations. It is projected that exposures to radiation over the lifetime of SNF operations could result in an excess of 0.40 fatal cancer among these workers and an increased risk of 6.4×10^{-4} to an individual worker who is present over this time period. The risks and numbers of excess fatal cancers, both from annual and lifetime operations, would be increased by about 15 percent if the impacts to workers associated with baseline activities (Section 4.12.2.1) were included. The health effects due to radiological doses to a noninvolved worker, i.e., an NTS worker involved in activities other than SNF, would be on the order of 1 percent of the occupational exposure to an SNF worker, based on analyses for the SRS and INEL sites.

5.12.1.4 Nonradiological Health Effects. As indicated in Table 5.7-4, the concentrations of all measured nonradiological pollutants at the NTS together with the inclusion of the Proposed Action would remain well within the health-based regulatory guidelines. The increases in pollutant concentrations from the Proposed Action would be negligible, compared to the existing baseline concentration; no adverse health effects from these pollutants would be anticipated.

The calculated maximum atmospheric concentrations of hazardous chemicals at the site boundary and onsite for the proposed action are presented in Table 5.7-5. The maximum concentrations at the site boundary are used to evaluate an exposure to a maximally exposed individual, whereas the maximum onsite concentrations could result in an exposure to a worker. Of the potential hazardous chemicals identified for the proposed action, cadmium, nickel and chromium VI (chrome) are carcinogens for which a total cancer risk was calculated. The remaining seven chemicals are noncarcinogens for which a hazard index was calculated. A hazard index value greater than 1 indicates a potential for adverse health effects.

Based on the maximum hazardous chemical concentrations at the site boundary, the lifetime fatal cancer risk and the hazard index to the maximally exposed member of the public would be only 5.4×10^{-13} and 2.5×10^{-3}, respectively. Based on the maximum concentrations onsite, the lifetime fatal cancer risk and hazard index to a worker would be only 2.7×10^{-12} and 1.3×10^{-2}, respectively. This indicates that there would be virtually no health impacts from nonradiological releases.

5.12.1.5 Industrial Safety. The measures of impacts for workplace hazards used in this analysis are (1) total reportable injuries and illnesses and (2) non-exposure-related fatalities in the work place.

Based on hazard rates for personnel of DOE and its contractors, it is estimated that 270 injuries and illnesses would be reported and 0.48 fatality would occur from all SNF construction activities. It is further estimated that 807 injuries and illnesses would be reported and 0.81 fatality would occur among SNF workers during lifetime operations.

5.12.2 Regionalization Alternative

Under the Regionalization Alternative, the radiological and nonradiological doses from operation of the proposed SNF facilities at the NTS could generally be lower than those described under the centralization alternative. Any corresponding health effects may also decrease.

5.13 Utilities and Energy

Direct changes in utility demand as a result of the Centralization and Regionalization Alternatives were compared, depending on available data, against either projected 1995 demand or the peak usage for the years 1988 through 1992 for each utility resource. Since utility usage at NTS is projected to decrease, this comparison is conservative. Impacts to provision of a utility are considered to occur if the demand for a utility is equal to or exceeds the available capacity within the designated Region of Influence. For the purpose of analysis, the Region of Influence for each resource is defined as the area served by the utility provider responsible for meeting the service demands of the NTS.

5.13.1 Centralization Alternative

5.13.1.1 Water Consumption. For the Centralization Alternative, approximately 0.43 liter per second (6.85 gallons per minute) of water would be required to operate the modules within the facility (Harr 1994). The 14 active wells had a capacity of 387 liters per second (6,139 gallons per minute) in 1993 (DOE/NV 1993a). The SNF facilities would require 0.1 percent of this amount. NTS wells would operate at 35 percent of total capacity, when the 1989 peak water usage of 134 liters per second (2,125 gallons per minute) was combined with the SNF facility requirements.

The active wells at Area 5 have a capacity of 38 liters per second (595 gallons per minute) (DOE/NV 1994c). The SNF facilities under the Centralization Alternative would require 1 percent of this amount. Water usage in Area 5 would increase to approximately 33 percent of the pump yield if the 1993 water usage of 12 liters per second (191 gallons per minute) for Area 5 is combined with the SNF facility requirements under the Centralization Alternative.

5.13.1.2 Electrical Consumption. Under the Centralization Alternative, the SNF facilities would require approximately 23,000 megawatt hours of electricity per year, or approximately 2.63 megavolt-amperes average demand (Harr 1994). The annual consumption of electricity of the SNF facilities would be approximately 12 percent of the 1995 annual consumption of electricity at NTS. The average electric demand of the SNF facilities would represent 6 to 7 percent of the projected 1995 peak electrical capacity of NTS. The average electric demand of the SNF facilities, combined with the peak electric demand of 39.5 megavolt-amperes, would utilize 94 to 105 percent of the transmission lines' current capacity. The 2.63 megavolt-amperes required for the SNF facility represents approximately 61 percent of the operating capacity of the substation at Area 5. The energy requirements of the SNF facility under the Centralization Alternative combined with the 1993 electric demand on the Frenchman Flat substation would utilize 63 percent of the substation capacity. It might be necessary to construct additional transmission lines or another substation to support the SNF facilities.

5.13.1.3 Fuel Consumption. Energy requirements for the SNF facilities under the Centralization Alternative were calculated assuming electrical power purchased from a utility was the primary source of energy; however, fossil fuels may be used to power backup generators and during construction activities. The amount of fuel that would be required for these operations would have little effect on fossil fuel usage at the NTS site.

5.13.1.4 Wastewater Disposal. Under the Centralization Alternative, approximately 0.43 liter per second (6.85 gallons per minute) of wastewater would be generated (Harr 1994). Currently, Area 5 has no wastewater facilities. A sewage treatment facility would need to be constructed for the SNF facilities under the Centralization Alternative.

5.13.2 Regionalization Alternative

The proposed SNF facilities under the Regionalization Alternative could consume less water, electricity, and fuel than under the Centralization Alternative. Less wastewater may also be generated; however, a sewage treatment facility would still need to be constructed.

5.14 Materials and Waste Management

Operation of the proposed SNF facilities would contribute transuranic, solid low-level, and sanitary waste as a consequence of transport, receipt, unloading, handling, and storage at the NTS. Under the SNF program, sources of potential contaminants would continue to be limited to construction support and site operation activities.

SNF storage activities would require the use of chemicals, and the majority of these would be expected to eventually become waste. Provisions would have to be made for the storage of the chemical raw materials used within the SNF complex as well as the waste material resulting from use. It was conservatively assumed that all chemical raw materials used by SNF would become hazardous wastes. Table 5.14-1 presents the estimated waste generation by waste classification for each of the two alternatives (Centralization and Regionalization) and by each of the two options (wet storage and dry storage).

5.14.1 Centralization Alternative

The Centralization Alternative would generate the greatest amount of waste from the SNF complex, since it is the alternative that contributes the larger amount of spent nuclear fuel to be stored. On an annual basis, the amount of waste generated by the SNF complex for this alternative would generally be greater than under the Regionalization Alternative. The handling capacity of the SNF complex is the factor that determines the amount of waste generation.

Table 5.14-1. Ten-year cumulative estimated waste generation for SNF alternatives at the NTS (m^3).

Time Period	1995-2004	2005-2014	2015-2024	2025-2034
	Centralization Alternative			
	Wet Storage Option			
Transuranic waste	160	160	160	160
Low-level waste	1,950	1,950	1,950	1,950
Hazardous waste	7.4×10^1	7.4×10^1	7.4×10^1	7.4×10^1
Sanitary waste	1.2×10^5	1.2×10^5	1.2×10^5	1.2×10^5
	Dry Storage Option			
Low-level waste	76	76	76	76
Sanitary waste	1.9×10^4	1.9×10^4	1.9×10^4	1.9×10^4
	Regionalization Alternative			
	Wet Storage Option			
Transuranic waste	<160	<160	<160	<160
Low-level waste	<1,950	<1,950	<1,950	<1,950
Hazardous	$<7.4 \times 10^1$	$<7.4 \times 10^1$	$<7.4 \times 10^1$	$<7.4 \times 10^1$
Sanitary waste	$<1.2 \times 10^5$	$<1.2 \times 10^5$	$<1.2 \times 10^5$	$<1.2 \times 10^5$
	Dry Storage Option			
Low-level waste	<76	<76	<76	<76
Sanitary waste	$<1.9 \times 10^4$	$<1.9 \times 10^4$	$<1.9 \times 10^4$	$<1.9 \times 10^4$

Source: Harr (1994).

5.14.1.1 Wet Storage Option.

5.14.1.1.1 Transuranic Waste—A small quantity (16 cubic meters, or 20.9 cubic yards) of transuranic waste would be generated per year due to the recovery and purification of transuranic products from the wet storage option (Harr 1994). Placement of this waste into the transuranic waste storage cell would have minimal impact on the current transuranic waste management at the NTS.

5.14.1.1.2 Low-Level Waste—The wet storage option would contribute liquid low-level waste as a result of its interim storage in water. This underwater storage would require filtered and deionized water to prevent possible corrosion problems with fuel elements and storage hardware; further waste would be generated from deionizer resin regeneration, filter backflushing, and chemical cleaning of the filter. An estimated 195 cubic meters (255 cubic yards) per year of low-level waste would be generated due to operation of the wet storage facility. Placement of this waste into the Radioactive Waste Management Site would he a viable option (see subsection 4.15.3). This quantity of low-level waste represents a minimal impact to the management of low-level waste at the NTS.

5.14.1.1.3 Hazardous Waste—Installation of the SNF complex would require additional management of hazardous wastes, including the placement of satellite storage areas within the SNF complex and more frequent offsite shipments of hazardous waste. An evaluation of the impact that the additional hazardous wastes generated by the wet storage option would be conducted as part of the required National Environmental Policy Act evaluation.

Additional hazardous waste accumulated would be transferred to the Hazardous Waste Accumulation Site, collected, and removed to an offsite EPA-permitted treatment, storage, and disposal facility. The potential for hazardous waste to adversely affect the environment as a result of an accidental spill would be limited due to the great depth to groundwater and the arid climate, thereby minimizing the likelihood of migration of surface and shallow subsurface contamination. Similarly, any leaks from new underground or aboveground storage tanks would have limited potential to affect the environment (DOE/NV 1992c).

It is estimated that the wet storage option would generate approximately 7.4 cubic meters (9.7 cubic yards) of hazardous waste annually. This quantity of hazardous waste represents a minimal impact to the management of hazardous wastes at the NTS.

5.14.1.1.4 Sanitary Waste—The SNF wet storage option would generate approximately 1.2 x 10^4 cubic meters (15,696 cubic yards) of sanitary waste annually. This quantity of sanitary waste would double the current sanitary waste disposal quantity at the NTS. This would require construction of additional septic/leach field capacity and/or additional sewage lagoon capacity, creating the need for additional land area for sanitary waste disposal.

5.14.1.2 Dry Storage Option. Unless a hazardous material were added to the fuel at the point of origination, hazardous material or mixed hazardous wastes would not be expected to be produced at a dry storage facility. With administrative controls applied at the storage facility to prevent hazardous material from coming in, the generation of mixed hazardous waste could be reduced or precluded. Any hazardous liquid and solid waste produced at the dry storage facility would be collected in a satellite accumulation area located inside the facility. Mixed waste would be stored onsite unless offsite storage and disposal facilities were licensed to accept radioactive waste.

Nonradioactive hazardous waste, such as oils, solvents, gloves, rags, and other materials associated with plant operation and maintenance, would be stored onsite until there were enough containers for shipment to an approved offsite treatment, storage, and disposal facility (Hale 1994).

5.14.1.2.1 Low-Level Waste—The low-level radioactive contaminated waste stream would result mainly from wastes generated during the decontamination operations of the cask, crane, and contaminated areas, from disposed personal protective equipment and clothing that would be used and disposed of during decontamination operations, and from the filters and ion exchange resins used to decontaminate the decontamination liquids. This waste would be sent to the waste packaging unit, where it would be compacted into drums for disposal. Old cans and lids removed in the canning process would be collected and placed into solid waste containers (Hale 1994). Approximately 7.6 cubic meters (9.9 cubic yards) of low-level waste would be generated annually from the dry storage facility. This quantity of low-level waste represents a minimal impact to the management of low-level waste at the NTS.

5.14.1.2.2 Sanitary Waste—Sanitary sewage is the only liquid effluent to be released from the facility. The SNF dry storage option would generate approximately 1.9 x 10^3 cubic meters (2.5 x 10^3 cubic yards) of sanitary waste annually. This quantity of sanitary waste would double the current sanitary waste disposal quantity at the NTS. This would require construction of additional septic/leach field capacity and/or additional sewage lagoon capacity, creating the need for additional land area for sanitary waste disposal.

5.14.2 Regionalization Alternative

The Regionalization Alternative would generate less waste from the SNF facility than would the Centralization Alternative, since it would contribute the smaller amount of SNF to be stored. The handling capacity of the SNF complex determines the amount of waste generation. For either the wet storage option or dry storage option, the wastes generated would be less than those presented for the Centralization Alternative. Therefore, Table 5.14-1 presents the estimated waste generation for SNF for this alternative as less than that generated for the Centralization Alternative. The impacts presented for each of the waste categories for the Centralization Alternative apply to the Regionalization Alternative as well.

5.15 Facility Accidents

A potential exists for accidents at facilities associated with the handling, inspection, and storage of spent nuclear fuel at the NTS. Accidents can be categorized into events that are abnormal (for example, minor spills), events a facility was designed to withstand, and events a facility is not designed to withstand. These categories are termed *abnormal, design basis, and beyond design basis* accidents, respectively. Summarized here are consequences of possible facility accidents for a member of the public at the nearest site boundary and at the nearest road, for the collective population within 80 kilometers (50 miles), for workers, and for the environment. See Section 5.11 for a summary of the assessment of transportation accidents.

A review of the historical record of accidents at the NTS is summarized in the following section. Methods used to assess potential future events are summarized in Section 5.15.2. Evaluations of accident impacts by alternative are summarized in Section 5.15.3 through 5.15.7. A summary comparison of accident impacts by alternative is given in Section 3.2. Additional supporting documentation for the accident impacts is given in a separate report (HNUS 1995).

This section examines the various activities that have been performed to assess the potential for accidents and their consequences for workers and the public for each alternative. A set of potential reasonably forseeable accidents over the 40-year period are described which envelop all accidents. Secondary impacts of accidents pertaining to cultural resources, economics, land use, endangered species, water resources, and ecology are also addressed. This section also covers emergency preparedness plans that have been established to mitigate the primary and secondary effects of accidents.

5.15.1 Historical SNF Accidents at NTS

There have been no SNF operations in the past several years at the NTS upon which to base an accident history.

5.15.2 Methodology

There are no facilities currently at the NTS for receiving, handling and storage of SNF that can be used as a basis for accident analysis. In the absence of suitable design details for the proposed SNF facilities during this stage of the SNF Management Program upon which to base an accident analysis, the approach makes use of accident scenarios and associated data that have been analyzed and documented for similar facilities. They include spent nuclear fuel facilities at INEL, the Hanford Site, SRS, and Naval sites.

5.15.2.1 Assumptions and Approach. A number of postulated accidents for similar facilities have been selected to serve as a common basis for estimating accident consequences for workers and the public at the NTS. Although the accident scenarios, source terms, and related assumptions are similar to those for other sites, the estimated consequences are unique to the

NTS because of site differences in modeling parameters pertaining to distances to site boundaries and population centers, population distributions, and meteorology. The GENII code (PNL 1988) was used to estimate accident consequences for the general public and for individuals onsite or at the site boundary, based on both 50 percent and 95 percent meteorology. Accident consequences and risk are described in terms of dose, latent cancer fatalities, and total health detriments for workers, for an individual at the site boundary, for a transient individual at the nearest public access, and for the public residing out to 80 kilometers (50 miles) from the proposed SNF facility. The estimated frequency of each selected accident is based on the reference source documentation.

The probability of an airplane crash into the facility is considered very small, because there are no nearby airports with large aircraft activity. For calculational purposes, the probability of such an accident is conservatively estimated at 10^{-6} per year. Potential accidents initiated by an airplane crash into the SNF facilities and the estimated consequences have been analyzed.

The secondary impacts of accidental releases of radioactive and hazardous materials are also addressed in a qualitative manner. Secondary impacts pertain to effects of accidents on land use, endangered species, water resources, cultural resources, and ecology.

5.15.2.2 Accident Screening. The potential accidents associated with existing SNF facilities and operations were screened to determine which ones to include in the accident analysis for the NTS. The source documentation for this effort was primarily Appendices A, B, C, and D of Volume 1 that were selected by a screening process for existing SNF facilities. Initiating events were reviewed, including natural phenomena (e.g., earthquakes and tornadoes) and human-initiated events (e.g., human error, equipment failures, fires, explosives, plane crashes, and terrorism). Accidents associated with Expended Core Facility (ECF) operations at the NTS were analyzed separately, and the results are documented in Appendix D. For the NTS the maximum reasonably foreseeable criticality and nonradiological accidents are associated with the ECF. The potential for a criticality exists while the fuel is in dry storage, during handling, and in the wet storage pool. Although the probability of any criticality is very low, a hypothetical criticality of 1×10^{19} fissions was postulated in the ECF wet pool as a basis for estimating the maximum reasonably foreseeable consequences of a criticality.

The selected accidents include beyond-design-basis events in order to reflect the magnitude of accident consequences that envelop all other accidents having a reasonable probability of occurrence. They also include other accidents with lower consequences and typically higher probabilities of occurrence, to show a range of accident types and consequences. The accidents included in this set are reasonably forseeable, meaning that there are one or more sequences of events that will lead to their occurrence, and the sequence with the highest probability of occurrence is greater than 1 x 10^{-7} per year. Accidents falling outside of this envelope, such as a meteorite impact, have been judged unreasonable because the probability of occurrence of less than 1 x 10^{-7} per year.

5.15.2.3 Accident Prevention and Mitigation. Under the Centralization and Regionalization Alternatives, the proposed SNF facilities at the NTS will be of new design and construction and incorporate the latest technology for safety. The accidents postulated for the SNF facilities are based on operations and safety analyses that have been performed at similar facilities. One of the major design goals for the proposed SNF facilities is to achieve a reduced risk to facility personnel and to public health and safety relative to that associated with similar functions at existing SNF facilities. Significant improvements would exist between the design criteria and safety standards of the new SNF facilities and those for the current facilities, reducing total risk. These would include changes in design to current DOE structural and safety criteria and to planned throughput and storage capacity.

The SNF facilities would be designed to comply with current Federal, state, and local laws, DOE Orders, and industrial codes and standards. This would provide facilities that are highly resistant to the effects of severe natural phenomena, including earthquakes, floods, tornadoes, high winds, as well as credible events as appropriate to the site, such as fires and explosions, and man-made threats to its continuing structural integrity for containing materials.

An emergency preparedness plan will also be prepared to lower the potential consequences of an accident to workers and the public. All workers receive evacuation training to ensure timely and orderly personnel movement away from high-risk areas. Plans and arrangements with local authorities will also be inplace to evacuate the general public that may be at risk of exposure to hazardous materials that are accidently released.

5.15.3 No Action Alternative

There are currently no SNF operations at NTS. The No Action Alternative is not applicable for NTS.

5.15.4 Centralization Alternative

There is a potential for the accidental release of radioactive substances during various stages of SNF handling operations and storage. The operations begin with the receipt of an SNF shipment by truck or rail carrier followed by the unloading of the shipping cask from the transport vehicle. If the SNF requires cooling, the cask is placed into an unloading pool where the SNF is withdrawn from the cask, moved to a temporary wet storage basin, and placed into a fuel rack. Some SNF that does not require cooling will be handled in a special cell, where it will undergo canning and/or characterization. SNF that does not have to be cooled and does not require canning and/or characterization will be loaded into a dry storage canister within a transfer cask and transported to modular above-grade dry storage. Accidents that may occur during these handling operations and storage may involve the release of radioactive material to air or water pathways. The cause of accidents may be due to internal initiators, such as operator error, terrorism, and equipment failure or external initiators, such as an aircraft crash into a facility.

5.15.4.1 Radiological Impacts. The set of accidents described below have been chosen to envelop the consequences of potential accidents for the proposed SNF facilities at the NTS. Although other accidents may occur, their estimated consequences are bounded by the accidents in the envelop or their probability of occurrence would be less than 1×10^{-6} per year. If such accidents were to occur, the dose and risk would be as shown in Tables 5.15-1 and 5.15-2 for 95 percent and 50 percent meteorology, respectively. Similarly, cancer fatalities are shown in Tables 5.15-3 and 5.15-4, and the health effects are shown in Tables 5.15-5 and 5.15-6.

5.15.4.1.1 Fuel Assembly Breach—Physical damage and breach of a fuel assembly could accidentally occur from its being dropped, from objects falling on it, or from the fuel part being cut. The fuel-cutting accident that has been postulated to occur at SRS SNF facilities is

Table 5.15-1. Summary of the Centralization Alternative accident analysis dose and risk estimates for the Nevada Test Site at 95 percent meteorology.

		95 Percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEI[a] (rem)	NPAI[b] (rem)	Worker[c] (rem)	Population (person-rem)	MEI (rem/yr)	NPAI (rem/year)	Worker (rem/yr)	Population (person-rem/yr)
Fuel assembly breach	1.6×10^{-1} [d]	2.0×10^{-3}	1.9 x 10-5	1.5×10^{-3}	1.3×10^{0}	3.2×10^{-4}	3.0×10^{-6}	2.4×10^{-4}	2.1×10^{-1}
Dropped fuel cask	1.0×10^{-4} [e]	1.3×10^{0}	2.7×10^{-2}	4.7×10^{0}	2.8×10^{2}	1.3×10^{-4}	2.7×10^{-6}	4.7×10^{-4}	2.8×10^{-2}
Severe impact and fire	1.0×10^{-6} [f]	9.3×10^{0}	9.9×10^{-2}	3.5×10^{0}	5.8×10^{3}	9.3×10^{-6}	9.9×10^{-8}	3.5×10^{-6}	5.8×10^{-3}
Wind-driven missile impact into dry storage	1.0×10^{-5}	3.5×10^{-3}	3.2×10^{-4}	1.2×10^{-2}	5.7×10^{-1}	3.5×10^{-8}	3.2×10^{-9}	1.2×10^{-7}	5.7×10^{-6}
Airplane crash into dry storage	1.0×10^{-6} [f]	1.5×10^{0}	7.7×10^{-2}	1.2×10^{1}	5.6×10^{2}	1.5×10^{-6}	7.7×10^{-8}	1.2×10^{-5}	5.6×10^{-4}
Airplane crash into dry cell facility	1.0×10^{-6} [f]	1.2×10^{1}	2.4×10^{-1}	2.3×10^{1}	7.0×10^{3}	1.2×10^{-5}	2.4×10^{-7}	2.3×10^{-5}	7.0×10^{-3}
Airplane crash into water pool	1.0×10^{-6} [f]	2.2×10^{-2}	1.4×10^{-4}	2.4×10^{-2}	5.8×10^{1}	2.2×10^{-8}	1.4×10^{-10}	2.4×10^{-8}	5.8×10^{-5}

a. Maximum exposed individual (MEI). Dose received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Dose received from inhalation and external pathways.

c. Dose received from inhalation and external pathways.

d. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

e. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

f. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-2. Summary of the Centralization Alternative accident analysis dose and risk estimates for the Nevada Test Site at 50 percent meteorology.

50 Percent meteorology									
		Dose				Risk			
Accident scenario	Frequency (per year)	MEI[a] (rem)	NPAI[b] (rem)	Worker[c] (rem)	Population[d] (person-rem)	MEI (rem/yr)	NPAI (rem/year)	Worker (rem/yr)	Population (person-rem/yr)
Fuel assembly breach	1.6×10^{-1} [e]	5.0×10^{-5}	2.9×10^{-7}	4.7×10^{-5}	3.4×10^{-2}	8.0×10^{-6}	4.6×10^{-8}	7.5×10^{-6}	5.4×10^{-3}
Dropped fuel cask	1.0×10^{-4} [f]	3.2×10^{-2}	4.1×10^{-4}	1.5×10^{-1}	6.9×10^{0}	3.2×10^{-6}	4.1×10^{-8}	1.5×10^{-5}	6.9×10^{-4}
Severe impact and fire	1.0×10^{-6} [g]	2.3×10^{-1}	1.5×10^{-3}	1.1×10^{-1}	1.4×10^{2}	2.3×10^{-7}	1.5×10^{-9}	1.1×10^{-7}	1.4×10^{-4}
Wind-driven missile into dry storage area	1.0×10^{-5}	8.7×10^{-5}	4.7×10^{-6}	3.7×10^{-4}	1.3×10^{-2}	8.7×10^{-10}	4.7×10^{-11}	3.7×10^{-9}	1.3×10^{-7}
Airplane crash into dry storage	1.0×10^{-6} [g]	3.7×10^{-2}	1.2×10^{-3}	3.9×10^{-1}	1.4×10^{1}	3.7×10^{-8}	1.2×10^{-9}	3.9×10^{-7}	1.4×10^{-5}
Airplane crash into dry cell facility	1.0×10^{-6} [g]	3.1×10^{-1}	3.7×10^{-3}	7.4×10^{-1}	1.7×10^{2}	3.1×10^{-7}	3.7×10^{-9}	7.4×10^{-7}	1.7×10^{-4}
Airplane crash into water pool	1.0×10^{-6} [g]	5.6×10^{-4}	2.0×10^{-6}	7.4×10^{-4}	1.4×10^{0}	5.6×10^{-10}	2.0×10^{-12}	7.4×10^{-10}	1.4×10^{-6}

a. Maximum exposed individual (MEI). Dose received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Dose received from inhalation and external pathways.

c. Dose received from inhalation and external pathways.

d. Dose received from inhalation, external, and ingestion pathways.

e. The value is $< 1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

f. The value is $< 1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

g. The value is $< 1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-3. Summary of the Centralization Alternative accident analysis cancer fatality and risk estimates for the Nevada Test Site at 95 percent meteorology.

		95 Percent meteorology							
Accident scenario	Frequency (per year)	Cancer fatalities				Cancer fatality risk (cancer fatalities/yr)			
		MEI[a]	NPAI[b]	Worker[c]	Population[d]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [e]	9.8×10^{-7}	9.3×10^{-9}	6.0×10^{-7}	6.6×10^{-4}	1.6×10^{-7}	1.5×10^{-9}	9.6×10^{-8}	1.1×10^{-4}
Dropped fuel cask	1.0×10^{-4} [f]	6.4×10^{-4}	1.4×10^{-5}	1.9×10^{-3}	2.8×10^{-1}	6.4×10^{-8}	1.4×10^{-9}	1.9×10^{-7}	2.8×10^{-5}
Severe impact and fire	1.0×10^{-6} [g]	4.7×10^{-3}	5.0×10^{-5}	1.4×10^{-3}	5.8×10^{0}	4.7×10^{-9}	5.0×10^{-11}	1.4×10^{-9}	5.8×10^{-6}
Wind-driven missile impact into dry storage	1.0×10^{-5}	1.7×10^{-6}	1.6×10^{-7}	4.9×10^{-6}	2.9×10^{-4}	1.7×10^{-11}	1.6×10^{-12}	4.9×10^{-11}	2.9×10^{-9}
Airplane crash into dry storage	1.0×10^{-6} [g]	7.4×10^{-4}	3.9×10^{-5}	4.8×10^{-3}	5.6×10^{-1}	7.4×10^{-10}	3.9×10^{-11}	4.8×10^{-9}	5.6×10^{-7}
Airplane crash into dry cell facility	1.0×10^{-6} [g]	6.1×10^{-3}	1.2×10^{-4}	1.8×10^{-2}	7.0×10^{0}	6.1×10^{-9}	1.2×10^{-10}	1.8×10^{-8}	7.0×10^{-6}
Airplane crash into water pool	1.0×10^{-6} [g]	1.1×10^{-5}	7.1×10^{-8}	9.6×10^{-6}	5.8×10^{-2}	1.1×10^{-11}	7.1×10^{-14}	9.6×10^{-12}	5.8×10^{-8}

a. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. The value is $< 1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

f. The value is $< 1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

g. The value is $< 1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-4. Summary of the Centralization Alternative accident analysis cancer fatality and risk estimates for the Nevada Test Site at 50 percent meteorology.

Accident scenario	Frequency (per year)	50 Pecent meteorology: Cancer fatalities				Cancer fatality risk (cancer fatalities/yr)			
		MEI[a]	NPAI[b]	Worker[c]	Population[d]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [e]	2.5×10^{-8}	1.4×10^{-10}	1.9×10^{-8}	1.7×10^{-5}	4.0×10^{-9}	2.2×10^{-11}	3.0×10^{-9}	2.7×10^{-6}
Dropped fuel cask	1.0×10^{-4} [f]	1.6×10^{-5}	2.1×10^{-7}	6.0×10^{-5}	3.5×10^{-3}	1.6×10^{-9}	2.1×10^{-11}	6.0×10^{-9}	3.5×10^{-7}
Severe impact and fire	1.0×10^{-6} [g]	1.2×10^{-4}	7.5×10^{-7}	4.5×10^{-5}	1.4×10^{-1}	1.2×10^{-10}	7.5×10^{-13}	4.5×10^{-11}	1.4×10^{-7}
Wind-driven missile impact into dry storage	1.0×10^{-5}	4.4×10^{-8}	2.4×10^{-9}	1.5×10^{-7}	6.7×10^{-6}	4.4×10^{-13}	2.4×10^{-14}	1.5×10^{-12}	6.7×10^{-11}
Airplane crash into dry storage	1.0×10^{-6} [g]	1.8×10^{-5}	6.0×10^{-7}	1.6×10^{-4}	6.8×10^{-3}	1.8×10^{-11}	6.0×10^{-13}	1.6×10^{-10}	6.8×10^{-9}
Airplane crash into dry cell facility	1.0×10^{-6} [g]	1.5×10^{-4}	1.9×10^{-6}	3.0×10^{-4}	1.7×10^{-1}	1.5×10^{-10}	1.9×10^{-12}	3.0×10^{-10}	1.7×10^{-7}
Airplane crash into water pool	1.0×10^{-6} [g]	2.8×10^{-7}	1.0×10^{-9}	3.0×10^{-7}	7.0×10^{-4}	2.8×10^{-13}	1.0×10^{-15}	3.0×10^{-13}	7.0×10^{-10}

a. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

f. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

g. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-5. Summary of the Centralization Alternative accident analysis health effects and risk estimates for the Nevada Test Site at 95 percent meteorology.

		95 Percent meteorology							
		Total health detriments[a]				Total health detriment risk (detriments/yr)			
Accident scenario	Frequency (per year)	MEI[b]	NPAI[c]	Worker[d]	Population[e]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1}[f]	1.4×10^{-6}	2.1×10^{-10}	8.4×10^{-7}	9.7×10^{-4}	2.2×10^{-7}	3.4×10^{-11}	1.3×10^{-7}	1.6×10^{-4}
Dropped fuel cask	1.0×10^{-4}[g]	9.3×10^{-4}	3.0×10^{-7}	2.6×10^{-3}	4.1×10^{-1}	9.3×10^{-8}	3.0×10^{-11}	2.6×10^{-7}	4.1×10^{-5}
Severe impact and fire	1.0×10^{-6}[h]	6.8×10^{-3}	1.1×10^{-6}	2.0×10^{-3}	8.5×10^{0}	6.8×10^{-9}	1.1×10^{-12}	2.0×10^{-9}	8.5×10^{-6}
Wind-driven missile impact into dry storage	1.0×10^{-5}	2.5×10^{-6}	3.4×10^{-9}	6.9×10^{-6}	4.2×10^{-4}	2.5×10^{-11}	3.4×10^{-14}	6.9×10^{-11}	4.2×10^{-9}
Airplane crash into dry storage	1.0×10^{-6}[h]	1.1×10^{-3}	8.8×10^{-7}	6.7×10^{-3}	8.2×10^{-1}	1.1×10^{-9}	8.8×10^{-13}	6.7×10^{-9}	8.2×10^{-7}
Airplane crash into dry cell facility	1.0×10^{-6}[h]	8.9×10^{-3}	2.7×10^{-6}	2.6×10^{-2}	1.0×10^{1}	8.9×10^{-9}	2.7×10^{-12}	2.6×10^{-8}	1.0×10^{-5}
Airplane crash into water pool	1.0×10^{-6}[h]	1.6×10^{-5}	1.5×10^{-9}	1.3×10^{-5}	8.5×10^{-2}	1.6×10^{-11}	1.5×10^{-15}	1.3×10^{-11}	8.5×10^{-8}

a. Maximum exposed individual (MEI). The estimated number of cancer fatalities, cancer non fatalities, and genetic defects resulting from the radiation exposure.

b. Radiation exposure received from inhalation, external, and ingestion pathways.

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation and external pathways.

e. Radiation exposure received from inhalation, external, and ingestion pathways.

f. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

g. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

h. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-6. Summary of the Centralization Alternative accident analysis health effects and risk estimates for the Nevada Test Site at 50 percent meteorology.

		50 Percent meteorology							
		Total health detriments[a]				Total health detriment risk (detriments/yr)			
Accident scenario	Frequency (per year)	MEI[b]	NPAI[c]	Worker[d]	Population[e]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [f]	3.7×10^{-8}	1.4×10^{-8}	2.6×10^{-8}	2.5×10^{-5}	5.9×10^{-9}	2.2×10^{-9}	4.2×10^{-9}	4.0×10^{-6}
Dropped fuel cask	1.0×10^{-4} [g]	2.3×10^{-5}	2.0×10^{-5}	8.4×10^{-5}	5.1×10^{-3}	2.3×10^{-9}	2.0×10^{-9}	8.4×10^{-9}	5.1×10^{-7}
Severe impact and fire	1.0×10^{-6} [h]	1.7×10^{-4}	7.2×10^{-5}	6.2×10^{-5}	2.1×10^{-1}	1.7×10^{-10}	7.2×10^{-11}	6.2×10^{-11}	2.1×10^{-7}
Wind-driven missile impact into dry storage	1.0×10^{-5}	6.4×10^{-8}	2.3×10^{-7}	2.1×10^{-7}	9.7×10^{-6}	6.4×10^{-13}	2.3×10^{-12}	2.1×10^{-12}	9.7×10^{-11}
Airplane crash into dry storage	1.0×10^{-6} [h]	2.7×10^{-5}	5.6×10^{-5}	2.2×10^{-4}	9.9×10^{-3}	2.7×10^{-11}	5.6×10^{-11}	2.2×10^{-10}	9.9×10^{-9}
Airplane crash into dry cell facility	1.0×10^{-6} [h]	2.2×10^{-4}	1.8×10^{-4}	4.2×10^{-4}	2.5×10^{-1}	2.2×10^{-10}	1.8×10^{-10}	4.2×10^{-10}	2.5×10^{-7}
Airplane crash into water pool	1.0×10^{-6} [h]	4.1×10^{-7}	1.0×10^{-7}	4.1×10^{-7}	1.0×10^{-3}	4.1×10^{-13}	1.0×10^{-13}	4.1×10^{-13}	1.0×10^{-9}

a. Maximum exposed individual (MEI). The estimated number of cancer fatalities, cancer non fatalities, and genetic defects resulting from the radiation exposure.

b. Radiation exposure received from inhalation, external, and ingestion pathways.

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways

d. Radiation exposure received from inhalation and external pathways.

e. Radiation exposure received from inhalation, external, and ingestion pathways.

f. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

g. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

h. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

chosen as representative of the fuel assembly breach accident (E. I. du Pont de Nemours & Co. 1983). During normal SRS operations, the inert, non-uranium-containing extremities of some SNF elements are cut off in the repackaging basin before the elements are bundled. The accident occurs when the actual uranium fuel is inadvertently cut, causing a radioactive release. The source term for this accident is shown in Table 5.15-7. The estimated frequency of occurrence for this accident is 1.6×10^{-1} per year, based on SRS operating experience with SNF. Because of anticipated differences in operations and facilities at the NTS, however, the actual frequency is expected to be much less than 1.6×10^{-1} per year.

5.15.4.1.2 Dropped Fuel Cask—The dropped fuel cask accident that has been postulated to occur at the Hanford Site (reference Volume 1, Appendix A) is chosen as representative of the dropped fuel cask/fuel handling accident for the new Centralization Alternative facility at NTS. This accident is initiated when a fuel cask is dropped and overturned in the fuel transfer area. Broken fuel elements spill out of the cask, within the pool building but away from the pool. It is assumed that the shipping cask ruptures, exposing all of the broken fuel elements in three canisters: 42 fuel elements, each containing 22.5 kilograms (50 pounds) of fuel. The source term for this accident is shown in Table 5.15-8. The probability of this accident is estimated to be less than 1×10^{-4} per year.

5.15.4.1.3 Severe Impact and Fire—The severe impact and fire accident that has been postulated to occur at the Hanford Site (reference Volume 1, Appendix A) is chosen as representative of the severe impact and fire/onsite transportation accident for the new Centralization Alternative facility at NTS. This accident assumes an unspecified initiating event that subjects the fuel assemblies to a severe impact, breach of the transport cask, and a fire. During the accident, the fuel pins rupture on impact or upon heating in the fire, which burns for an hour before being extinguished. Volatiles, particulates, and noble gases are released to the atmosphere. The source term for a release of 540 curies is shown in Table 5.15-9. The estimated probability of occurrence for this accident, reflecting the fact that the facilities of this site would be new, is less than 1×10^{-6} per year.

5.15.4.1.4 Wind-driven Missile Impact into Storage Casks—The wind-driven missile impact into storage casks accident that has been postulated to occur at the Naval Reactors Site (reference Volume 1, Appendix D) is chosen as representative of the wind-driven

Table 5.15-7. Estimated radionuclide releases for a fuel assembly breach accident at the NTS.[a]

Radionuclide	Release (Ci)
Iodine-131	7.1×10^{-2}
Iodine-133	1.4×10^{-30}
Krypton-85	1.8×10^{2}
Xenon-133m	1.1×10^{-8}
Xenon-133	1.1×10^{0}

a. Source: E. I. du Pont de Nemours & Co. (1983).

Table 5.15-8. Estimated radionuclide releases for a dropped fuel cask accident at the NTS.[a]

	Release (Ci)	
Radionuclide	Onsite (2 hours)	Offiste (8 hours)
Plutonium-236	1.3×10^{-8}	5.4×10^{-8}
Plutonium-238	2.9×10^{-3}	1.2×10^{-2}
Plutonium-239	6.7×10^{-3}	2.7×10^{-2}
Plutonium-240	3.5×10^{-3}	1.4×10^{-2}
Plutonium-241	2.7×10^{-1}	1.1×10^{0}
Plutonium-242	1.3×10^{-6}	5.1×10^{-6}
Americium-241	5.7×10^{-3}	2.3×10^{-2}
Curium-244	2.8×10^{-4}	1.1×10^{-3}
Europium-154	5.4×10^{-3}	2.1×10^{-2}
Cesium-134	7.9×10^{-3}	3.2×10^{-2}
Cesium-137	4.5×10^{-1}	1.8×10^{0}
Cerium-144	1.7×10^{-3}	6.8×10^{-3}
Praseodymium-144	1.7×10^{-3}	6.8×10^{-3}
Praseodymium-144m	2.0×10^{-5}	8.1×10^{-5}
Promethium-147	1.2×10^{-1}	4.9×10^{-1}
Antimony-125	7.3×10^{-3}	2.9×10^{-2}
Tellurium-125m	1.8×10^{-3}	7.3×10^{-3}
Ruthenium-106	3.2×10^{-3}	1.3×10^{-2}
Strontium-90	3.5×10^{-1}	1.4×10^{0}
Yttrium-90	3.5×10^{-1}	1.4×10^{0}

a. Source: Volume 1, Appendix A, Table A-1.

Table 5.15-9. Estimated radionuclide releases for a severe impact and fire accident at the NTS.[a]

Radionuclide	Release (Ci)
Tritium	4.6×10^{1}
Krypton-85	4.0×10^{2}
Strontium-90	2.7×10^{-2}
Ruthenium-106	1.3×10^{0}
Cesium-134	1.7×10^{1}
Cesium-137	8.0×10^{1}
Plutonium-238	8.9×10^{-4}
Plutonium-239	1.6×10^{-3}
Plutonium-240	1.8×10^{-3}
Plutonium-241	7.3×10^{-2}
Americium-241	1.0×10^{-3}

a. Source: Volume 1, Appendix A, Table A-14.

missile accident for the new Centralization Alternative facility at NTS. This accident is initiated by natural phenomena, a major wind storm or tornado in excess of facility design basis. In this scenario, a large object is propelled by the wind into a storage container, causing the container seal to be breached. No fuel damage results from the impact because of the strength of the containers used. The source term is based on the spent nuclear fuel corrosion film. One percent of the original corrosion film on the fuel is released from the cask to the atmosphere. The source term is shown in Table 5.15-10. The probability of this event is estimated to be less than 1×10^{-5} per year, based on a design basis tornado probability of 1×10^{-3} per year and a missile impact with damage probability of less than 1×10^{-2}.

5.15.4.1.5 Airplane Crash Into Dry Storage—The airplane crash into dry storage accident that has been postulated to occur at the Naval Reactors Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the dry storage area accident for the new Centralization Alternative facility at NTS. This accident initiated by an airplane crash into the SNF dry storage facility. The accident is postulated to cause damage to a single storage cask. Due to the severity of the impact, the cask seal is assumed to be breached, resulting in damage to the fuel and the release of corrosion products, located on the SNF exterior, to the environment. The impact also causes a fire and a release of fission products. It is assumed that 1 percent of all of the fuel units stored inside the cask are damaged either by the impact or by the fire, and that those fission products are available for release. Of the available fission products, 100 percent of the noble gases, 3 percent of the halogens, 1.1 percent of the cesium, and 0.1 percent of the remaining solids are released to the environment. Also, 10 percent of the original corrosion products from the fuel units are released from the cask to the atmosphere. The source term for this accident is shown in Table 5.15-11. The probability of this accident is small and is assumed to be less than 1×10^{-6} per year.

5.15.4.1.6 Airplane Crash into Dry Cell Facility—The airplane crash into the dry cell facility accident that has been postulated to occur at the naval Reactors Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the canning and characterization cell accident for the new Centralization Alternative facility at NTS. This accident is initiated by an airplane crash into the dry cell facility. The accident is postulated to cause significant damage to the building, resulting in the loss of containment and filtered exhaust

Table 5.15-10. Estimated radionuclide releases for a wind-driven missile impact into a storage cask at the NTS.[a]

Radionuclide	Release (Ci)
Cobalt-60	9.58×10^{-2}
Iron-55	1.76×10^{-1}
Cobalt-58	3.54×10^{-2}
Manganese-54	5.98×10^{-3}
Iron-59	5.11×10^{-4}

a. Source: Volume 1, Appendix D, Section F.1.4.2.2.1.

Table 5.15-11. Estimated radionuclide releases for an airplane crash into dry storage facility at the NTS.[a]

Radionuclide	Release (Ci)
Cesium-134	2.6×10^{1}
Cesium-137	3.6×10^{1}
Plutonium-238	5.9×10^{-2}
Barium-137m	3.1×10^{0}
Strontium-90	3.1×10^{0}
Cerium-144	7.2×10^{0}
Niobium-95	4.4×10^{0}
Yttrium-90	3.1×10^{0}
Ruthenium-106	6.1×10^{-1}

a. Source: Volume 1, Appendix D, Section F.1.4.2.2.2.

systems. The fuel units inside the dry cell are damaged by the impacts and fire. The impact also results in the release of corrosion products to the environment. For this accident scenario, 1 percent of the fuel units stored inside the dry cell are assumed to be damaged by either the impact or the resultant fire and those fission products would be available for release. Of the fission products available for release, 100 percent of the noble gases, 3 percent of the halogens, 1.1 percent of the cesium, and 0.1 percent of the remaining solids are released to the environment. Ten percent of the available corrosion products are released to the environment. The source term for this accident is shown in Table 5.15-12. The probability of this accident is estimated to be less than 1 x 10^{-6} per year.

5.15.4.1.7 Airplane Crash into Water Pool—The airplane crash into the SNF water pool accident that has been postulated to occur at the Naval Reactors Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the SNF water pool accident for the new Centralization Alternative facility at NTS. This externally initiated accident occurs when an airplane crashes into an SNF water pool and damages the fuel units stored there. Fission products and corrosion products are released from the fuel units into the water pool, but the pool water is not released to the environment. The presence of the pool water results in only a release of gaseous fission products to the atmosphere. In this accident scenario 1 percent of all the fuel units stored inside the pool are postulated to be damaged and those fission products are available for release. Of the available fission products, 100 percent of the noble gases and 25 percent of the halogens are released to the pool water. Due to the presence of pool water, there is a reduction of the halogen release by a factor of 10 prior to release to the atmosphere. The source term for this accident is shown in Table 5.15-13. The probability of this accident is estimated to be less than 1 x 10^{-6} per year.

5.15.4.2 Nonradiological Hazards. The two bounding accidents involving nonradiological hazards are a chemical spill and fire and a diesel fuel fire. Both of these accidents are associated with the Expended Core Facility operations and the accident frequencies and impacts are addressed in Volume 1, Appendix D. The analyses of these accidents considered the impacts to workers on the site as well as to the offsite population. The impacts were measured in terms of potential heath effects due to exposure to toxic chemicals released during these accidents. Since the ECF at this site will be a new design and construction, it will incorporate all applicable

Table 5.15-12. Estimated radionuclide releases for an airplane crash into dry cell facility at the NTS.[a]

Radionuclide	Release (Ci)
Cesium-134	4.5×10^{1}
Cesium-137	6.2×10^{1}
Plutonium-238	1.0×10^{-1}
Barium-137m	5.4×10^{0}
Strontium-90	5.5×10^{0}
Cerium-144	1.3×10^{1}
Niobium-95	7.7×10^{0}
Yttrium-90	5.5×10^{0}
Ruthenium-106	1.1×10^{0}

a. Source: Volume 1, Appendix D, Section F.1.4.2.3.3.

Table 5.15-13. Estimated radionuclide releases for an airplane crash into an SNF water pool at the NTS.[a]

Radionuclide	Release (Ci)
Iodine-129	7.6×10^{-4}
Iodine-131	1.6×10^{-2}
Tritium	4.3×10^{2}

a. Source: Volume 1, Appendix D, Section F.1.4.2.1.4.

standards and regulations and therefore limit the potential exposures to the workers and the public in the event of an accident.

5.15.4.3 Secondary Impacts. In the event of an accidental release of radioactive substances, there is a potential for secondary impacts to cultural resources, endangered species, water resources, and public and agricultural land use, the ecology in the vicinity of the accident, national defense, and local economics. In order to assess the impacts, a severe accident and the resulting release of radioactive material were evaluated. The accident chosen for evaluation was an airplane crash into the Centralization Alternative canning and characterization (dry) cell. Utilizing the 50 percent meteorology and the typical flat topography of the proposed SNF site, the dispersion of radioactive material and the resulting dose were calculated. Figure 5.15-1 shows the isodose lines ranging from 870 millirem per year down to 87 millirem per year, which is approximately equivalent to cosmic and terrestrial background radiation. The farthest distance between the accident site and the 87 millirem per year line is 8,000 feet (2,400 meters). Therefore, in order to minimize the potential impact of an accident on the non-NTS personnel and the public, the SNF facility should be located at least 8,000 feet (2,400 meters) from the NTS boundary. Given the available space within Area 5 and the large buffer zone surrounding the proposed SNF site and the NTS, the final siting location could easily accommodate this design constraint. This design constraint could be applied to other environmental resources during the final siting process. The secondary impacts in other environmental resources which would not be accommodated as easily are summarized below. Table 5.15-14 presents a summary of the postulated severe accident secondary impacts on the environment, economy, and national defense. The evaluation was performed using 50 percent meteorology.

5.15.5 Decentralization Alternative

The Decentralization Alternative is not applicable for the NTS.

5.15.6 1992/1993 Planning and Basis Alternative

There are currently no SNF operations at NTS. The 1992/1993 Planning Basis Alternative is not applicable for NTS.

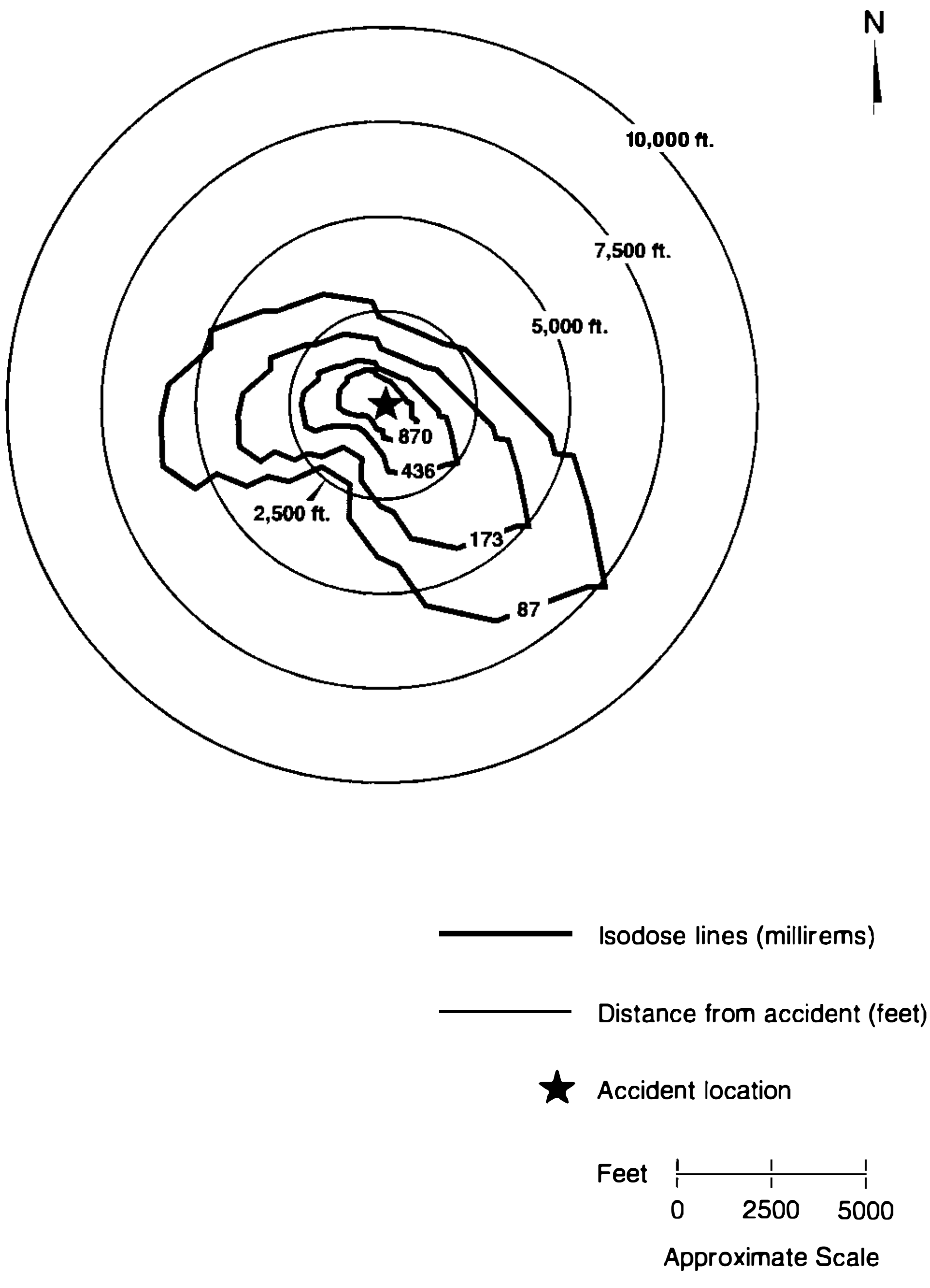


Figure 5.15-1. Typical Isodose lines for an airplane crash into a dry cell accident with 50 percent meteorology for northeastern Area 5 of the NTS.

Table 5.15-14. Secondary impacts of the Centralized Alternative accidents at NTS.

Environmental or social factor	Impact
Land Use	Possible minor impact. The dispersion of radioactive material would be limited within the NTS boundaries. The major NTS facilities in the vicinity of the proposed SNF site include the Radioactive Waste Management Site and the Liquified Gaseous Fuels Spill Test Facility.
Cultural Resources	Possible minor impact. Surveys conducted for other Area 5 activities have indicated only scattered artifacts in the vicinity of the proposed SNF site. No major prehistoric/historic sites are anticipated to be located in the vicinity of the proposed SNF site. Access to any random artifacts found during the accident investigation and cleanup would have to be restricted until radioactive decay had occurred.
Aesthetic and Scenic Resources	No impact. The area of contamination does not envelop aesthetic and scenic resources.
Water Resources	No impact. The nuclear testing program has dispersed radioactive material in the vicinity of the proposed SNF site during aboveground nuclear tests. Due to the great depths of the groundwater, the groundwater was not contaminated. It is anticipated that an accident would not alter the pathways to the groundwater.
Ecological Resources	Possible impact. Many threatened or endangered plants and animals, except fish species, are potentially on or near the NTS.
Treaty Rights	No impact. There are no onsite areas subject to Native American Treaty rights.
National Defense	No impact. The area of contamination does not envelop U.S. military or defense industry facilities.
Economic Impacts	Possible minor impact. The dispersion of radioactive material would be limited within the NTS boundaries. The major NTS facilities in the vicinity of the proposed SNF site include the Radioactive Waste Management Site and the Liquified Gaseous Fuels Spill Test Facility.

5.15.7 Regionalization Alternative

Under the Regionalization Alternative, new facilities would be constructed and operated for SNF. Details for the new facilities have not been defined, but it is reasonable to expect that they would be similar to but with less throughput and storage requirements than those needed for the Centralization Alternative. Due to smaller throughput and storage requirements, the potential for accidents (i.e., probability of occurrence) will be similar to but less than those described for the Centralization Alternative. The accident consequences would be similar for both alternatives. Consequently, it is reasonable to assume the accident consequences and risks described for the Centralization Alternative envelop the Regionalization Alternative.

5.15.8 Emergency Preparedness and Plans

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

Officials at each DOE site have specified the emergency preparedness requirements for the DOE facilities under their jurisdiction in a manner consistent with the relevant DOE Orders. All existing facilities have emergency plans and procedures that either implement the DOE and site requirements or are integrated with the site planning.

The Nevada Operations Office Emergency Preparedness Plan is designed to minimize or mitigate the impact of any emergency upon the health and safety of employees and the public. The plan integrates all emergency planning into a single entity to minimize overlap and duplication, and to ensure proper responses to emergencies not covered by a plan or directive. The plan is based upon the concept that the Manager, Nevada Operations Office, has the capability to manage, counter, and recover from an emergency occurring within the Nevada Operations Office responsibility.

The Nevada Operations Office plan provides for (1) identification and notification of personnel for any emergency that may develop during operational or nonoperational hours; (2) the receipt of warnings, weather advisories, or any other information that may provide advance warning of a possible emergency; and (3) prearranged actions which may be taken to minimize the effect of the emergency. The plan is based upon current Nevada Operations Office vulnerability assessments, resources, and capabilities regarding emergency preparedness.

5.16 Cumulative Impacts and Impacts from Connected or Similar Actions

The NTS already contains several major DOE and non-DOE facilities, unrelated to SNF, that would continue to operate throughout the operating life of the proposed SNF management facilities. The activities associated with these existing facilities produce environmental consequences that have been included in the baseline environmental conditions (Chapter 4) against which Sections 5.1 through 5.15 have assessed the environmental consequences of the Centralization and Regionalization Alternatives. This section uses the environmental baseline conditions presented in Chapter 4 to assess potential cumulative impacts from the proposed SNF management facilities, if constructed at the NTS, plus other reasonably forseeable activities.

In addition to the proposed SNF management facilities, reasonably foreseeable activities considered in this cumulative impact assessment include the proposed Expended Core Facility (described in Volume 1, Appendix D), activities included in the present Five-Year Plan and Master Plan for the NTS (DOE/NV 1993b), and the potential geologic repository at the Yucca Mountain site. Major programmatic initiatives consist of constructing the following: facilities and site improvements for a new consolidated testing area sponsored by Los Alamos and Lawrence Livermore National Laboratories; a Transuranic Waste Certification Building; refurbishment or expansion of several existing facilities; construction of several small office buildings; several site assessment and remediation projects; several roadway upgrading or improvement projects; several flood control projects; and several utility installation or upgrade projects. In addition, a number of communications, security, an safety improvements identified in the Master Plan are under consideration throughout the NTS.

Specifically with respect to Area 5, a number of projects are proposed (DOE/NV 1993b). Continued use of the Radioactive Waste Management Site and the Spill Test Facility is proposed. Providing storage for transuranic waste and hazardous waste prior to offsite disposal is also proposed. Additional projects have also been proposed to provide utility and infrastructure upgrades and improvements. These projects include replacing the Frenchman Flat power substation and a number of construction projects for water Service Area C including connecting the Yucca Flat and Frenchman Flat water systems, and adding additional tanks and water lines in the area. Nearby proposals identified for Area 6 include following a formal, expansion-oriented land-use plan for the Control Point, Yucca Lake, and the Construction Facilities.

The potential geologic repository at the Yucca Mountain site, which could involve construction and operation of a geologic repository for spent nuclear fuel and high-level waste on NTS land and other federal land on the western boundary of the NTS, is also considered in this cumulative impacts analysis. Considering the relatively isolated location of the NTS, future new offsite activities (other than the potential geologic repository at Yucca Mountain) are assumed to be of limited scope.

The following cumulative impacts analysis considers the potential incremental effects from the proposed SNF management facilities and the proposed Expended Core Facility in detail. The potential incremental impacts from activities proposed in the Five-Year Plan, and Master Plan the potential geologic repository at the Yucca Mountain site, and from future offsite activities are assessed in a more qualitative manner.

5.16.1 Centralization Alternative

Separate analyses of potential cumulative impacts from the Centralization Alternative against the environmental baseline conditions presented in Chapter 4 are provided below.

5.16.1.1 Land Use. Construction of the proposed SNF management facilities would require the dedication of approximately 90 acres (0.36 square kilometer) of undeveloped land on the NTS. Construction of the proposed Expended Core Facility would require the dedication of an additional 30 acres (0.12 square kilometer) of undeveloped land, increasing the total land requirement to 120 acres (0.48 square kilometer). This represents less than 1 percent of the roughly 450,000 acres (1,800 square kilometers) of undeveloped land remaining on the 864,000 acre (3,500 square kilometers) NTS. Additional unknown areas of undeveloped land, generally parcels of under 100 acres (0.4 square kilometer), might have to be dedicated to some of the activities proposed in the Five-Year Plan and Master Plan. Many of these proposed activities do not require the dedication of undeveloped land. Land on the southwestern part of the NTS has already been allocated for the potential Yucca Mountain repository and current site characterization for a potential geologic repository at the Yucca Mountain site.

Considering the large area of undeveloped land on the NTS, the cumulative dedication of land to all reasonably foreseeable activities on NTS would not likely serve to further limit the availability of land on the NTS for future development. Large areas of undeveloped land are available for development off of the NTS, and any future offsite development coupled with the proposed onsite development discussed above is not likely to create regional land shortages that could severely limit future regional development.

5.16.1.2 Occupational and Public Health. The annual collective effective dose equivalent from the existing NTS facilities to the population within 50 miles (80 kilometers) of the NTS is 0.0052 person-rem. Added to this baseline, operation of the proposed SNF management facilities might contribute an additional 0.082 person-rem, increasing the cumulative effective dose to 0.087 person-rem.

The annual collective effective dose equivalent from the existing NTS facilities to a potential maximally exposed individual at the site boundary is 0.011 millirem per year. Operation of the proposed SNF management facilities might contribute an additional 0.12 millirem per year, resulting in a cumulative annual dose of 0.13 millirem per year to this maximally exposed individual.

The total annual baseline worker dose seen from normal NTS operations is about 4 person-rem. The total annual SNF management facility worker dose is expected to be roughly 32 person-rem. Hence, the cumulative annual dose might be 36 person-rem.

Over the planned 40-year operational lifetime of the SNF management facility, a total population dose of 3.5 person-rem will be observed from continuous operation of the existing NTS facilities and the SNF management facility. This equates to a risk of fatal cancer of 4.4×10^{-5} over the 40-year span. For the maximally exposed individual, the total dose over the 40-year period equates to a risk of fatal cancer of 2.6×10^{-6}. For the SNF management worker, the total dose over the 40-year span corresponds to a risk of fatal cancer of 6.4×10^{-4}.

Additional radiological impacts are not expected from operation of the proposed Expended Core Facility. Analysis has shown that the dose to all individuals considered (workers, and offsite individuals) from Expended Core Facility operations might be much less than one millirem per year.

5.16.1.3 Noise. Increases in noise levels from construction and operation of the SNF management facilities and the Expended Core Facility would be limited to temporary, minor construction noise and small increases in traffic noise occurring along various access routes to the NTS due to increases in employment. Because of the NTS's large size and sparsely inhabited surroundings, any cumulative noise levels generated on the NTS by the proposed SNF management facilities, the proposed Expended Core Facility, the potential geologic repository at the Yucca Mountain site, and activities proposed in the Five-Year Plan and Master Plan would not propagate offsite at levels that would impact the general population. Although the cumulative offsite noise level attributed to future offsite activities can not be estimated, the potential incremental addition attributable to the proposed SNF management facilities would be minimal. Minor increases in traffic noise on U.S. Route 95 could be possible due to increases in activity on and near the NTS.

5.16.1.4 Groundwater and Surface Water Resources. Operation of the proposed SNF management facilities would require the withdrawal of an estimated 3.6 million gallons per year (13.6 million liters per year) of groundwater from the Ash Meadows Subbasin. Operation of the proposed Expended Core Facility would require the withdrawal of an estimated additional 2.5 million gallons per year (9.5 million liters per year) from that subbasin, resulting in a combined withdrawal of an estimated 6.1 million gallons per year (23.1 million liters per year). The water demands for the potential geologic repository at the Yucca Mountain site would be met by the Alkali Flat Furnace Creek Ranch Subbasin and therefore would not contribute to the cumulative water withdrawals from the Ash Meadows Subbasin. Information concerning the water demands of activities in the Five-Year Plan, Master Plan, or future offsite activities is not available.

Although total withdrawals of groundwater from the Ash Meadows Subbasin have not exceeded the subbasin perennial yield, localized withdrawals of groundwater in the Frenchman Flat hydrographic area of the Ash Meadows Subbasin have exceeded the estimate of precipitation recharge for the area. This recharge estimate was exceeded for more than thirty years with no decline in static water levels. Accurate measurement of static water levels are, however, precluded by numerous conditions on the NTS. Because of hydrogeologic complexities, regional groundwater flow at the NTS is not constrained by the hydrographic basins which are defined by local topography. Therefore any potential groundwater overdraft in the Frenchman Flat hydrographic area indicated by previous yield estimates are likely be made up by untapped groundwater from neighboring hydrographic basins. Localized impacts could occur if the perennial yield of Frenchman Flat hydrographic area is exceeded. Potential impacts include depletion of water stored locally in the regional aquifer, removal of that groundwater from other potential uses, and the potential modification of the rate and direction of contaminant migration resulting from underground nuclear testing. The complex issues of groundwater contamination and use are being addressed in the Resource Management Plan being prepared in conjunction with the NTS site-wide EIS.

5.16.1.5 Biotic Resources. Construction of the proposed SNF management facilities would require the disturbance of approximately 90 acres (0.36 square kilometer) of desert habitat supporting flora and fauna characteristic of the ecotone between the Mohave Desert and the Great Basin. Construction of the proposed Expended Core Facility would require the disturbance of an additional 30 acres (0.12 square kilometer) of desert habitat, resulting in a combined conversion of 120 acres (0.48 square kilometer) of terrestrial habitat to developed uses.

Additional areas of desert habitat would be lost during construction of activities proposed in the Five-Year Plan and Master Plan, during construction of the potential geologic repository at the Yucca Mountain site, and during future offsite construction activities. Considering the broad extent of desert habitat on and surrounding the NTS, the cumulative loss of desert habitat would be minimal.

The NTS lies within the range of the desert tortoise, a federally listed threatened species. If the desert tortoise occurred in areas subject to development, tortoises could be injured from construction activities. The proposed SNF management facilities (and the proposed Expended Core Facility) would be constructed at the edge of the tortoise's range, however, and few have been found in the affected area. Habitat losses due to construction of the proposed SNF management facilities and other proposed onsite and offsite construction activities could result in a slight cumulative loss of habitat for the desert tortoise. The U.S. Fish and Wildlife Service would be consulted in accordance with Section 7 of the Endangered Species Act prior to construction of the potential SNF management facilities to ensure that any potential cumulative effect on desert tortoise populations would be minimal. The U.S. Fish and Wildlife Service would also have to be similarly notified and given an opportunity to comment prior to construction of the potential geologic repository at the Yucca Mountain site and prior to any other major construction activities.

5.16.1.6 Air Quality. The potential cumulative air emissions from the proposed SNF management facilities and the proposed Expended Core Facility would not result in an exceedance of the National Ambient Air Quality Standards or Nevada state criteria. Also, there would be no exceedance of Federal National Emissions Standards for Hazardous Air Pollutants or DOE radiological standards. Air emissions from the other planned activities have not yet been defined.

5.16.1.7 Socioeconomics. Operation of the proposed SNF management facilities might generate up to 800 new jobs during the year 2005 and beyond. Operation of the proposed Expended Core Facility might generate up to 562 additional jobs during that year, resulting in a combined increase of up to 1,362 new jobs. The 7,091 jobs presently forecasted for the NTS in the year 2005 might be increased by 19 percent, to as much as 8,453 jobs. The 752,356 jobs presently forecasted for the surrounding area in the year 2005 might be increased by less than 1 percent, to as much as 753,718 jobs. Additional employment increases could also result from the potential geologic repository at the Yucca Mountain site, activities proposed in the Five-Year Plan and Master Plan, and new offsite activities, but specific estimates are not available.

The cumulative effect of the employment increases discussed above would depend on future actions at the NTS and throughout the regional economy. These employment increases could cause minor fluctuations in employment and housing demands. However, activities at the NTS generally have a relatively modest effect on long-term regional economic growth and productivity in Clark County because of the implicit growth projections in the services and retail trade sectors driving long-term growth in the Las Vegas Metropolitan Statistical Area. Additionally, in recent years the shutdown of nuclear testing activities at the NTS has caused employment levels to fall. These losses have not been considered in long-term employment forecasts. If nuclear testing activities do not resume at the NTS, the projected employment increases noted above could be offset by employment losses.

5.16.1.8 Transportation. An estimated 4.0×10^{-4} and 1.4×10^{-3} accident occupational fatalities and accident nonoccupational fatalities might occur over the 40-year life of the proposed SNF management facilities due to the transportation of hazardous material to the facilities. This does not include fatalities due to leakage of hazardous waste. Similar data are not available for the other planned activities.

5.16.1.9 Waste Management. Operation of the proposed SNF management facilities would generate an estimated 203 cubic meters (266 cubic yards) per year of low level waste and an estimated 16 cubic meters (21 cubic yards) per year of transuranic waste. Operation of the proposed Expended Core Facility would generate an additional 425 cubic meters (556 cubic yards) of low level waste (for a combined total by both facilities of 628 cubic meters (821 cubic yards)) but would not generate any additional transuranic waste. No other radioactive waste, including high level waste or mixed waste, would be generated by either facility. Comparable data for the potential geologic repository at the Yucca Mountain site or for offsite activities or activities proposed in the Five-Year Plan and Master Plan is not available. All wastes generated by the proposed SNF management facilities and other planned activities on the NTS would be treated and disposed of in accordance with all applicable Federal and state regulations.

5.16.1.10 Other Resources. The absence of impacts, or very minimal impacts, from the proposed SNF management facilities to cultural resources, aesthetic and scenic resources, utilities, and geologic resources ensures that their potential contribution to cumulative impacts affecting these resources would be negligible.

5.16.2 Regionalization Alternative

Because impacts from the proposed SNF management facilities under the Regionalization Alternative would be equal to or less than those under the Centralization Alternative, the potential cumulative impacts would also be equal or less. Generally, the Regionalization Alternative requires less construction and smaller scale operations, and the potential for cumulative impacts is therefore less.

5.17 Adverse Environmental Effects That Cannot Be Avoided

5.17.1 Overview

This chapter discusses potentially unavoidable adverse impacts to the environment resulting from construction and operation of the proposed SNF facilities at the NTS under the Centralization and Regionalization Alternatives. Unavoidable adverse impacts are impacts which cannot be mitigated by changes in project design, operation, or construction, or by other measures.

5.17.2 Centralization Alternative

Operation of the proposed SNF facilities at the NTS under the Centralization Alternative would increase the radiation dose rate to the maximally exposed individual by 0.12 millirem/year, resulting in only a minimal increase in cancer risk. The number of fatal cancers per year of operations on the NTS from existing sources and the SNF facilities would be 4.4×10^{-5}.

Construction of the proposed SNF facilities would require the disturbance of approximately 90 acres (0.36 square kilometer) of undeveloped land. Although this represents less than 1 percent of the undeveloped land on NTS, it would eliminate potential terrestrial wildlife habitat, including habitat potentially suitable for the federally listed desert tortoise. It would also require the dedication of a small land parcel potentially suitable for other construction projects, but similar land parcels are abundant on the NTS.

Operation of the proposed SNF facilities would require the withdrawal of an estimated 3.6 million gallons (13.6 million liters) per year of groundwater from the Ash Meadows Subbasin. Existing localized withdrawals of groundwater from Frenchman Flat hydrographic area of this subbasin already exceed the estimate of precipitation rechange for the area. However, the total withdrawal from the Ash Meadows Subbasin does not exceed its total perennial yield. Any water withdrawn would therefore not be discharged at Ash Meadows and the other discharge points in the deserts southwest of NTS.

The potential impacts from the Centralization Alternative to the other environmental resources discussed in Chapter 5 are not unavoidable adverse impacts.

5.17.3 Regionalization Alternative

Potential unavoidable adverse impacts associated with the Regionalization Alternative would resemble those discussed above for the Centralization Alternative. The extent of the impacts could be less due to the reduced land requirements, reduced extent of construction disturbance, and reduced scale of operations.

5.18 Relationship Between Short-Term Use of the Environment and the Maintenance and Enhancement of Long-Term Productivity

Implementation of any of the SNF management alternatives would cause some adverse impacts to the environment and permanently commit certain resources. These resources include use of the environment and those associated with construction and operation of the SNF management facilities.

The proposed alternatives for SNF management would require the short-term use of resources including energy, construction materials, and labor in order to achieve the objective of safety managing SNF to minimize the risk to workers, the public, and the environment.

Development of new SNF interim management facilities would commit lands to those uses from the time of construction through the cessation of operations, at which time the facilities could be converted to other uses or decontaminated, decommissioned, and the site restored to its original land use.

5.19 Irreversible and Irretrievable Commitments of Resources

5.19.1 Overview

This chapter discusses the irreversible and irretrievable commitments of resources resulting from the use of materials that can not be recovered or recycled, or that must be consumed or reduced to irrecoverable forms.

5.19.2 Centralization Alternative

Construction and operation of SNF facilities under the Centralization Alternative would require commitments of electrical energy, fuel, concrete, steel, sand, gravel and miscellaneous chemicals. Groundwater to operate the SNF facilities would not be discharged in the deserts to the southwest of NTS. More detailed analyses would be required to determine irreversible effects on localized groundwater availability. The land dedicated to the SNF facilities would become available for other rural uses following closure and decommissioning.

5.19.3 Regionalization Alternative

Irreversible and irretrievable commitments of resources associated with the Regionalization Alternative would resemble those discussed above for the Centralization Alternative. However, the extent of these resource commitments could be less, due to the reduced land requirements and reduced scale of operations.

5.20 Potential Mitigation Measures

5.20.1 Pollution Prevention

The DOE Nevada Field Office (DOE/NV) published a Waste Minimization and Pollution Prevention Awareness Plan in June 1991 to reduce the quantity and toxicity of hazardous, mixed, and radioactive wastes generated at DOE/NV facilities. The plan is designed to reduce the possible pollutant releases to the environment and thus increase the protection of employees and the public. All DOE/NV contractors and NTS users that exceed the EPA criteria for small-quantity generators are establishing their own waste minimization and pollution prevention awareness programs that are implemented by the DOE/NV plan. Contractor programs ensure that waste minimization activities are in accordance with Federal, state, and local environmental laws and regulations, and DOE Orders (DOE/NV 1993c).

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of wastes generated, and implementation of recycling programs. Goals also include incorporation of waste minimization concepts and technologies in planning and design of new processes and facilities, and in upgrades of existing facilities. A waste minimization task force composed of representatives from each contractor and NTS user has been established to coordinate DOE/NV waste minimization and pollution awareness activities (DOE/NV 1993c).

5.20.2 Potential Mitigation Measures

Potential impact avoidance and mitigation measures are addressed in Chapter 5, Sections 1 through 15 as appropriate.

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7.0 ABBREVIATIONS AND ACRONYMS

°C	degrees Celsius
CFR	Code of Federal Regulations
Ci	curie(s)
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
EIS	environmental impact statement
ECF	Expended Core Facility
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
FEMA	Federal Emergency Management Agency
g	gram
gal	gallon(s)
hr	hour
INEL	Idaho National Engineering Laboratory
kg	kilogram
km	kilometer
kv	kilovolt
ℓ	liter
m	meter
m^3	cubic meter
mi	mile
mi^2	square mile
min	minute
mph	miles per hour
mR	milliroentgen
mrem	millirem
MTHM	metric tons of heavy metal
MW	Megawatt
nCi	nanocurie
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission

NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl
pCi	picocurie(s)
PEIS	Programmatic Environmental Impact Statement
PM^{10}	particulate matter less than 10 microns in diameter
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
SNF	spent nuclear fuel
SRS	Savannah River Site
TVA	Tennessee Valley Authority
μg	micrograms
USGS	U.S. Geological Survey
yr	year

OAK RIDGE RESERVATION

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FIGURES

TABLES

TABLES (continued)

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1. INTRODUCTION

This part assesses the impacts of construction and operation of proposed spent nuclear fuel (SNF) facilities at the Oak Ridge Reservation (ORR). The ORR is being evaluated for these facilities because of the area available, the apparently suitable site environmental parameters, previous U.S. Department of Energy activities involving radioactive materials at the site, and the planned long-term government control of the site.

This appendix is organized as follows. Chapter 1 is the introduction, Chapter 2 sets the stage for the area under analysis by providing an overview of the ORR and a discussion of the Regulatory Framework and the SNF Management Program, and Chapter 3 explains the SNF alternatives being considered at the site.

Chapter 4 describes the human and natural environment that could be affected as a result of the introduction of an SNF facility at the ORR. Environmental parameters such as water resources, socioeconomics, biological resources, and air quality are examples of those characterized.

Chapter 5 enumerates the environmental consequences that might be anticipated, summarizes the cumulative impacts, describes unavoidable adverse impacts, and describes the irreversible and irretrievable commitment of resources that might be anticipated if an SNF facility were built at the ORR. Chapter 6 contains the references used to develop this part of the environmental impact statement. Chapter 7 contains a list of abbreviations and acronyms used in this part of the environmental impact statement.

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2. OAK RIDGE RESERVATION SITE BACKGROUND

2.1 Overview

2.1.1 Site Description

The Oak Ridge Reservation (ORR) is located on approximately 34,667 acres (140 square kilometers) of federally owned land within the incorporated city limits of Oak Ridge, Tennessee (see Figure 2.1-1). The City of Oak Ridge and the ORR lie between the Cumberland and Southern Appalachian mountain ranges. Knoxville is located approximately 25 miles (40 kilometers) southeast of the ORR and is the largest city in the area. The population varies within the five counties surrounding the ORR. The area around Knoxville is a heavily populated and highly developed urban area, whereas the area surrounding the ORR is sparsely populated, with the exception of the city of Oak Ridge, which is considered to have medium density population. The two main land uses in the five counties surrounding the ORR are forestry and agriculture.

Within the ORR there are three primary complexes: the Y-12 Plant, the K-25 Site (formerly the Oak Ridge Gaseous Diffusion Plant), and the Oak Ridge National Laboratory (ORNL) (see Figure 2.1-2). Currently these facilities are being used for research, development, and production.

The Y-12 Plant is located on the eastern portion of the ORR known as Bear Creek Valley. The Y-12 Plant serves as a key manufacturing technology center for the development and demonstration of unique materials, components, and services of importance to DOE and the nation. This mission is accomplished througb the reclamation and storage of nuclear materials, the manufacture of components to the nation's defense capabilities, support to national security programs, and services provided to other customers as approved by DOE (MMES 1994a).

The K-25 Site is located on the northwestern portion of the ORR. Its mission is to provide a base of operation for the Energy Systems Environmental Restoration and Waste Management programs, thus serving as tbe "platform" for the restoration of the environment and management of DOE wastes through leadership and central management of the Environmental Restoration

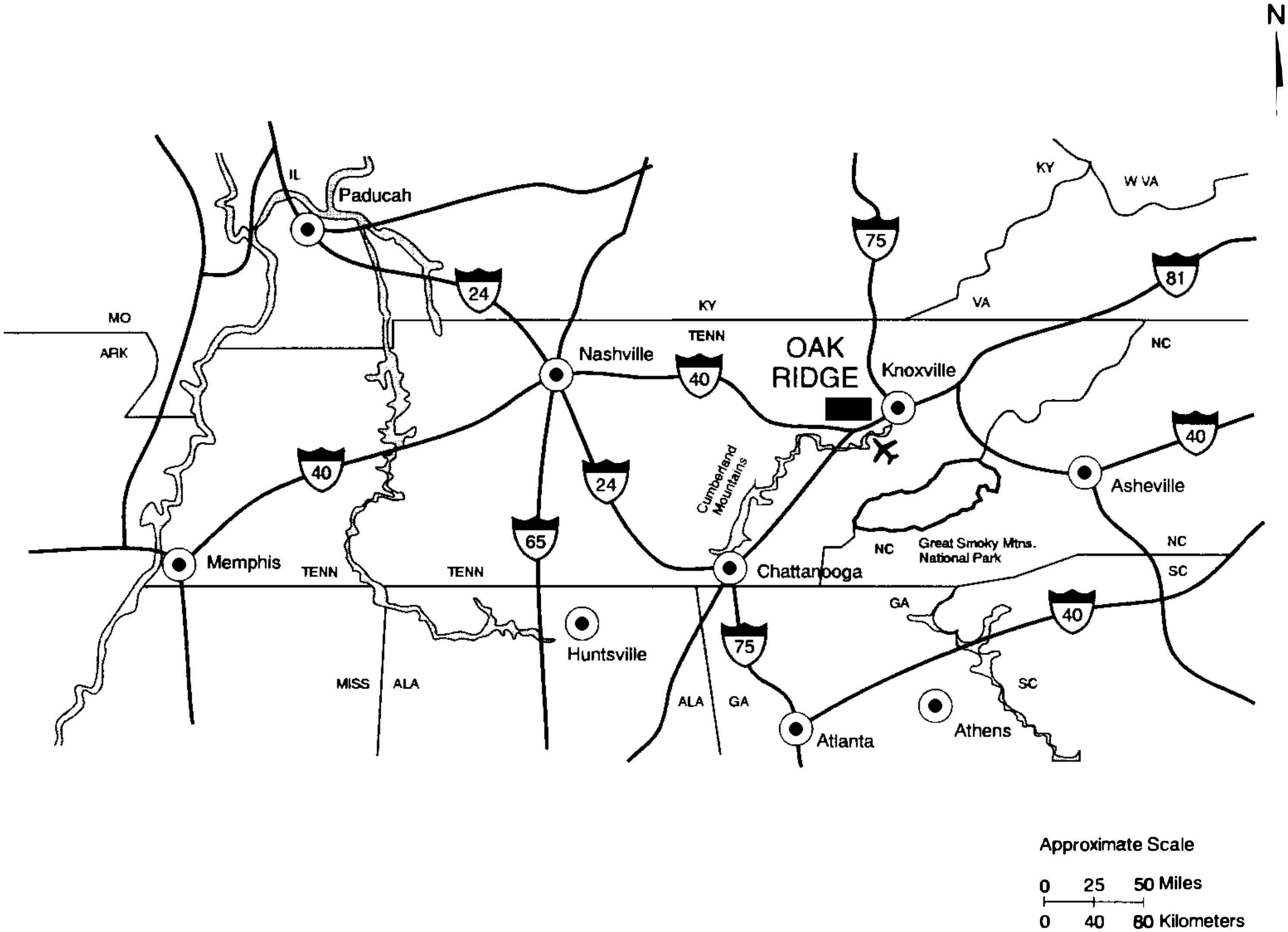


Figure 2.1-1. Oak Ridge Reservation regional map.

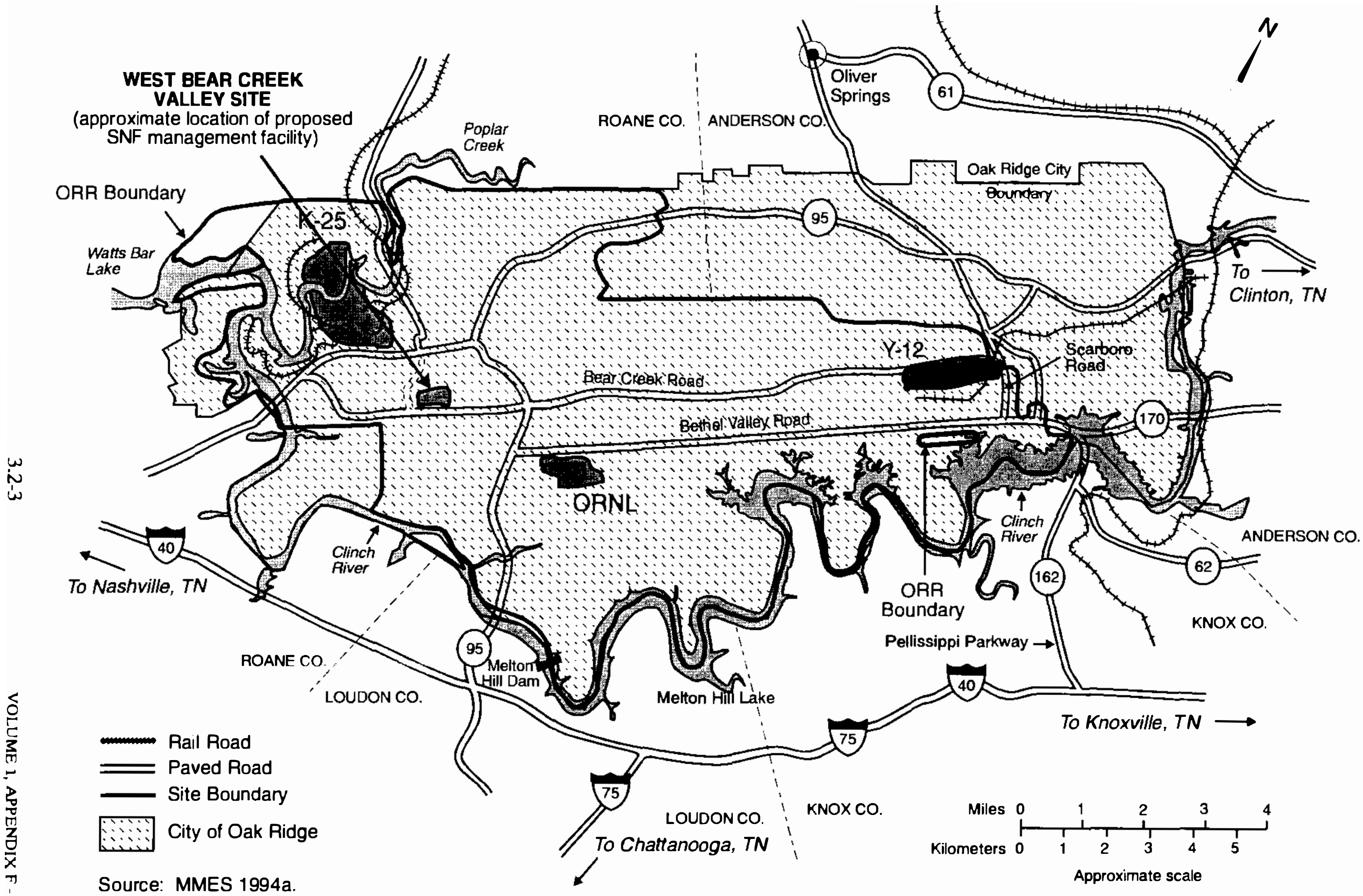


Figure 2.1-2. Oak Ridge Reservation site and transportation.

and Waste Management and Technology Development Programs in support of DOE, sites managed for DOE by Energy Systems, other elements of the Federal Government, and the public. The Toxic Substances Control Act incinerator is managed by and located on the K-25 Site (MMES 1994a).

The ORNL is located in the southern portion of the ORR. The primary mission of ORNL is to perform leading edge research and development in support of nonweapons roles of DOE (MMES 1994a). The ORNL uses test and experimental reactors to perform research and for small-scale radioisotope production activities. The amount of spent nuclear fuel (SNF) generated by these facilities, the amount expected to be generated through the year 2035, and accommodations being undertaken at the present time to store the fuel currently being generated are discussed in the following sections.

The buildings located off the ORR but owned and/or operated by the U.S. Department of Energy (DOE) are 1) the Scarboro Facility, 2) the Central Training Facility, 3) the Transportation Safeguards Division Maintenance Facility, and 4) some ancillary and administrative facilities and structures. The majority of the facilities used by various plant protection and security groups are located within the plant's boundary. Other offsite facilities include the DOE Oak Ridge Operations Office, the DOE Office of Scientific and Technical Information, the Oak Ridge Associated Universities facilities, the American Museum of Science and Energy, the prime contractor's "Townsite" facilities, the National Oceanic and Atmospheric Administration's Atmospheric Turbulence and Diffusion Laboratory, and others. With the exception of the Federal Office Building and space leased from the private sector, all facilities are located on DOE-owned land.

The proposed site of the SNF management facility is located on 100 acres (0.40 square kilometer) of land designated as the West Bear Creek Valley site (see Figure 2.1-2) (La Grone 1994; MMES 1994b). The proposed SNF storage facility will require 90 of the 100 acres (0.36 of the 0.40 square kilometer) set aside for the facility (Johnson, V. 1994).

The proposed SNF management facility is on Bear Creek Road adjacent to the Clinch River on the west end of the ORR. The westernmost boundary of the proposed SNF facility is less than 1 mile (1.6 kilometers) from the ORR boundary. Across Bear Creek Road from the proposed SNF management facility there is a privately owned industrial park (MMES 1994b).

2.1.2 Site History

The ORR was originally purchased in the early 1940s to house the large-scale production of fissionable material for the first nuclear weapon in the world. The original tract of land purchased was 56,833 acres (230 square kilometers). Portions of the original tract were used to build the City of Oak Ridge for the people who constructed and operated the ORR. Residential and business areas of the city were sold, and the ORR has been reduced to its present size.

ORNL began in 1943 as the Clinton Laboratories, a pilot plant for testing and development of the plutonium-239 production and chemical separations processes. Major facilities at the ORNL included the X-10 Graphite Reactor, a chemical pilot plant, and numerous support laboratories and shops. The ORNL's initial mission was fulfilled by 1945, but because of its unique capabilities, new research and development programs were initiated in energy, materials, and environmental technology (DOE 1988).

Since 1945 emphasis at ORNL has been on exploration of the use of nuclear science and technology, which continues as a major component of research and development of the laboratory. A number of additional nuclear reactors and supporting facilities have been built and operated at ORNL since the original mission associated with the Manhattan Project. Research and development in nuclear science and technology is supported currently by one operating research reactor, the High Flux Isotope Reactor. ORNL has proposed the Advanced Neutron Source, which would take over many of the tasks now carried out hy the High Flux Isotope Reactor (Brown 1994a; Hoel 1994).

In 1943 the Y-12 Plant was constructed as part of the Manhattan Project. The Y-12 Plant separated fissionable isotopes of uranium-235 by the electromagnetic process, which was used in the world's first atomic bomb, detonated on August 5, 1945 (MMES 1990; DOE 1987). Since that time Y-12 has developed into a highly sophisticated nuclear weapons component manufacturing and development engineering organization and currently is used for weapons disassembly.

The Oak Ridge Gaseous Diffusion Plant, now the K-25 Site, was used to produce enriched uranium for U.S. nuclear weapons. It also provided an industrial toll enrichment service, in which uranium was enriched for use in nuclear-powered reactors around the world. In 1987, the Oak Ridge Gaseous Diffusion Plant was permanently shut down.

2.1.3 Mission

The missions of the primary plant complexes within ORR are:

- Energy Research and Development at ORNL.

- Reclamation and Storage of Nuclear Material, Manufacturing of Defense Hardware, and National Security, Technology Transfer, and Work for Others Programs at Y-12.

- Environmental Restoration and Waste Management at the K-25 Site (MMES 1994a).

The mission of ORNL includes services that only research reactors provide, including, 1) the production of transuranium isotopes used in basic research, medical, defense, and industrial applications, 2) neutron scattering research to determine fundamental structure and properties of materials, 3) production of unique isotopes for medical treatment and research, 4) production of special commercial isotopes, and 5) irradiation of structural and fuel materials for fusion energy reactors and advanced nuclear reactors (Brown 1994a; Hoel 1994).

2.1.4 Oak Ridge Reservation Operations Management

Martin Marietta Energy Systems, Inc., operates the major facilities at the ORR (Y-12 Plant, K-25 Site, and ORNL). They are under contract to and administered by the DOE Oak Ridge Operations Office. Current missions and functions can be grouped into the following four categories: defense production activities; environmental management activities; other DOE activities; and work for others.

2.2 Regulatory Framework

The National Environmental Policy Act (NEPA) of 1969 (42 USC 4321-4347, as amended) provides Federal agency decision makers with a process to systematically consider the potential environmental consequences of agency decisions. The DOE has prepared this environmental impact statement (EIS) in conformance with the requirements of NEPA to evaluate the potential impacts of programmatic decisions on the management of SNF. This EIS provides the necessary background, data, and analyses to help decision makers understand the potential environmental consequences of each alternative.

On October 22, 1990, the DOE published a Notice of Intent in the *Federal Register* (FR 1990) announcing its intent to prepare a programmatic EIS addressing environmental restoration and waste management (including SNF management) activities across the entire DOE complex. On October 5, 1992, the DOE published a Notice of Intent in the *Federal Register* (FR 1992) announcing its intent to prepare an EIS addressing environmental restoration and waste management and SNF activities at the Idaho National Engineering Laboratory. For further programmatic discussion of this topic, see Volume 1.

Significant state environmental and nuclear materials management laws applicable to the ORR include the following (listed alphabetically):

- Air Pollution Control Regulations (Chapter 1200-3)
- Air Quality Act (Title 68 Chapter 201-101)
- Emergency Rules--Hazardous Substance Remedial Action (Chapter 1200-1-13)
- Emission Standards and Monitoring Requirements for Additional Control Areas (Chapter 1200-3-19)

- Hazardous Substance Site Remedial Action (Chapter 1200-1-13)
- Hazardous Waste Management (Chapter 1200-1-11)
- Licensing Requirements for Land Disposal of Radioactive Waste (Chapter 1200-2-11)
- New Source Performance Standards (Chapter 1200-3-16)
- Prevention of Hazards and Pollution (Chapter 1200-1-6)
- Rules and Regulations Applied to Tennessee Codes Annotated §69-1-1 (Chapter 1200-4-8)
- Solid Waste Processing and Disposal (Chapter 1200-1-7)
- Underground Storage Tank Program (Chapter 1200-1-15)
- Visible Emission Regulations (Chapter 1200-3-5)
- Volatile Organic Compound (Chapter 1200-3-18)

2.3 Spent Nuclear Fuel Management Program

In the past, reactor-irradiated nuclear materials, which include SNF and reactor-irradiated target material, have been stored prior to reprocessing activities to recover plutonium, tritium, and other isotopes. In the past several years, however, the DOE has either phased out or stopped its reprocessing of these materials. With this change, reactor-irradiated nuclear materials were being stored for longer periods of time than originally planned. The amount of reactor-irradiated nuclear materials and the conditions of storage for the materials were in question throughout DOE facilities.

In an effort to assess whether extended storage conditions for reactor-irradiated nuclear materials are safe (i.e., whether protection exists for workers, the public, and the environment), the DOE commissioned a study. This assessment also grouped any vulnerabilities of the storage conditions into three categories where management attention could be directed: less than 1 year, 1 to 5 years, and greater than 5 years. In November 1993, the DOE published the *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*, hereafter referred to as the *Spent Fuel Working Group Report*, as a result of the assessment efforts (DOE 1993b; 1994b).

As a result of the *Spent Fuel Working Group Report*, a *Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities* was also commissioned to address what was discovered in the original Working Group Report. Phase I of the *Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities* was published in February 1994. Phase II and Phase III were issued April 1994 and October 1994, respectively. To address the vulnerabilities identified in the *Spent Fuel Working Group Report*, individual action plans were developed to reflect the DOE's sense of urgency, concern for worker protection, commitment to minimize environmental impacts, and need for compatible long-term solutions.

The ORR was assessed as part of the *Spent Fuel Working Group Report*. SNF located on the ORR is currently stored in facilities at the ORNL. The SNF at ORR is primarily spent fuel from research or experimental reactors that are operating or have operated at ORNL. Samples of SNF left over from research on fuel elements removed from commercial or demonstration reactors utilized by DOE predecessor agencies for advancement of nuclear science are also present. In the past, most of the SNF from the Oak Ridge research and experimental reactors was chemically processed to recover fissile materials at Savannah River Site (Brown, 1994a; Hoel 1994).

This section describes the status of the SNF at the ORR using the information presented in the *Spent Fuel Working Group Report*, the *Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities*, the *Spent Fuel Inventory Data* developed for the SNF EIS, and through discussions with ORR. If fuel can be contact handled, it has not been listed in the Spent Fuel Inventory as

SNF. The SNF management program at ORR utilizes 10 facilities for storage. These facilities and their SNF contents are summarized on Table 2.3-1.

2.3.1 Building 3525 - Irradiated Fuels Examination Laboratory

This two-story brick structure was built in 1963 and contains hot cells. The facility mission continues to be disassembly and examination of irradiated fuel and components. Building 3525 contains 1 unit of research reactor fuel in the form of fuel samples and targets (DOE 1993b; Wichmann 1995a, b).

2.3.2 Building 4501 - High-Level Radiochemical Laboratory

Constructed in 1951, this facility contains centrally located hot cells supported by various laboratories capable of handling radioactive materials. SNF is in dry storage at this facility. Building 4501 contains 0.006 metric tons of heavy metal (MTHM) of DOE-owned commercial fuel (DOE 1993b; Wichmann 1995a, b).

2.3.3 Building 7920 - Radiochemical Engineering Development Center

The Radiochemical Engineering Development Center is a multipurpose hot cell facility with equipment, shielding, and containment provisions to safely process and store significant quantities of highly radioactive targets. This facility was specifically built to prepare and process targets from the High Flux Isotope Reactor. Building 7920 contains 0.024 MTHM of research reactor fuel in the form of fuel samples in dry storage (DOE 1993b; Wichmann 1995a, b).

2.3.4 Dry Storage Facilities 7823A, 7827, and 7829

Now closed to further storage, these shielded, retrievable storage facilities are stainless-steel dry wells placed in the ground in Solid Waste Storage Area 5 North. They vary from 8 to 30 inches (20 to 76 centimeters) in diameter and from 10 to 15 feet (3 to 4.6 meters) in depth. The wells are placed on a concrete pad and are held in place by concrete collars or slabs and are surrounded by dirt. Spent fuel and other materials were placed in the wells beginning in 1972.

Table 2.3-1. Oak Ridge Reservation SNF Storage Facilities.

Facility name	Material stored at facility	Heavy metal mass (MTHM)
High Flux Isotope Reactor (HFIR) Pool	HFIR fuel	0.45
Bulk Shielding Reactor (BSR) Pool	BSR & ORR fuel	0.01
Molten Salt Reactor Experiment (MSRE)	MSRE fuel	0.037
Bldg. 4501	Misc. LWR fuels	0.006
Tower Shielding Reactor (TSR)	TSR fuel	0.0092
Facility 7823A	Misc. fuel	0.0008
Facility 7827	Misc. fuel	0.0837
Facility 7829	Peach Bottom	0.0137
Bldg. 7920	Dresden-1 fuels	0.024
Bldg. 3525	Misc. fuels	
Solid Waste Storage Area 6	KEMA Suspension Test Reactor fuel[a]	0.037

Source: Wichmann (1995a,b)

a. See Section 2.3.5.6.

Facility 7823A contain 0.0008 MTHM; facility 7827 contains 0.0837 MTHM; and facility 7829 contains 0.0137 MTHM. Activities to address the vulnerabilities in these facilities include 1) transferring the fuel, 2) adding a new inner liner and relocating fuel in modified units, and 3) overpacking any fuel in suspect condition. These activities are expected to be completed in fiscal year 1996 (DOE 1994b; 1993b; Wichmann 1995a, b).

2.3.5 Research Reactors

Six existing reactors and one planned reactor are expected to be generating and storing SNF at the ORNL. They are the High Flux Isotope Reactor (currently operating), the Tower Shielding Reactor No. II (shut down in 1992), the Bulk Shielding Reactor (shut down in 1991), the Oak Ridge Research Reactor (shut down in 1987), the Molten Salt Reactor Experiment (shut down in 1969), the KEMA Suspension Test Reactor, and the Advanced Neutron Source Reactor (planned to start up in 2002 or 2003) (ANS 1988).

2.3.5.1 High Flux Isotope Reactor. The High Flux Isotope Reactor is a beryllium-reflected, light water cooled and moderated, flux-trap-type reactor. The reactor uses aluminum-clad fuel plates containing highly enriched uranium-235. The reactor became operational in 1965 and its current power level is 85 megawatts. Reactor missions include production of isotopes for medical and industrial applications, neutron-scattering experiments, and various material irradiation experiments (ANS 1988; DOE 1993b).

The High Flux Isotope Reactor is operating. At the present time there are 62 fuel assemblies amounting to 0.45 MTHM from the research reactor fuel in onsite wet storage. The High Flux Isotope Reactor currently does not use onsite dry storage. If the reactor continues operation through the year 2035, the predicted SNF production will be an additional 110 fuel assemblies totalling 1.58 MTHM. (Holt 1993; ORNL 1992a; Wichmann 1995a, b).

Onsite storage at the reactor facility would have to be expanded to accommodate this projected SNF generation rate. At the present time, reracking the existing storage facility and installing modular dry-storage units at the High Flux Isotope Reactor are being considered. With the installation of the dry-storage units, the potential for future expansion of storage facilities is expected to continue indefinitely (ORNL 1992a).

In the past, SNF assemblies were shipped in casks via truck to the Savannah River Site, and the haseline plan is to continue shipments there. However, the Savannah River Site has limited space and plans to accept only 20 fuel assembly shipments from the High Flux Isotope Reactor. If shipment of SNF to another DOE storage facility is precluded or the commencement of reracking at the High Flux Isotope Reactor is not approved by the DOE, the reactor will be required to shut down because the present pool storage racks cannot accommodate additional fuel after early 1995 (Clark 1994).

2.3.5.2 Tower Shielding Reactor No. II and Tower Shielding Facility Building 7708. The 1 megawatt Tower Shielding Reactor No. II is a light water moderated, movable tank, research reactor which was shut down in 1992. There are no plans for resuming operations at this time. Tower Shielding Reactor No. II has no containment and was used at ground level or suspended from towers. The research included testing shielding designs and obtaining associated data (ANS 1988; DOE 1993b).

The Tower Shielding Reactor No. II was placed in standby in September 1992 pending DOE direction to prepare the facility for shutdown. At that time, the only existing Tower Shielding Reactor No. II fuel assembly was being stored in the reactor core. For handling and storage purposes, an element is an integral core assembly composed of 4 upper central plates, 4 lower central plates, 12 annular plates, a central plug, and 4 fuel plates. One element, 0.0092 MTHM, is being stored in the reactor core. The corrective actions associated with the vulnerabilities identified in the *Spent Fuel Working Group Report* for the Tower Shielding Reactor No. II and Tower Shielding Facility Building 7708 are: 1) implement access control to the Tower Shielding Reactor No. II area; 2) implement emergency operating procedures for the Tower Shielding Reactor, i.e., those applicable to a seismic event requiring the experimental area to be checked for hazards by knowledgeable staff before personnel enter the area; 3) implement radiation protection controls requiring that a survey be completed by Radiation Protection personnel to verify acceptable radiation levels prior to granting access to a radiological area; and 4) remove the fork-lift from Building 7708 to eliminate a potential fire hazard and transfer the fuel pins to the Y-12 area for long-term storage to eliminate the potential of an activity release in the same building (completed January 1994). All of these corrective actions plans have been completed and are being implemented (Holt 1993; ORNL 1994; DOE 1994b; Wichmann 1995a, b).

Present options being discussed for storage of this fuel include shipment to the Savannah River Site or onsite dry storage at ORNL. Because this reactor is shut down, no additional elements are expected to accumulate through the year 2035 (Holt 1993; ORNL 1994).

2.3.5.3 Bulk Shielding Reactor. The 2 megawatt Bulk Shielding Reactor is an open pool, light water moderated and reflected, training and research reactor. This reactor was built in 1951 and shut down in 1991; there are no plans for resumption of operations at this time (ANS 1988; DOE/OSTI 1993; DOE 1993b).

The Bulk Shielding Reactor is shut down and currently has no elements in the reactor or in on-site dry storage. Seventy-three of 90 storage locations are occupied in the onsite wet storage. There are 41 elements from the Bulk Shielding Reactor and 32 elements from the Oak Ridge Research Reactor for a total of 0.010 MTHM in the storage area. As the reactor is shut down, no additional fuel is expected to be added to the inventory through the year 2035; therefore, no expansion of storage facilities onsite is expected (DOE 1993b; Wichmann 1995a, b).

2.3.5.4 Oak Ridge Research Reactor. The Oak Ridge Research Reactor was shut down permanently in 1987 and has been defueled. Most of the fuel was transported to the Savannah River Site, but some of the fuel was transferred to the Bulk Shielding Reactor pool. Refer to the discussion of the spent fuel inventory in subsection 2.3.5.3 (Holt 1993; ANS 1988; ORNL 1992b).

2.3.5.5 Molten Salt Reactor Experiment. The Molten Salt Reactor Experiment operated from June 1965 to December 1969 at a nominal power level of 8 megawatts. The purpose of the reactor was to test the practicality of a molten-salt reactor concept for central power station applications. The circulating fuel solution was a mixture of fluoride salts containing uranium fluoride as the fuel. The initial charge was uranium-235, but this was later replaced with a charge of uranium-233. Processing capabilities were included as part of the facility for on-line fuel additions, removal of impurities, and uranium recovery. Following reactor shutdown, the fuel and flush salts were drained to critically safe storage tanks and isolated (Hargrove 1993).

The inventory at the Molten Salt Reactor Experiment consists of approximately 4,650 kilograms (9,514 pounds) of fuels salt mixture. The uranium salt is predominantly uranium-233 (31 kilograms [68 pounds]) with lesser amounts of uranium-234, uranium-235, and uranium-238. The balance of the fuel salt is composed of lithium fluoride (LiF, 64.5 percent), beryllium fluoride (BeF_2, 30.3 percent), and zirconium fluoride (ZrF_4, 5.0 percent). The Molten Salt Experiment contains 0.037 MTHM as the reactor is shutdown, no additional SNF is expected to be generated through the year 2035 (DOE 1993b; Hargrove 1993; Wichmann 1995a, b).

Radioactive material migration has been detected from the storage tanks. This vulnerability could result in unnecessary personnel exposure. If left unabated, radiation levels could increase to a point where access would be difficult. ORNL is determining appropriate corrective actions and expects to implement its corrective action plan during fiscal year 1995 (DOE 1994b; 1993b).

2.3.5.6 KEMA Suspension Test Reactor. The KEMA Suspension Test Reactor was an experimental fluidized bed test reactor. The fuel, consisting of one core, was placed in Solid Waste Storage Area 6 and totals 0.037 MTHM. The area of Solid Waste Storage Area 6 where the fuel was placed is being managed by DOE as part of waste area grouping 6, an environmental restoration program activity, under the Comprehensive Environmental Response, Compensation, and Liability Act. As the reactor is shutdown, no additional SNF is expected to be generated through the year 2035 (Wichmann 1995a, b).

2.3.5.7 Advanced Neutron Source Reactor. The Advanced Neutron Source Reactor is currently in the conceptual design stage and has been proposed to be operational in the year 2002 or 2003. Its principal purpose will be for neutron beam experiments, but it will also be used for some isotope production (Holt 1993; DOE/OSTI 1993).

Since the current schedule projects initial operation of the Advanced Neutron Source Reactor in the year 2002 or 2003, spent fuel is not expected to be generated until 2004. Estimates are that 18 elements per year will be discharged. (For handling and storage purposes, an element is an integral core assembly composed of two concentric fuel plates.) A total of 576 SNF elements are predicted to be produced if the reactor is in operation from the years 2002 through 2035 (Holt 1993). As this reactor is in the conceptual design stage, the SNF expected to be generated is not included in the SNF Inventory Data.

3. SPENT NUCLEAR FUEL ALTERNATIVES

This chapter describes the spent nuclear fuel (SNF) management alternatives evaluated by the U.S. Department of Energy (DOE) for this Programmatic Environmental Impact Statement (EIS) that are applicable to the Oak Ridge Reservation (ORR). The ORR generates and stores SNF as a result of reactor research activities. Unlike the Hanford Site, the Idaho National Engineering Laboratory (INEL), and the Savannah River Site (SRS), SNF management is only a minor part of the ORR mission. Therefore, the No Action, Decentralization, and 1992/1993 Planning Basis alternatives could have minimal to no impact on ORR operations. However, the Regionalization and Centralization Alternatives would produce major impacts on ORR operations.

3.1 Description of Management Alternatives

3.1.1 Alternative 1 - No Action

The No-Action Alternative is restricted to the minimum actions necessary for the continued safe and secure management of SNF. As defined, this alternative stipulates no SNF shipments to or from DOE facilities. While the ORR generates and stores SNF as a result of reactor research activities, it does not receive SNF from offsite generators except occasionally in small quantities for specific research assignments. No offsite SNF would be shipped to the ORR under this alternative, nor would SNF be shipped offsite, which could affect the planned shipment of High Flux Isotope Reactor assemblies to the SRS. SNF storage capacity at the ORR for the existing High Flux Isotope Reactor would be adequate only through the year 2002. This could result in the shutdown of this reactor after this date. The proposed Advanced Neutron Source Reactor would need to consider this situation in the design and operation activities.

The environmental effects of the No-Action Alternative are essentially the same as those of current onsite SNF storage and are included in the affected environment discussions covering current site operations.

Implementation of the No-Action Alternative at ORR could lead to the shutdown of the High Flux Isotope Reactor as a result of filling the SNF storage capacity. If the High Flux Isotope Reactor were shutdown, it would eliminate the national capacity to provide transuranic isotopes, eliminate the only western-world source of some medical isotopes, and eliminate the nationally and internationally important capability for research and development in the structure of materials and irradiation effects on materials (Brown 1994a; Hoel 1994).

This alternative for the ORR is not analyzed or discussed further in this or subsequent chapters except in the Facility Accidents section, 5.15.

3.1.2 Alternative 2 - Decentralization

Decentralization involves storage of SNF at or close to generation sites. Under this alternative no offsite SNF would be shipped to the ORR nor would SNF be shipped offsite. The environmental effects of this alternative are the same as those of the No-Action Alternative. The environmental effects of current onsite SNF storage are included in the affected environment discussions covering current site operations. Consequently, this alternative is not analyzed or discussed further in this or subsequent chapters for the ORR. Construction of new SNF storage facilities could be initiated under this option.

The Decentralization Alternative would allow DOE to upgrade and/or replace facilities for the management of the SNF currently located on site. This alternative would allow for continued operation of the High Flux Isotope Reactor by allowing new dry-storage facilities for newly generated and existing SNF in the High Flux Isotope Reactor pool. To allow the High Flux Isotope Reactor to continue operations until a dry storage facility is available, a dry-storage cask may be acquired. DOE could propose an interim, retrievable, aboveground, dry-storage facility for consolidating the SNF at ORR. DOE could also prepare facilities as necessary for the characterization and packaging of SNF for interim storage. The fuel in the Molten Salt Reactor Experiment reactor would need conditioning and stabilization before being relocated to the new facility, or the Molten Salt Reactor Experiment fuel would need special storage facilities (Brown 1994a; Hoel 1994).

3.1.3 Alternative 3 - 1992/1993 Planning Basis

The 1992/1993 Planning Basis Alternative is DOE's documented 1992/1993 plan for the management of DOE and Naval SNF. This plan would include the shipment of SNF from the ORR to other DOE sites as necessary to permit continued operation of ORR research reactors. The environmental effects of current onsite SNF storage are included in the affected environment discussions covering current site operations. Under this alternative, the amount of SNF storage at ORR would not increase. Therefore, this alternative would not have a measurable impact on the environment since there would be no changes to current ORR operations. Consequently, this alternative is not analyzed or discussed further in this or subsequent chapters for the ORR.

At ORR, this alternative would be very similar to the Decentralization alternative except that some SNF would be shipped to SRS. The SNF currently stored at the High Flux Isotope Reactor and Bulk Shielding Reactor pools, and at the Tower Shielding Reactor would be shipped to SRS. Only 20 elements from the High Flux Isotope Reactor can be shipped to SRS unless other arrangements can he made. If the quantity of High Flux Isotope Reactor fuel that can be shipped to SRS is limited to 20 elements, then the High Flux Isotope Reactor will require dry-storage facilities to continue operation. DOE could prepare an interim, retrievable, aboveground, dry-storage facility for consolidating the SNF remaining at ORR. This facility would be similar to the one built under Alternative 2 except it would probahly be smaller (Brown 1994a; Hoel 1994).

3.1.4 Alternative 4 - Regionalization

3.1.4.1 Overview. The Regionalization Alternative consists of two subalternatives. Subalternative A would distribute existing and new SNF between the Hanford Site, INEL, and SRS by SNF type. Under Subalternative B, SNF would be distributed to either an eastern or western regional site based on geographical location. SNF east of the Mississippi River would be shipped to the eastern regional site (i.e., SRS or ORR). SNF west of the Mississippi River would be shipped to the western regional site (i.e., Hanford Site, INEL, or Nevada Test Site [NTS]). Additionally all Naval SNF would be shipped to only one of the regional sites, but not both. A regional site will only receive all the Naval fuel if also selected as the Naval site. The ORR would be the alternative to the SRS as the eastern regional site, and the NTS would be the alternative to both the Hanford Site and INEL as the western regional site.

3.1.4.2 Regionalization Subalternative B. The following fuels would be transported to the ORR for storage under the Regionalization Subalternative B:

- Naval-type SNF (if selected)
  - All, including from the INEL, shipyards, and prototypes
- Hanford Production SNF
  - From eastern sites
- Graphite SNF
  - From eastern sites
- DOE-owned commercial SNF
  - From eastern sites, including the West Valley Demonstration Project and B&W Lynchburg
- Experimental - Stainless Steel SNF
  - From eastern sites, including the Foreign Research Reactors, and non-DOE domestic research reactors
- Experimental - Zirconium SNF
  - From eastern sites, including the SRS
- Experimental - Other
  - From eastern sites
- SRS Production and Aluminum SNF
  - From eastern sites, including SRS, Brookhaven National Laboratory, Foreign Research Reactors, and non-DOE domestic research reactors.

All SNF presently in storage at DOE facilities would arrive at the ORR stabilized and canned to the extent necessary for safe transportation. However, this SNF may need to be uncanned, stabilized, prepared, and recanned at the ORR to ensure safe interim storage. New non-DOE domestic and Foreign Research Reactor SNF would arrive in a state necessary for safe transportation but uncanned. This fuel would be stabilized, prepared, and canned at the ORR to ensure safe interim storage. All fuel would be cooled for a minimum of 120 days prior to shipping and 5 years before being placed in dry storage.

The ORR currently has only limited-capacity facilities suitable for receiving, canning, storing, or supporting the research activities necessary for the safe management of SNF. As a result, a new SNF management complex would be built at the ORR under the Regionalization Subalternative B. The SNF management complex would include the following:

- SNF receiving and canning facility
- Technology development facility
- Interim dry storage area
- Expended Core Facility similar to the one currently at the INEL (if selected for Naval fuel receipt).

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 technology development facility would 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. If ORR is selected for Naval fuel receipt, Naval SNF would be examined at the Expended Core Facility prior to being turned over for interim storage management.

The SNF management complex which would be built at the ORR under the Regionalization Alternative would have the same components as that built under the Centralization Alternative. The dry storage component would be smaller, however, due to the smaller SNF inventory that would be transported to the ORR under the Regionalization Alternative. The other components of the SNF management complex would be the same general size as those built under the Centralization Alternative. This is because the inventories of new uncanned fuel which would be sent to the ORR under the Regionalization and Centralization Alternatives would be very similar. Additionally, since the major portion of the potential radiological and chemical releases and waste generation rates are associated with these components, the Regionalization Alternative is not analyzed separately but is compared to the Centralization Alternative in a semiquantitative manner.

If the ORR was not chosen as the eastern regional site, all SNF at the ORR would be shipped to the SRS. An exception would be those fuels for which there is no available technology for stabilization to permit safe transport. There is a small quantity of SNF from the Molten Salt Reactor Experiment that is stored in tanks at the ORR. Currently, technology to stabilize this SNF for transport does not exist. Under this alternative, if ORR were to ship SNF to the SRS, this Molten Salt Reactor Experiment SNF would continue to be stored at the ORR until it could be stabilized for safe shipment.

Based on the projected schedule for operation of additional regional SNF storage facilities, the option for acquiring dry storage facilities at the ORR would be maintained to ensure continued High Flux Isotope Reactor operation (Brown 1994a; Hoel 1994).

3.1.5 Alternative 5 - Centralization

3.1.5.1 Overview. Under the Centralization Alternative, all existing and new SNF would be shipped to one DOE site. There are five Centralization options considered in this EIS: the Hanford Site, the INEL, the SRS, the NTS, and the ORR. If the ORR was chosen as the centralization site, all SNF stored at the Hanford Site, INEL, SRS, and other sites currently storing DOE fuel would be transferred to the ORR.

3.1.5.2 Centralization Alternative Option D. The following fuels would be transported to the ORR for storage under Centralization Alternative Option D:

- Naval-type SNF
  - From the INEL, shipyards, and prototypes
- Hanford Production SNF
  - From the Hanford Site
- Graphite SNF
  - From the INEL and the Public Service of Colorado

- DOE-owned commercial SNF
  - From the Hanford Site, INEL, West Valley Demonstration Project, and B&W Lynchburg
- Experimental - Stainless Steel SNF
  - From the Hanford Site, INEL, SRS, Foreign Research Reactors, and non-DOE domestic research reactors
- Experimental - Zirconium Clad SNF
  - From the INEL and SRS
- Experimental - Other
  - From the ORNL
- SRS Production and Aluminum Clad SNF
  - From the INEL, SRS, ORNL, Los Alamos National Laboratory, Brookhaven National Laboratory, Foreign Research Reactors, and non-DOE domestic research reactors.

All SNF presently in storage at DOE facilities would arrive at the ORR stabilized and canned to the extent necessary for safe transportation. However, this SNF may need to be uncanned, stabilized, prepared, and recanned at the ORR 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 ORR to ensure safe interim storage. All fuel would be cooled a minimum of 120 days prior to shipping and 5 years before being placed into dry storage. Additionally, Naval SNF would be examined at the ORR before it was turned over for interim storage management.

Although the ORR has a number of experimental and pilot facilities, probably none of them is suitable for receiving, canning, storing, or supporting research activities necessary for the safe management of SNF, unless they are extensively upgraded and expanded. As a result, a new SNF management complex would be built at the ORR under the Centralization Alternative Option D. The SNF management complex would include the following:

- SNF receiving and canning facility
- Technology development facility

- Interim dry storage area
- Expended Core Facility for Naval-type fuel similar to the one currently at the INEL.

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 technology development facility would 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 SNF would be examined at a new Expended Core Facility constructed at the ORR prior to being turned over for interim storage management.

The SNF management complex which would be built at the ORR under the Centralization Alternative would have the same components as that built under the Regionalization Alternative. However, the dry storage component would be about 10 times larger, due to the larger SNF inventory that would be transported to the ORR under the Centralization Alternative. The other components of the SNF management complex would be the same general size as those built under the Regionalization Alternative. This is because the inventories of new uncanned fuel which would be sent to the ORR under the Centralization and Regionalization Alternatives would be very similar. Additionally, the major portion of the potential radiological and chemical releases and waste generation rates are associated with these components and would not be significantly different for the Regionalization Alternative. Therefore, this alternative is used as the basis for a semiquantitative comparison with the Regionalization Alternative.

If the ORR is not chosen as the centralization site, all SNF at the ORR would be shipped to the selected centralization site. An exception would be those fuels for which there is no available technology for stabilization to permit safe transport. There is a small quantity of SNF from the Molten Salt Reactor Experiment that is stored in tanks at the ORR. Currently, technology to stabilize this SNF for transport does not exist. Under this alternative, if ORR were to ship SNF to the SRS, this Molten Salt Reactor Experiment SNF would continue to be stored at the ORR until it could be stabilized for safe shipment.

Based on the projected schedule for operation of additional centralized SNF storage facilities, the option for acquiring dry storage facilities at the ORR would be maintained to ensure storage facilities at the ORR would be maintained to ensure continued High Flux Isotope Reactor operation (Brown 1994a; Hoel 1994).

3.2 Comparison of Alternatives

Table 3.2-1 shows a comparison of the alternatives. The Regionalization Alternative column does not include the requirements of the Naval Expended Core Facility, although this facility may be constructed at the site under this alternative. The Centralization Alternative column does include the requirements of the Naval Expended Core Facility, which are presented in Volume 1, Appendix D, since this facility will be built at the site under this alternative.

Table 3.2-1. Comparison of alternatives at the Oak Ridge Reservation.

Parameter	Regionalization Subalternative B at ORR	Centralization Option D[a]
Land for new facilities (acres)	90	120
Site area (acres)	34,667	34,667
Percent of site area	0.26	0.35
SNF-related employment[b]	556	1,118
Baseline site employment	17,082	17,082
Percent of baseline site employment	3.3	6.5
Estimated maximum latent cancer fatalities in 80-km population per year, SNF management operations[c]	2.5×10^{-3}	2.5×10^{-3}
Estimated cancer fatalities in 80-km population per year, other site operations	2.7×10^{-2}	2.7×10^{-2}
Estimated probability of cancer fatalities in MEI per year, SNF management operations[c]	3.1×10^{-6}	3.1×10^{-6}
Estimated probability of cancer fatalities in MEI per year, other site operations	9.2×10^{-6}	9.2×10^{-6}
Estimated probability of cancer fatality in average worker per year, SNF management operations[c]	1.6×10^{-5}	1.6×10^{-5}
Estimated probability of cancer fatality in average worker per year, other site operations	1.1×10^{-6}	1.1×10^{-6}
Water use (million gallons) per year, SNF management	3.6	6.1
Baseline water use (million gallons) per year, site operations	6,680	6,680
Percent of baseline site water use	0.05	0.09
Electricity use (megawatt-hours) per year, SNF management	23,000	33,000

Table 3.2-1. (continued).

Parameter	Regionalization Subalternative B at ORR	Centralization Option D[a]
Baseline electricity use (megawatt-hours) per year, site operations	1,000,000	1,000,000
Percent of baseline site electricity use	2.30	3.30
Sewage discharge (million gallons) per year, SNF management	3.6	6.1
Baseline sewage discharge (million gallons) per year, site operations	200	200
Percent of baseline site sewage discharge	1.8	3.1
High-level waste (cubic meters) per year, SNF management	0	0
Transuranic waste (cubic meters), SNF management	16	16
Mixed waste (cubic meters), SNF management	0	0
Low-level waste (cubic meters), SNF management	203	628
Estimated maximum cancer fatalities in 80-km population from maximum risk accident[d]	2.1×10^{-2}	
Frequency of occurrence (number per year)[d]	1.6×10^{-1}	
Estimated maximum risk of cancer fatalities in 80-km population from maximum risk accident (cancer fatalities per year)[d]	3.4×10^{-3}	
Estimated maximum worker cancer fatalities from maximum risk accident[d]	1.9×10^{-3}	
Frequency of occurrence (number per year)[d]	1.0×10^{-4}	
Estimated maximum risk of worker cancer fatalities from maximum risk accident (latent cancer fatalities per year)[d]	1.9×10^{-7}	

a. Centralization Option includes the Naval Expended Core Facility (ECF) results from Volume 1, Appendix D. Centralization without ECF would be the same as for Regionalization.

b. Annual average SNF direct construction and operation jobs over the 10-year period 1995 to 2005.

c. Excludes baseline site operations.

d. Centralization Option is the same as the Regionalization Option for the SNF Management Facility and does not include the Naval Expended Core Facility accident analyses results from Volume 1, Appendix D.

4.0 AFFECTED ENVIRONMENT

4.1 Overview

This chapter describes the existing environmental conditions in areas potentially affected by a programmatic decision to site spent nuclear fuel (SNF) facilities at the Oak Ridge Reservation (ORR) under the Centralization and Regionalization alternatives. Topics were selected for analysis based upon their potential to be affected by these alternatives. Each topic is addressed in the detail necessary to serve as a baseline for assessment of potential environmental consequences in Chapter 5.

4.2 Land Use

The ORR occupies an area of approximately 34,667 acres (140 square kilometers) in eastern Tennessee, in a predominantly rural area about 25 miles (40 kilometers) west of Knoxville. The ORR, which is bordered on the southeast and southwest by the Clinch River, is within the jurisdictional boundaries of the City of Oak Ridge, and also lies within Roane and Anderson Counties (MMES 1989).

The ORR consists of three plants located on three separate sites: the Y-12 Plant (1.3 square miles or 3.4 square kilometers); the Oak Ridge National Laboratory (ORNL) (1.8 square miles or 4.7 square kilometers); and the K-25 Site (1.1 square miles or 2.8 square kilometers) (MMES 1989).

Land use activities at the ORR have historically occurred within the boundaries of the three main plant sites. However, more recently, other ORR lands have also begun to be used. ORR land was first utilized for waste storage in the mid-1940s and for environmental research in the 1950s. A forestry management program was initiated in 1964, and the first comprehensive forest management program was released in 1965. The ORR has been used by research institutions, universities, and government agencies as a site for the study of terrestrial ecology, aquatic ecology, forestry, and agriculture. In 1980, Department of Energy (DOE) designated approximately 21 square miles (54 square kilometers) of undeveloped ORR land as a National

Environmental Research Park, which today provides protected land areas for research and education in the environmental sciences (MMES 1989).

Land use outside the three main plant sites falls into seven general categories: multi-purpose research and development; support services; waste management; environmental restoration; natural areas; public recreational park; and national environmental research park (Figure 4.2-1). Approximately 58 percent of the land on the ORR (20,051 acres or 31 square miles) can be classified as undeveloped due to its current land use designation (MMES 1994a).

Land uses bordering the ORR are primarily forest and agricultural. Residential and commercial are the only other significant uses of land in the vicinity, and occur along the northeast and northwest boundary of the ORR in the City of Oak Ridge. The land areas bordering the ORR comprise woodlands (mostly hardwood forests), small farms, and rural residences. Commercial forestry and agriculture account for approximately 76 percent of the total land use in this region (MMES 1994a).

The entire ORR has been placed under the forestry, agriculture, industry, and research zoning classification by the City of Oak Ridge, although this designation does not bind DOE land use decisions on the site. DOE land use plans applicable to the ORR include the *Oak Ridge Reservation Site Development and Facilities Utilization Plan*, issued in 1989 and updated in 1990; the *City of Oak Ridge Comprehensive Plan and Zoning Ordinance*, issued in 1985 and updated in 1988; and the *Resource Management Plan for the U.S. DOE Oak Ridge Reservation*, first issued in 1984.

The region surrounding the ORR has numerous local, state, and national public recreation areas (Figure 4.2-2). Federal outdoor recreation facilities include the Great Smoky Mountains National Park; the Cherokee National Forest; the Cumberland Gap National Historic Park; the Big South Fork National River and Recreation Area; and the Obed Wild and Scenic River (MMES 1994a). State parks near the ORR site include the Frozen Head State Natural Area; the Big Ridge State Park; the Cove Lake State Park; the Fall Creek Falls State Park; the Pickett State Rustic Park; the Panther Creek State Park; and the Hiwassee State Scenic River (MMES 1994a).

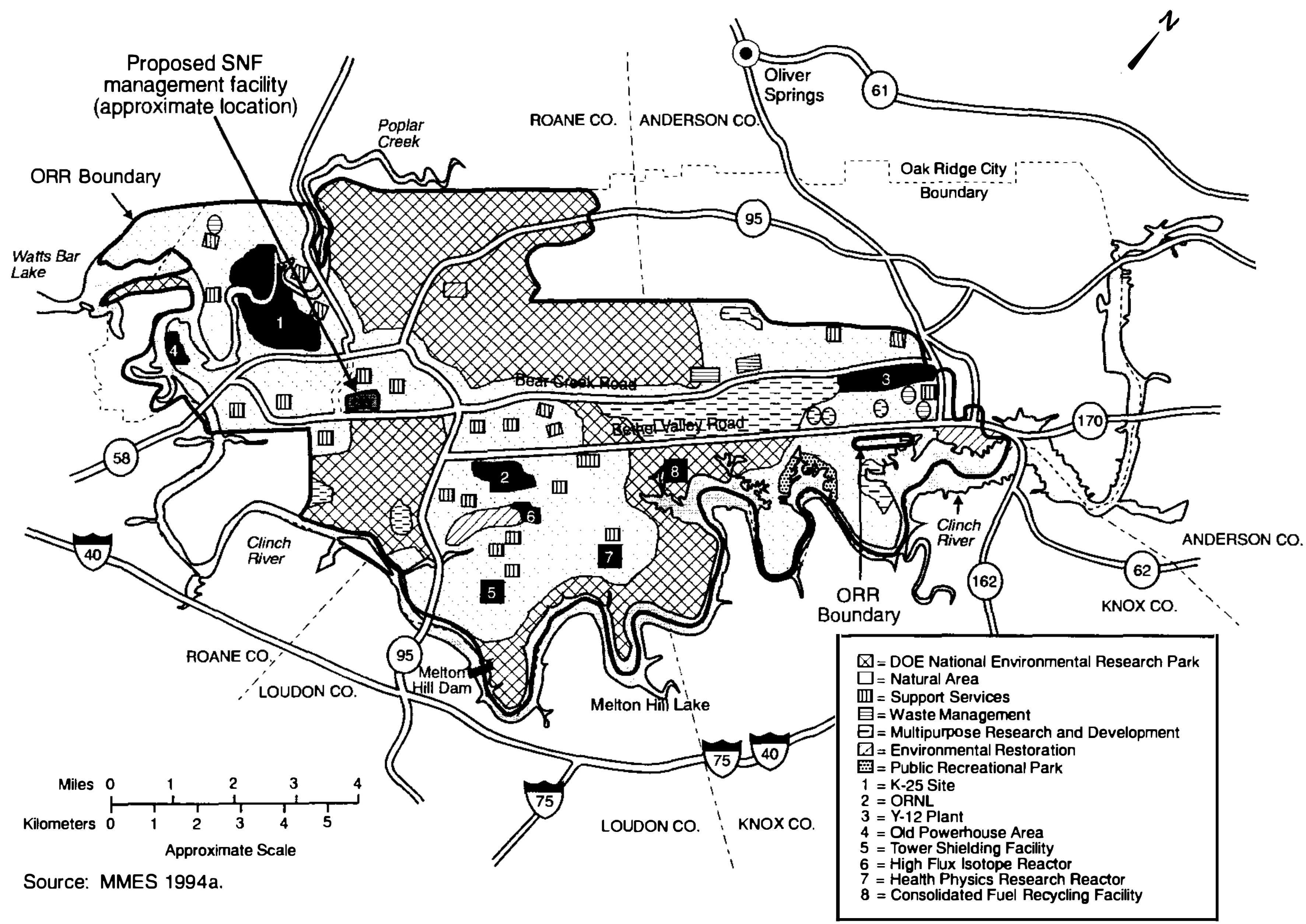


Figure 4.2-1. Generalized land use at the Oak Ridge Reservation.

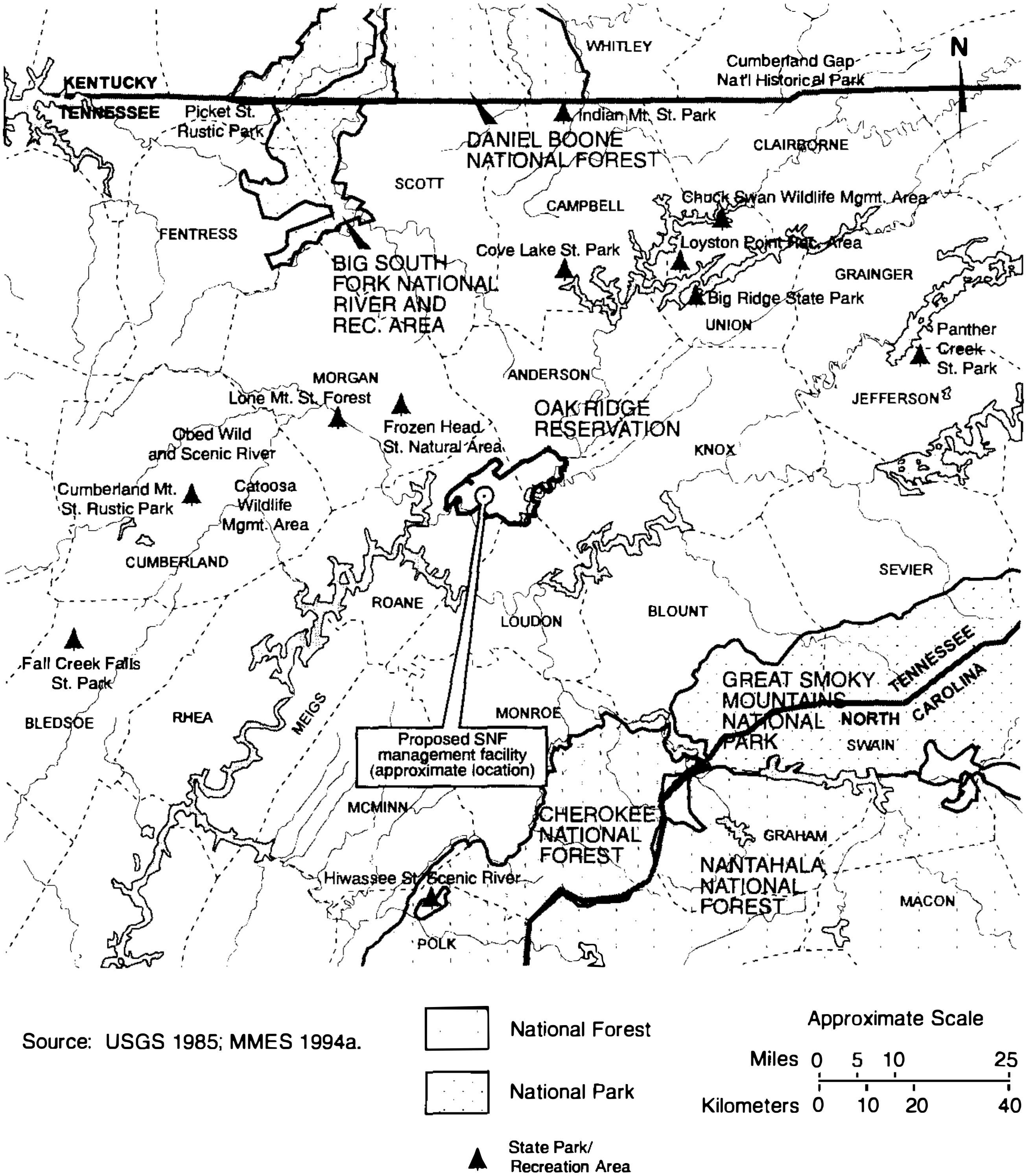


Figure 4.2-2. Recreation areas in the vicinity of the Oak Ridge Reservation.

Several lakes exist within the ORR surrounding region, offering year-round recreational activities such as fishing and boating. Wildlife management areas that allow in-season hunting include the Big South Fork National River and Recreation Area, Catoosa Wildlife Management Area, Chuck Swan Wildlife Management Area, and the ORR (MMES 1994a).

Numerous locally funded recreational areas exist near the ORR, the closest being in the City of Oak Ridge. The City of Oak Ridge has 2 golf courses, 11 athletic fields, 36 tennis courts, 12 playground areas, and a public outdoor swimming pool (MMES 1994a).

Clark Center Recreational Park, located on the ORR, is a 90-acre (0.36-square-kilometer) recreational area that is open to the public. The park consists of three shelters, a boat ramp, two softball fields, a swimming area, and a paved access road. It is located approximately 2 miles (3.2 kilometers) south of the Y-12 Plant (MMES 1994a).

The ORR is a controlled area with public access limited to through traffic on Tennessee State Routes 95, 58, 62, 162, and 170 (MMES 1991b).

The site proposed for SNF activities is located within the West Bear Creek Valley Area, located in the western portion of the ORR site near the site boundary. This area of the ORR is currently in the Natural Areas land use category and is designated for future Waste Management land use (MMES 1994a). The area is designated as a Potential Site for a Future Programmatic Initiative in the most recent ORR Master Plan (MMES 1994a). With the exception of an industrial park, land uses bordering the ORR in the area of West Bear Creek Valley are primarily agricultural farmland and commercial forest, with sparsely located residences (MMES 1994a).

The industrial park located just to the south of the proposed SNF management facility on Bear Creek Road houses two organizations. The Scientific Ecology Group, Inc., employs about 700 to 800 people and is a low-level radioactive waste incinerator who's commercial operation began in 1989. International Technology, Inc., operates a hazardous and radioactive waste geotechnical laboratory and a pilot lab, also on Bear Creek Road. This International

Technology, Inc., operates a hazardous and radioactive waste geotechnical laboratory and a pilot lab, also on Bear Creek Road. This International Technology, Inc., facility is an extension of the Knoxville office and employs about 10 people at the facility (IT undated a, undated b; SEG undated).

There are no onsite areas that are subject to Native American Treaty rights or contain any prime or unique farmland.

4.3 Socioeconomics

4.3.1 Region of Influence

The socioeconomic information presented in this Programmatic Environmental Impact Statement covers the baseline conditions in the Region of Influence. The Region of Influence is defined as the region in which the principal direct and indirect socioeconomic effects of actions at the ORR are likely to occur and are expected to be of consequence for local jurisdictions. The Region of Influence includes the current residential distribution of the DOE and contractor personnel employed by the ORR, the probable location of offsite contractor operations, and the probable location of labor and capital supporting indirect economic activity linked to the ORR. The Region of Influence includes the counties where 92 percent of DOE and contractor personnel employed by ORR reside. The Region of Influence includes the counties of Anderson, where 34 percent of ORR personnel reside, Knox (36 percent), Roane (16 percent), and Loudon (6 percent) (Truex 1991 [Table J]).

4.3.2 Regional Economic Activity and Population

Regional economic linkage supporting production activity at the ORR occurs primarily with Anderson, Knox, and Roane counties, where most of the supporting contractors offsite and labor and capital supporting indirect economic activity linked to the ORR are located.

4.3.2.1 Anderson County. Most of the industrial and commercial development, dominated by energy-related companies specializing in manufacturing and research and development in support of the ORR, has occurred in the City of Oak Ridge in Anderson County and Roane County.

The major employment sectors in Anderson County in 1990 were services, manufacturing, government, and retail trade. As a percentage of Anderson County wage and salary employment, the service and manufacturing sector each accounted for 30 percent, the government sector 13 percent, and retail trade 11 percent. The number of employed persons in Anderson County in 1990 was 39,596. Jobs in Anderson County have increased 3 percent annually between 1980 and 1990, and are projected to continue to increase at an average rate of less than 1 percent annually for the next several years (U.S. Department of Commerce 1993). Since 1988, the unemployment level for Anderson County has remained below the national unemployment rate. The unemployment rate reached a low of 4.4 percent in 1990 and has slowly increased to 5.6 percent in 1992 (Anderson County 1993; Department of Economic and Community Development Industrial Development Division 1993).

Approximately 40 percent of the Anderson County population resides in the City of Oak Ridge, with an additional 42 percent in rural areas, and the remaining 18 percent in other municipalities in Anderson County (Anderson County 1993). Between 1980 and 1990, the population in Anderson County increased by over 1 percent from 67,500 to 68,250 persons (0.10 percent annually). The population in Anderson County is projected to continue to grow at an average rate of less than 1 percent annually over the next several years, reaching 76,100 persons by 2004 (U.S. Department of Commerce 1993).

4.3.2.2 Knox County. In Knox County, the major employment sectors in 1990 were service, manufacturing, retail trade, and government. As a percentage of Knox County wage and salary employment, the service sector accounted for approximately 27 percent, retail trade 20 percent, manufacturing 12 percent, and government 17 percent. The total number of persons employed in Knox County in 1990 was 215,948. Jobs have increased 2 percent annually between 1980 and 1990, and are projected to continue to grow at an average rate of less than 1 percent annually for the next several years (U.S. Department of Commerce 1993). The unemployment rate for Knox County was 4.6 percent in 1992 (Department of Economic and Community Development Industrial Development Division 1992).

Between 1980 and 1990, the population in Knox County increased 5 percent from 319,700 to 335,750. The population in Knox County is projected to continue to increase at an average rate of less than 1 percent annually for the next several years, reaching 377,130 persons by 2004 (U.S. Department of Commerce 1993).

4.3.2.3 Roane County. Development that has occurred in Roane County has been predominantly residential. In Roane County, the major employment sectors in 1990 were retail trade, manufacturing, services, and government. As a percentage of wage and salary employment in Roane County, retail trade accounted for approximately 26 percent, manufacturing 24 percent, services 22 percent, and government 15 percent. The total number of persons employed in Roane County in 1990 was 24,640. Jobs have increased less than 1 percent annually between 1980 and 1990, and are projected to continue to increase at an average rate of less than 1 percent annually for the next several years (U.S. Department of Commerce 1993). The unemployment rate for Roane County was 6.8 percent in 1992 (East Tennessee Development District 1993).

Between 1980 and 1990, the population in Roane County decreased 2.5 percent, from 48,430 to 47,230. The population in Roane County is projected to increase at an average rate of less than 1 percent annually for the next several years, reaching 52,670 persons by 2004.

4.3.2.4 Loudon County. Total employment in Loudon County in 1990 was 12,560 persons. In 1990, the farming sector accounted for a considerably larger percentage, while the services and government sector accounted for a smaller percentage of total jobs than in Anderson, Knox, and Roane counties (U.S. Department of Commerce 1993). The unemployment rate for Loudon County was 6.7 percent in 1992, dropping from 7.2 percent in 1991 due to increase in construction and mining jobs (East Tennessee Development District 1993).

The population of Loudon County increased by 1 percent annually, from 28,700 in 1980 to 31,300 in 1990. The population of Loudon County is projected to increase at an average rate of less than 1 percent annually for the next several years, reaching 32,900 persons by 2004 (U.S. Department of Commerce 1993).

4.3.2.5 Oak Ridge Reservation. The employment level at the ORR in 1994 was 18,200 persons (Truex 1995). In 1993, there were approximately three full-time-equivalent employment positions involved in SNF operations on the ORR (Brown 1994b). Employment levels are expected to decrease to 16,980 by the year 1999 and are projected to remain constant through the year 2004 (Fritts 1994).

4.3.2.6 Aggregate Regional Economic and Demographic Baseline. For the purposes of establishing a regional baseline to compare potential impacts for the programmatic analyses in Section 5.3, regional economic and demographic data for the four-county Region of Influence were aggregated to form one region (Table 4.3-1).

The total population of the Region of Influence, shown in Table 4.3-1, is projected to be 489,230 persons in 1995, and is projected to grow at an annual average rate of less than 1 percent, reaching 538,820 persons in 2004. The labor force of the Region of Influence is also projected to grow at an annual average rate of less than 1 percent, growing to 360,000 persons in 2004. The total employment in the Region of Influence is projected to grow at an annual average rate of approximately 1 percent, growing from 292,700 jobs in 1995 to 338,070 jobs in 2004.

4.3.3 Public Service, Education and Training, and Housing Infrastructure

4.3.3.1 Police and Fire. ORR fire protection services are provided by the fire departments on the reservation. The ORR fire departments have mutual aid agreements among themselves and with the City of Oak Ridge (MMES 1989).

Twelve city, county, and state law enforcement agencies provide police protection in the Region of Influence. In 1990, the largest law enforcement agency in the four-county Region of Influence was in Knoxville, with 296 sworn officers (FBI 1991). Law enforcement on the ORR is provided by the City of Oak Ridge Police Department. Security enforcement, established to meet the Atomic Energy Act and mission requirements, is provided by the prime management and operations contractor (MMES 1989).

Table 4.3-1. Aggregate regional economic and demographic indicators for ORR.[a]

Years	Regional employment	Regional labor force	Regional population
1995	311,700	332,000	506,600
1996	315,100	335,700	510,300
1997	318,600	339,400	51,400
1998	322,100	343,100	517,900
1999	325,700	346,900	521,700
2000	329,300	350,700	525,500
2001	331,500	353,000	528,800
2002	333,700	355,400	532,100
2003	335,900	357,700	535,500
2004	338,000	360,000	538,800
2005	340,300	362,400	542,200
Average Annual Growth Rate	0.9%	0.9%	0.7%

a. Sources: U.S. Department of Commerce 1993; East Tennessee Development District 1993.

Note: Aggregate region includes the Roane, Anderson, Loudon and Knox Counties. Labor force projection developed for this study.

4.3.3.2 Education and Training. Four school districts, Anderson, Knox, Loudon, and Roane, provide public education services in the Region of Influence. In 1990, the four school districts had an average daily membership of 66,510 students. Knox County had the highest average daily membership of 50,324 students (Tennessee Department of Education 1992).

4.3.3.3 Housing. Between 1980 and 1990, the number of housing units in the Region of Influence increased 14 percent from 181,299 to 206,234. In 1980 and 1990, the homeowner vacancy rates in the Region of Influence averaged 1.4 and 1.5 percent, respectively (Census 1982, 1991).

Housing additions in the Region of Influence peaked at 3,882 units in 1990, but declined to 3,662 in 1991. In 1992, however, housing additions increased to a total of 3,880 units (East Tennessee Development District 1993).

4.4 Cultural and Paleontological Resources

4.4.1 Archeological Sites and Historic Structures

For approximately 10,000 years, people have inhabited the ORR site. A cultural resources survey conducted in 1975 did not identify any cultural resources on the proposed site for the SNF management facilities. Therefore, no prehistoric or historic resources are expected to be located on the proposed site for the SNF management facilities (Fielder 1975).

4.4.2 Native American Resources

In the early 1700s, the Overhill Cherokee lived in the area that is now the ORR. The tribe remained in the area until 1838, when it was moved forcibly to Oklahoma under Federal orders (Oakes et al. 1984a). While the Cherokee may retain cultural affiliation with their ancestral home, there are no known Native American resources on the proposed site for the SNF facilities.

4.4.3 Paleontological Resources

The ORR is underlain by nine geologic formations or groups ranging in age from Early Camhrian to Early Mississippian. On the ORR, the only formations known to contain fossils are the Knox Group (which does not usually contain fossils hut does contain small coiled gastropods in a limestone bed); the Chickamauga Limestone (which contain many fossils including brachiopods, bryozoans, gastropods, cephalopods, crinoid stems, corals, and trilobites); the Sequatchie Formation (which does not have an abundant supply of fossils in the formation, but does contain large brachiopods, colonial corals, and bryozoans within several thin beds of gray limestone); the Rockwood Formation (which contains crinoid stem fossils in the upper half of the formation); and the Fort Payne Chert, which contains many casts of crinoid stems (McMaster 1988). No unusual paleontological remains from the ORR were identified.

4.5 Aesthetics and Scenic Resources

Visual or scenic resources comprise the natural and man-made features that give a particular environment its aesthetic qualities. These features form the overall impression that a viewer receives of an area or its landscape character. Visual sensitivity is assessed by considering the activities, awareness, and expectations of the public within a given area. High visual sensitivity exists when a view is rare, unique, or in other ways special to viewers. Medium visual sensitivity exists when a view is similar to others in the area or is of secondary importance relative to other significant aspects of the area. Low visual sensitivity exists when a view has little value to viewers and an intrusion or alteration of that view would have no impact on viewers.

Scenic resources at the ORR and the surrounding area are set in a landscape of heavily forested, predominantly parallel ridges with steep slopes interspersed with relatively flat valleys, known physiographically as the Ridge and Valley Province. Due to the rolling topography at the ORR, approximately 62 percent of the reservation is located on slopes of less than 14 percent (MMES 1994a). The reservation is framed by the Clinch River at the west, south, and eastern boundary, and by Poplar Creek to the north. The vegetation present at the reservation is primarily a mixture of deciduous and coniferous forest covering approximately 80 percent of the site (MMES 1989). Roads providing public access to the interior of the site include State Routes 95 and 58, along with Bethel Valley Road (Figure 4.2-1).

The location of the proposed SNF management facilities, under the Centralization Alternative, is set along the north side of Bear Creek Road west of State Route 95, between the extension of Blair Road and State Route 95, at the western end of the reservation. The public has access to Bear Creek Road west of State Route 95. As a result, the entrance to the site will be visible to traffic on Bear Creek Road (MMES 1994a). The proposed facilities would consist of 90 acres (0.36 square kilometer), 85 of which would be located within security fencing. The facility would have the appearance of industrial buildings ranging in height from one to three stories. The site would receive and unload up to one truck shipment per day, or a total of 5,500 truck shipments over the 40-year operation period. The site would be set on the south side of Pine Ridge midway between the top of the ridge, with elevations ranging between 900 and 1,100 feet (274 and 335 meters), and Bear Creek Valley, with an elevation of approximately 700 feet (213 meters) (TVA 1987). Chestnut Ridge, located south of Pine Ridge on the reservation, faces the site.

Under the Regionalization Alternative, the location of the proposed SNF facility would remain the same but would be reduced in area and extent. Operation of the facilities would also be reduced, resulting in the receipt of fewer truck shipments over the 40-year operation period.

The viewshed surrounding the ORR consists mainly of sparsely populated rural land. The City of Oak Ridge, along the northeast portion of the site, is the only adjacent urban area. Views of DOE facilities from areas surrounding the reservation include those from public roadways such as Interstates 40 and 75, U.S. Route 70, and State Routes 62, 162, and 95. The reservation can also be viewed from the south bluffs along the Clinch River. The Great Smoky Mountains National Park and the Blue Ridge Mountains are approximately 70 miles southeast of the ORR and are generally not visible from the reservation (MMES 1989). In general, views are limited by the rolling terrain, heavily forested vegetation, and hazy atmospheric conditions.

The developed areas of the ORR could generally be classified as having low visual sensitivity. The remainder of the site ranges from low to moderate visual sensitivity. Of the jurisdictions that may be affected by the construction and operation of the proposed SNF facilities, only the City of Oak Ridge in its Comprehensive Plan has provided policies that promote elements of scenic resource enhancement and preservation through streetscape design, landscaping, lighting, and signage improvements at entrances to the urban area and the city center. One entrance to the urban area that promotes scenic resource enhancement and preservation is Illinois Avenue, crossing the northeast portion of the ORR (City of Oak Ridge 1989).

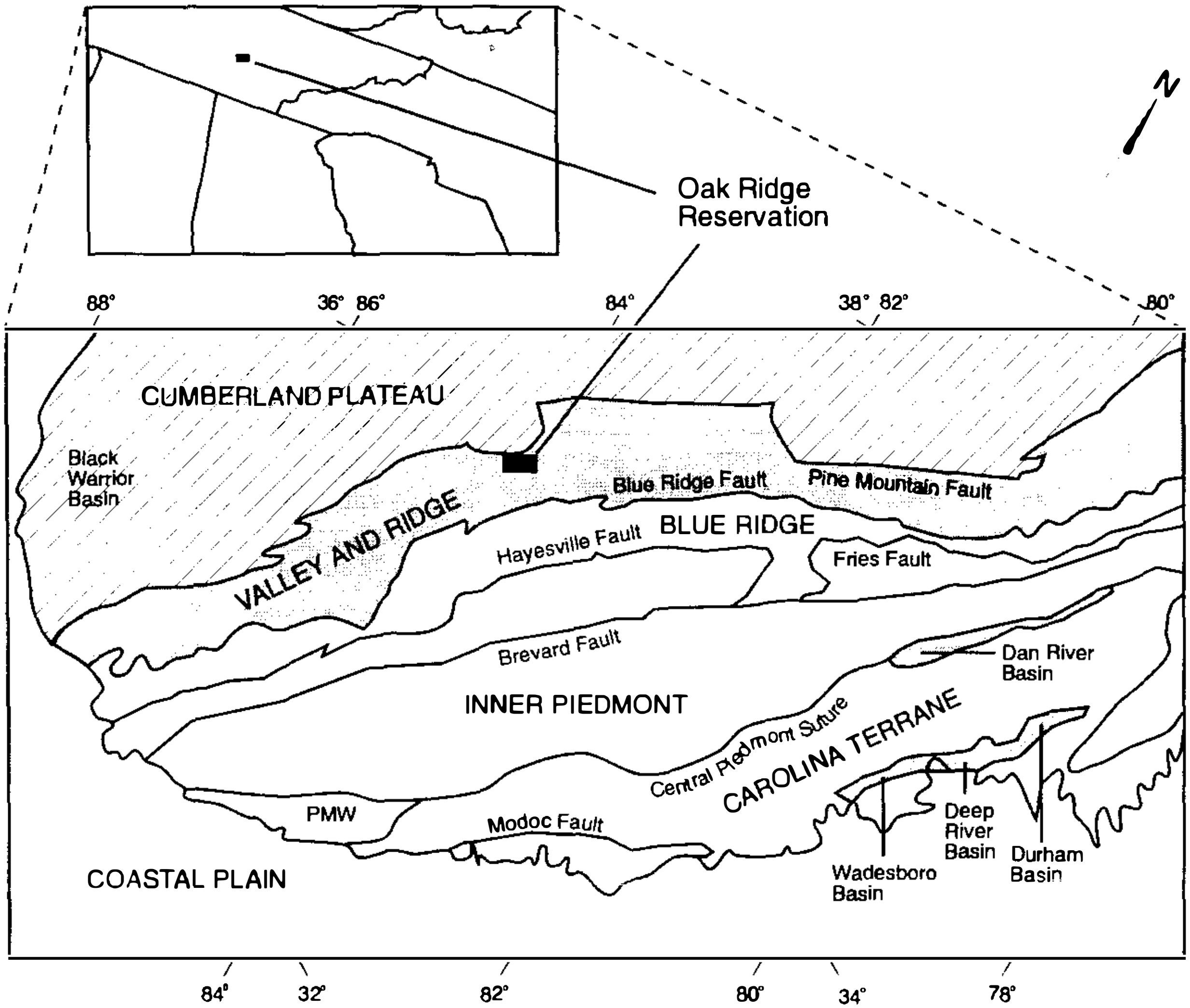
4.6 Geologic Resources

This section provides a general description of the geology, soils, geologic resources, and seismic, volcanic, and other geologic hazards at the ORR and surrounding area. This section also describes any existing impacts to the geology and geologic resources resulting from past and present human activities at the ORR.

4.6.1 General Geology

As shown in Figure 4.6-1, the ORR lies entirely within the western portion of the Valley and Ridge Province, near the boundary with the Cumberland Plateau. The Valley and Ridge Province, a zone of folded and faulted sedimentary rocks in the Appalachian mountain belt, is characterized by numerous linear ridges and valleys that trend approximately southwest-northeast as shown on Figure 4.6-2. The rocks of the Valley and Ridge Province in eastern Tennessee are Early Cambrian to Early Mississippian in age. A stratigraphic column for the ORR southeast of East Fork Ridge (south of Interstate 95) is shown on Figure 4.6-3. A generalized geologic map of the ORR is shown on Figure 4.6-2. Most of the ORR is underlain by the Rome Formation and Conasauga, Knox, and Chickamauga Groups, sedimentary rocks of Cambrian and Ordovician age (Hatcher et al. 1992). A geologic cross-section of the ORR is shown on Figure 4.6-4.

The Rome Formation consists of interbedded sandstone, siltstone, and shale. The base of the Rome is not exposed in the Oak Ridge area, but consideration of regional structural trends suggests that the Rome Formation is in fault contact with younger rocks. On the Copper Creek and Whiteoak Mountain thrust sheets the Rome is 120-180 meters (390-590 feet) thick, and on



Source: Hatcher et al. 1992.

Miles 0 50 100
Kilometers 0 50 100
Approximate Scale

Figure 4.6-1. Generalized map of the southern Appalachian geologic provinces showing the location of the Oak Ridge Reservation.

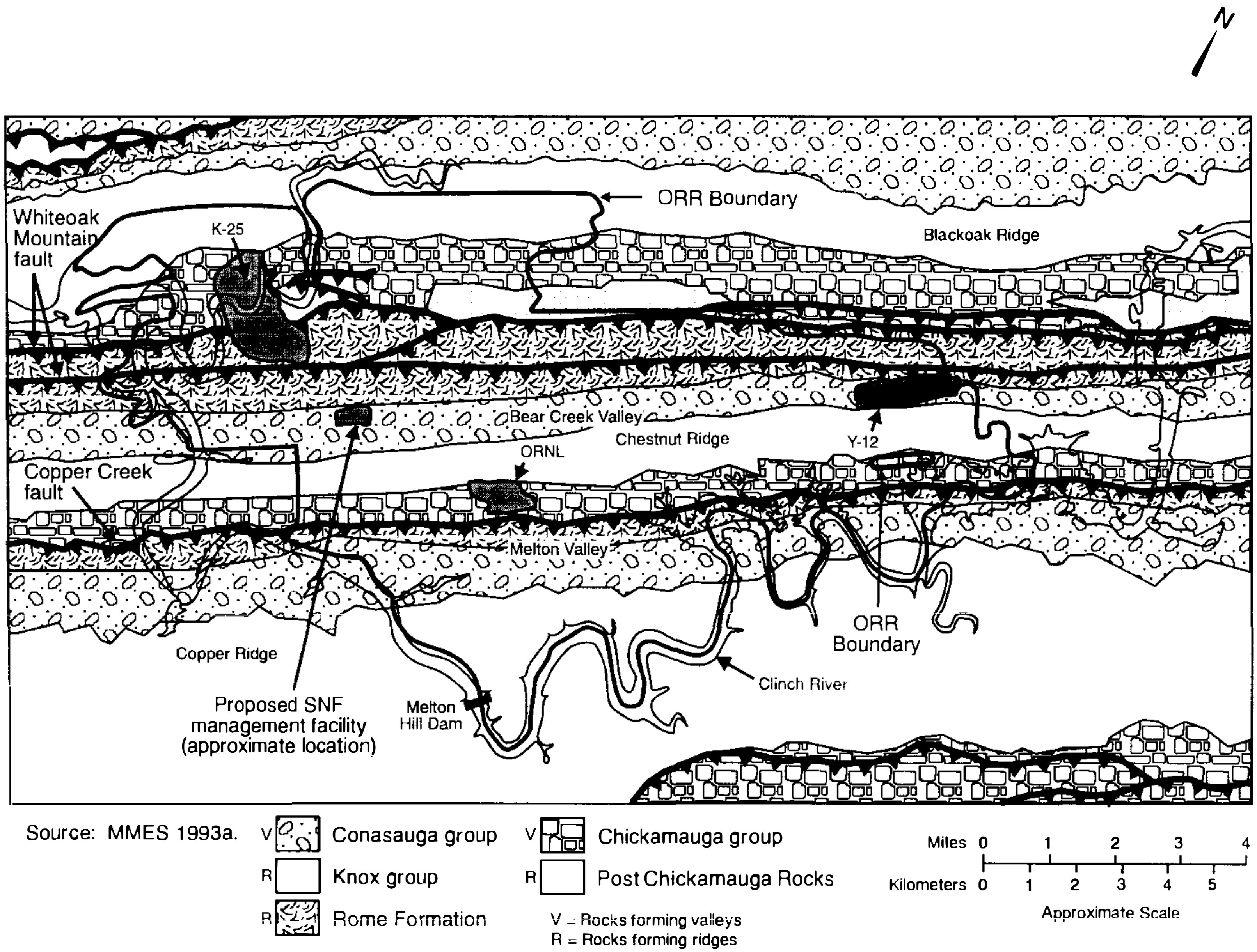
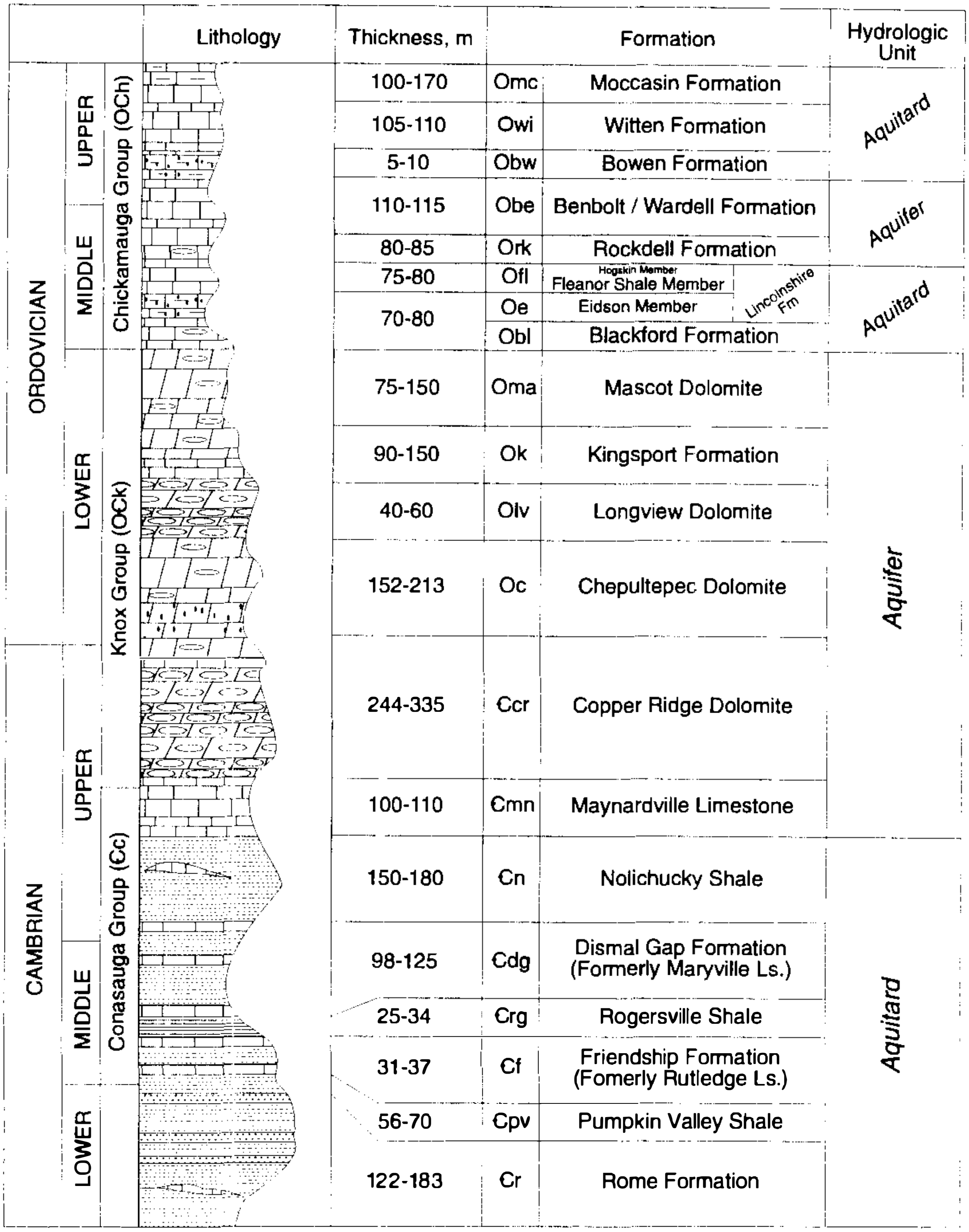


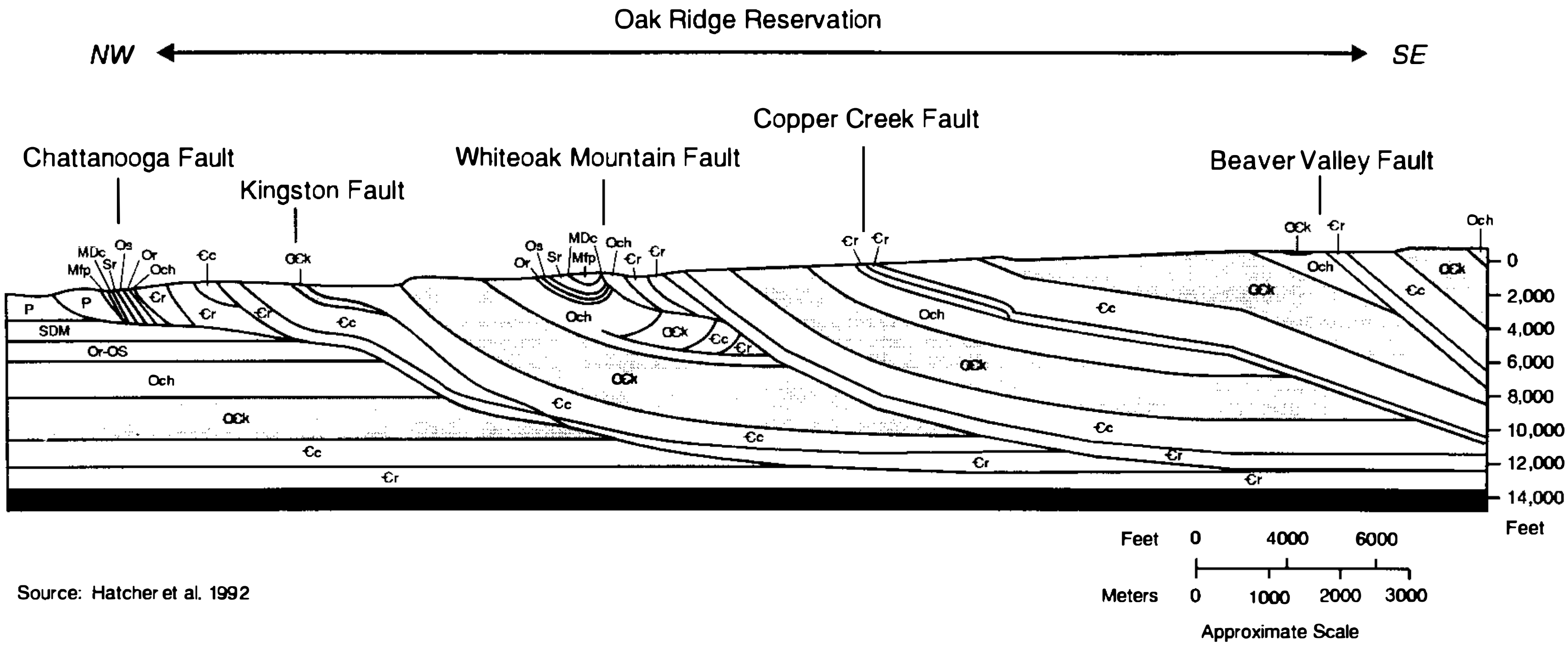
Figure 4.6-2. Geologic map of the Oak Ridge Reservation



1 meter = 3.2808 feet

Source: Modified from Hatcher et al. 1992.

Figure 4.6-3. Stratigraphy of the ORR on the Whiteoak Mountain and Copper Creek Thrust Sheets.



Ꞓr = Rome Formation

Ꞓc = Conasauga Group

OꞒk = Knox Group

Och = Chickamauga Group (Supergroup)

Or = Reedsville Shale

Os = Sequatchie Formation

Sr = Rockwood Formation

SDM = Silurian, Devonian, and Mississippian Units

MDc = Chattanooga Shale

Mfp = Fort Payne Formation

P = Pennsylvanian Units

Figure 4.6-4. Generalized geologic profile beneath the Oak Ridge Reservation.

the Kingston thrust sheet it is over 450 meters (1,500 feet) thick (Hatcher et al. 1992). Thrust sheets carry the name of the fault at their front, or northwest edge. Faults are shown on Figure 4.6-4. The transition between the sandstones of the Rome Formation and the overlying Pumpkin Valley Shale of the Conasauga Group occurs rather abruptly, as the more resistant sandstones grade into the less resistant shales.

The formations of the Middle to Upper Cambrian Conasauga Group are primarily limy shales interlayered with shales, limestones, and siltstones. At the ORR, the Conasauga Group is divided into six units (see Figure 4.6-3). Approximately 450 meters (1,500 feet) of the Conasauga Group is exposed at the ORR. The transition from the Conasauga Group to the overlying Knox Group is gradational, with the dominant rock type shifting from shale and dolomitic limestones in the Conasauga Group to dolomites with occasional limestones in the Knox Group.

At the ORR, as in the rest of eastern Tennessee, the Upper Cambrian to Lower Ordovician Knox Group is divided into five formations, which are shown on Figure 4.6-3. The Knox Group is approximately 914 meters (3,000 feet) thick on the ORR and consists primarily of thick beds of silty dolomite (Hatcher et al. 1992). Above the Knox Group is the Middle to Upper Ordovician Chickamauga Group. See Figure 4.6-3 for the units that comprise the Chickamauga on the Whiteoak Mountain thrust sheet.

Surface relief at the ORR typically ranges from a ridge crest to valley floor relief of 30 to 69 meters (100 to 225 feet) (Lee and Ketelle 1987). Surface elevations on the ORR range from a maximum of 413 meters (1,356 feet) National Geodetic Vertical Datum at the crest of Melton Hill (see Figure 2.1-2) to a minimum of 226 meters (740 feet) National Geodetic Vertical Datum near Mile 10 on the Clinch River (Boyle et al. 1982). A series of crests and ridges that trend northeast and southwest make up the ORR (Figure 4.6-2). In general, the crests or ridges are composed of resistant sandstone or dolomite beds. Limestone and shale generally form the ridge flanks and valley bottoms.

Sinkholes, large springs, caves, and other karst features are common in the Knox Group, and those parts of the ORR underlain by limestones and dolomites (certain units in the Conasauga, Knox, and Chickamauga Groups) are for the most part classified as karst terranes.

In a karst terrane there is very little surface drainage because of the diversion of surface waters to subterranean (underground) flow routes. These subterranean routes are caves and other enlarged openings that have formed through dissolution of the carbonate rock. Four major karst zones exist at the ORR that appear to be related to distinct stratigraphic horizons (Ketelle 1982). These four karst zones all occur in the Knox Group, specifically in the Copper Ridge Dolomite, near the base of the Chepultepec Dolomite, near the top of the Chepultepec Dolomite, and in the Kingsport Formation (Ketelle 1982). Karst development is also present to varying degrees in the carbonate rocks of the Conasauga Group, most notably in the Maynardville Limestone. In Bear Creek Valley, karst development in the Maynardville Limestone causes variations in discharge along Bear Creek as the surface water and groundwater components vary in dominance (Lee et al. 1988). Bear Creek Valley is underlain by calcareous shale and limestone of the Conasauga Group (Bailey and Lee 1991). Although no site-specific geologic characterization has been conducted at the West Bear Creek Valley site, it appears the proposed SNF management facility is located over the lower Conasauga Group strata not normally characterized by karst development.

The soils occurring in the ORR are predominantly clay, although chert and quartz are also present. Soils developed in the Conasauga are clay. Hatcher et al. (1992) provides detailed information on soils. Many of the soils belong to the broad group of Ultisols, which are reddish or yellowish, moderately acidic soils. Entisols, which are thin surface soils over bedrock that show little development of soil horizons, are found locally in steeply sloping areas. In addition, small areas of inceptisols are found in alluvial areas adjacent to streams (Boyle et al. 1982). These are young soils, also with minimal horizon development. Soils on the ORR tend to retain moisture and are typically 90 percent saturated below a depth of 3 meters (10 feet) (Ketelle and Huff 1984). Depths of soil profiles on the ORR vary from 15 centimeters (6 inches) on slopes to 18 meters (60 feet) over dolomites in the Knox Group (Boyle et al. 1982).

4.6.2 Geologic Resources

The known resources of the geologic units exposed on the ORR are limited to industrial minerals, including quarry rock and clay. These industrial minerals are of low unit value and can be found elsewhere. Quarry rock has been mined at several major locations throughout ORR, but no quarries are currently in operation (Oakes et al. 1984b).

There has been extensive seismic testing by private companies along roads traversing the ORR to explore for deep accumulations of oil and gas. Land has been leased by major oil companies west and northwest of K-25 off the ORR; no exploratory wells have been drilled and the status of oil and gas resources underlying the ORR is unknown at this time (Oakes et al. 1984b).

4.6.3 Seismic and Volcanic Hazards

There is no evidence that there has been volcanic activity in the vicinity of the ORR for more than 1 million years.

4.6.3.1 Historical Seismic Activities. From 1811 to 1975, only five major earthquakes or earthquake series have affected the ORR area. These are the New Madrid, Missouri, earthquake series, and the Charleston, South Carolina; Knoxville, Tennessee; Strawberry Plains, Tennessee; and Kingston, Tennessee earthquakes. The New Madrid earthquake series of December 1811 to February 1812 produced maximum Modified Mercalli Intensity disturbances of V to VI in the ORR area. A Modified Mercalli Intensity V earthquake is felt by everyone. Typical damage includes some dishes, windows, etc. being broken, a few instances of cracked plaster, and unstable objects being overturned. A Modified Mercalli Intensity VI earthquake is also felt by all, and many become frightened and run outdoors. Typical damage includes some heavy furniture moved and a few instances of fallen plaster or damaged chimneys. A Modified Mercalli Intensity of VI is approximately equal to a Richter Magnitude 4.7 (Griggs and Gilchrist 1977).

The 1844 Knoxville earthquake, which occurred approximately 40 kilometers (25 miles) from the ORR, had an epicenter shaking of Modified Mercalli Intensity VI. The Charleston earthquake of 1886 had a Modified Mercalli Intensity of V to VI at the ORR, as did the 1913 Strawberry Plains earthquake. The 1930 Kingston earthquake, 8 kilometers (5 miles) northwest of the ORR, had an epicenter shaking of Modified Mercalli Intensity V (Boyle et al. 1982).

When intensities are reported at epicenters, they would have been less at the ORR, as intensities diminish with distance.

A Modified Mercalli Intensity VII earthquake does not typically cause severe damage, but rather causes breaking of weak chimneys at the roof line, cracks in masonry, and the falling of plaster, loose bricks, and stones. No Modified Mercalli Intensity VII earthquakes have been recorded at the ORR during the 165-year period from 1811 to 1975. Earthquakes with a Modified Mercalli Intensity of VII generally occur one order of magnitude less frequently than earthquakes with a Modified Mercalli Intensity of V to VI. Seismic records indicate that the ORR is located in a region of moderate seismic activity having an average of one to two earthquakes per year, with seismic activity occurring in bursts followed by long periods of no activity. No deformation of recent surface deposits has been detected, and seismic shocks from the surrounding, more seismically active areas are dissipated by distance from the epicenters (Boyle et al. 1982).

The underlying structure of the ORR is complex due to the extensive faulting and deformation characteristic of the region. There are three regional thrust faults in the ORR area, the Kingston, Whiteoak Mountain, and Copper Creek Faults (see Figure 4.6-4). All three strike to the northeast and dip to the southeast. Latest movement on the faults was Late Pennsylvanian/Early Permian (280 to 290 million years ago); consequently, they are not considered to be capable faults at present (Oakes et al. 1984b). According to 10 CFR Part 100, Appendix A, capable faults include those faults that have exhibited movement at or near the ground surface at least once during the past 35,000 years or movement of a recurring nature within the past 500,000 years.

4.6.3.2 Seismicity Studies. Four seismic studies have been specifically conducted for the ORR for which the results have been published. Three of these studies have been summarized by Beavers et al. (1982), and were performed by Blume in 1973, Dames and Moore in 1973, and TERA in 1981. The first two studies were directed toward the seismic hazards at the K-25 Site (formerly the Oak Ridge Gaseous Diffusion Plant), and the latter focused on ORNL (Beavers et al. 1982).

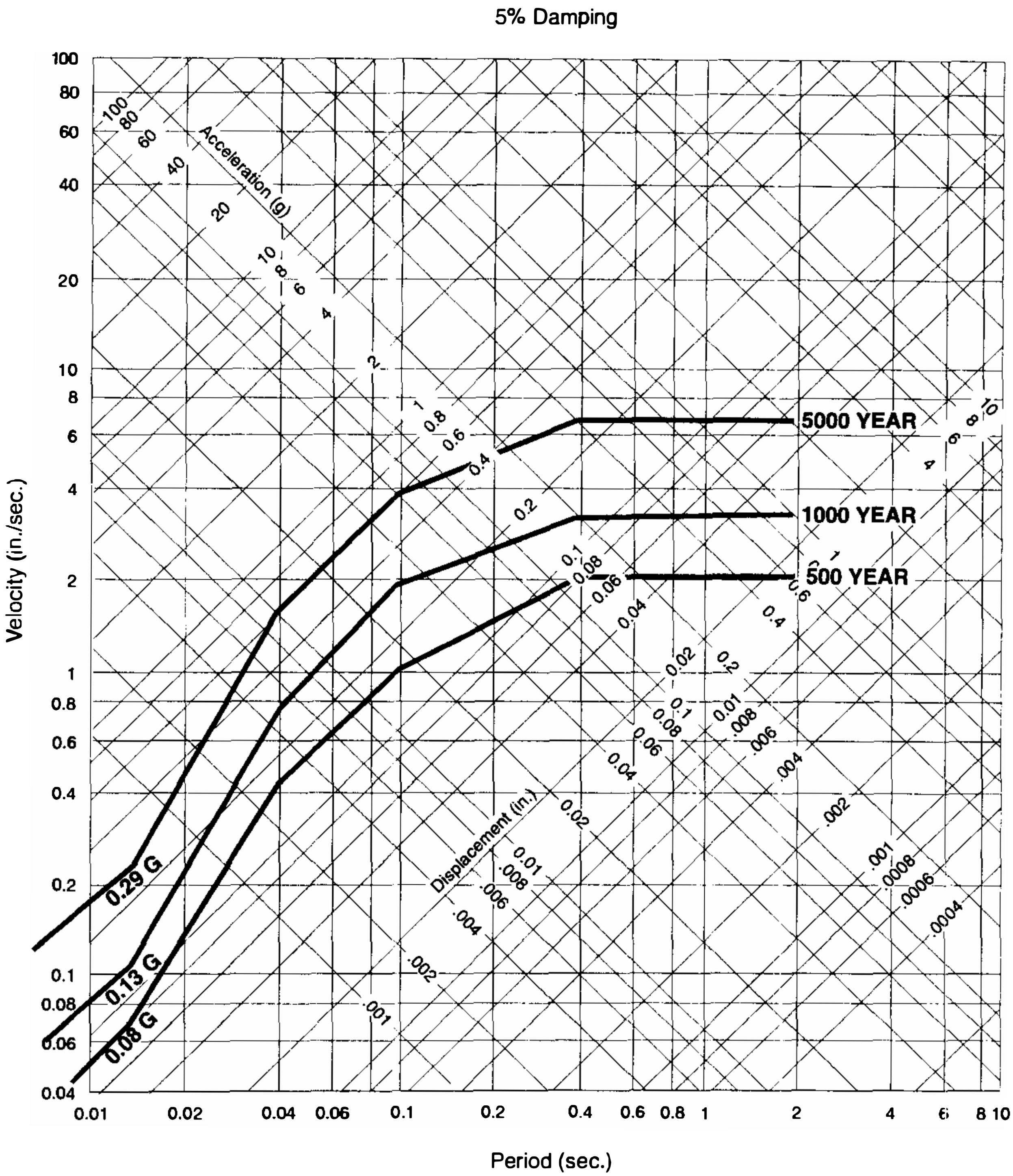
These three early studies presented preliminary analysis and conclusions. The fourth study (McGuire et. al. 1992), is a more recent seismic analysis for the entire ORR. DOE Standards 1020 (DOE 1994a) and 1024 (DOE 1992b) summarize the results of recent seismic analyses at DOE sites and show that the peak ground accelerations for the ORR for 500-year, 1,000-year, 2,000-year and 5,000-year seismic events are 0.08g, 0.13g, 0.19g and 0.29g, respectively.

Figure 4.6-5 presents the site specific uniform hazard response spectra for horizontal rock motion which were approved by DOE Headquarter's Office of Nuclear Energy on August 25, 1993 (Benedict 1993). The response spectra noted on Figure 4.6-5 are for top of rock sites.

4.6.3.3 DOE Seismic Design Criteria. DOE Order 5480.28 requires that the *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards, UCRL-15910* (Kennedy et al. 1990), be used for natural phenomena hazards design and evaluation criteria until a DOE standard is issued. In April 1994, DOE-STD-1020 was issued to replace UCRL-15910.

At the SNF management facility site the categorization of each structure, system and component would be determined in accordance with DOE Standard DOE-STD-1021, *Performance Categorization Criteria for Structures, Systems and Components at DOE facilities Subjected to Natural Phenomena Hazards.*

A maximum horizontal ground surface acceleration of 0.19g at ORR is estimated to result from an earthquake that could occur once every 2,000 years (DOE, 1994a). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. DOE orders, standards and site specific procedures require that potential seismic hazards for existing and new facilities be evaluated on a facility specific basis.



Adapted from source: Benedict 1993.

Figure 4.6-5. Oak Ridge - Site Specific Uniform Hazard Response Spectra for Horizontal Rock Motion

4.7 Air Resources

4.7.1 Climatology

Except where indicated, the information presented in this section is derived from Fitzpatrick 1982 and NOAA 1991.

The ORR site is located within the Great Valley of Tennessee in which the Cumberland Plateau borders to the northwest and the Great Smoky Mountains lie to the southeast. Climate at the ORR is influenced by these terrain features.

The climate and meteorology in the lowlands are generally unlike those that occur in the more mountainous regions of the southeastern United States. Daytime winds are usually southwesterly, while night-time winds are northeasterly, at least during periods of light wind. The elevated ridges of the Cumberland Plateau and Great Smoky Mountains encompassing the valley impede wind speeds to a moderate degree. The Cumberland Plateau retards the drainage of cold air from the northwest into the valley during winter, thus reducing the probability of extremely cold temperatures.

The average daily temperature at the Oak Ridge National Weather Service Station, considered representative of the ORR, was 14.2°C (57.5°F) for the period of record 1961-1990. The average daily temperatures varied from a low of 2.6°C (36.7°F) in January to a high of 24.8°C (76.6°F) in July.

Humidity data are maintained at the Knoxville National Weather Service with a period of record from 1961-1990. Records are reported for humidity readings during the hours 0100, 0700, 1300, and 1900 (local time). The 0700 and 1900 values will be reported here. The mean 0700 relative humidity was 86 percent with the mean monthly maximum of 92 percent occurring in July and August, and the mean monthly minimum of 80 percent occurring during February and March. The mean 1900 relative humidity is 63 percent with the mean monthly maximum of 68 percent occurring in September and December, and the mean monthly minimum of 52 percent occurring in April.

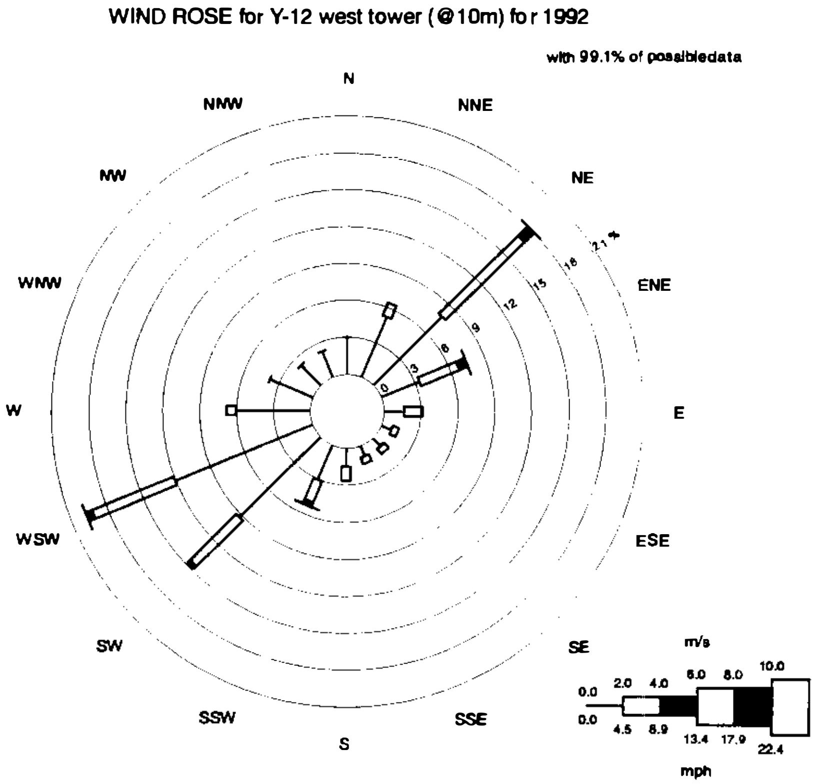
The mean wind speed measured at the Oak Ridge National Weather Service over the period 1969 to 1984 was 2.0 meters per second (4.4 miles per hour) at an average height above ground of about 13 meters (41 feet). At a meteorological tower at the ORR the mean wind speed was 2.1 meters per second (4.7 miles per hour) at about 10 meters (33 feet) above ground level. Wind speeds in the ORR area are influenced by local topographic conditions and are generally higher on top of the ridges than in the valleys.

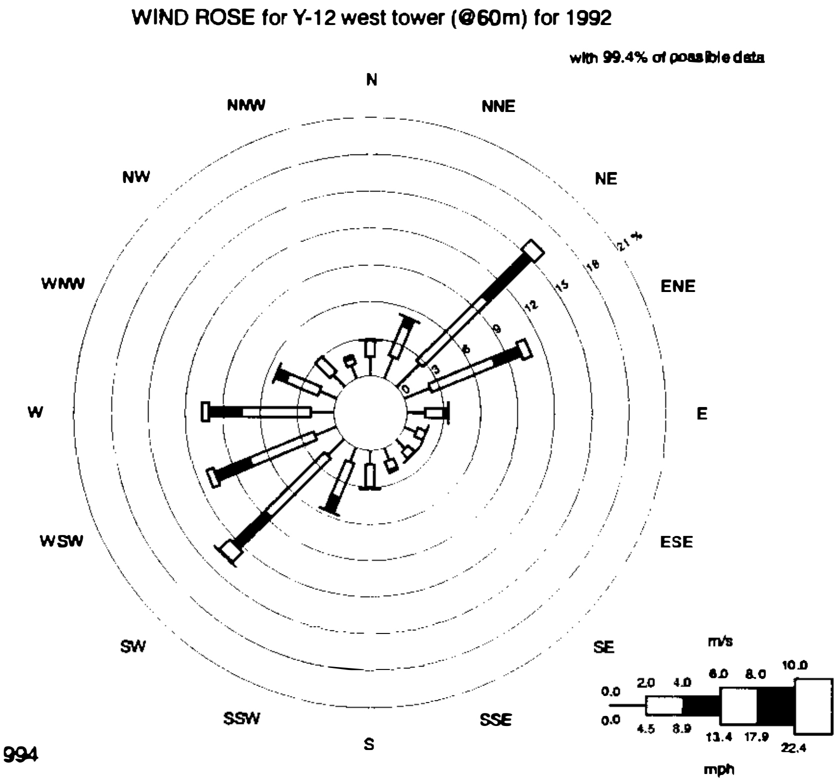
The wind direction above the ridgetops and within the valleys tends to follow the orientation of the valleys. The prevailing wind direction is from the southwest, with a secondary maximum from the northeast during the winter, spring, and summer months. The situation is reversed in the fall.

Figure 4.7-1 shows 1992 wind roses for the 10- and 60-meter levels of the Y-12 west meteorological tower. The annual 10-meter level on the Y-12 west meteorological tower shows peak wind direction frequencies from the west-southwest, with the secondary peak from the northeast. The annual 60-meter level shows wind direction frequencies from the northeast and a secondary peak from the southwest. Since the valley floor is inclined, cold air will drain down the valley during stable periods. Both wind rose levels show the influence of the topography on the wind direction.

Damaging winds are uncommon in the region. Peak gusts recorded in the Great Valley are generally in the 27- to 31-meter-per-second (60- to 70-mile-per-hour) range for the months of January through July; in the 22- to 27-meter-per-second (50- to 60-mile-per-hour) range for August, September, and December; and in the 16- to 20-meter-per-second (35- to 45-mile-per-hour) range in October and November. The maximum gust reported in the region was about 37 meters per second (82 miles per hour); it occurred during the month of March at Chattanooga. Knoxville has reported a peak gust of about 33 meters per second (73 miles per hour) and Oak Ridge a gust of about 26 meters per second (59 miles per hour).

Winter is the wettest of the seasons in the ORR area; March and December are the wettest months and October the driest. The annual average precipitation measured at the ORR in Bethel Valley from 1944 through 1964 was 130.9 centimeters (51.5 inches), while the annual





Source: Sharp 1994

Figure 4.7-1. Wind Roses for Y-12 west tower (@ 10 and 60m) for 1992 at ORR.

average precipitation for the National Weather Service in Oak Ridge from 1961 through 1990 was 137.2 centimeters (54.0 inches). The maximum monthly precipitation was 48.9 centimeters (19.3 inches) in July 1967, while the maximum rainfall in a 24-hour period observed at the Oak Ridge National Weather Service was recorded in August 1960 at 19.0 centimeters (7.5 inches).

On average there are about 51 thunderstorm days per year at the Oak Ridge National Weather Service station. The summer thunderstorms, which may be accompanied by strong winds, heavy precipitation, or, less frequently, hail, occur primarily during the late afternoon and evening hours. Summer thunderstorms are attributable primarily to convective activity resulting from solar heating of the ground and generally moist atmospheric conditions. Thunderstorm activity in the winter months is attributable mainly to frontal activity.

The Great Valley of Tennessee is infrequently subject to tornadoes. The western half of the state has experienced three times as many tornadoes as the eastern half, where the ORR is located. The ORR did experience a tornado from a severe thunderstorm on February 21, 1993 (MMES 1993b). The tornado path passed the Y-12 Plant in an east-northeast direction for approximately 21 kilometers (13 miles), ending just north of Knoxville. The wind speeds associated with this tornado ranged from 18 meters per second (40 miles per hour) to nearly 58 meters per second (130 miles per hour), depending on the location along the path (MMES 1993b).

Hurricanes are rarely sustained once they reach as far inland as the Great Valley due to the rapid loss of energy when they are cut off from their source of moisture. The remnants of nine hurricanes that were classified as devastating after crossing the coastline of the United States have traversed the borders of Tennessee in the last 70 years.

Atmospheric dispersion improves as wind speed increases, conditions become more unstable, and the depth of the mixing height increases. The transport and dispersion of airborne material are direct functions of air movement. Transport directions and speeds are governed by the general patterns of air flow (and by the nature of the terrain), whereas the diffusion of airborne material is governed by small-scale, random eddying of tbe atmosphere (i.e., turbulence). Turbulence is indicated by atmospheric stability classification. Data collected at

Y-12 for calendar year 1992 were classified using the vertical temperature difference (i.e., between 60- and 10-meter levels) in accordance with Nuclear Regulatory Commission Regulatory Guide 1.23 (NRC 1986). The atmospheric conditions are unstable (i.e., Stability Classes A through C) approximately 5 percent of the time, neutral (Class D) approximately 43 percent of the time, and stable (Classes E through G) approximately 52 percent of the time at the 10-meter level.

4.7.2 Air Monitoring Networks

This section discusses the air monitoring networks of the ORR. Atmospheric emissions from the ORR facilities are monitored by stack monitors and by a network of ambient air monitoring stations on the perimeter of each major ORR operations area (ORNL, the Y-12 Plant, and K-25 Site), as well as on the ORR perimeter and throughout the surrounding communities.

4.7.2.1 Radiological Monitoring Network. Twelve of the ambient air monitoring stations on the perimeter of the Y-12 Plant routinely monitor total suspended uranium particulates. The ORNL perimeter monitoring network consists of four stations that monitor radiation parameters (i.e., gross alpha, gross beta, iodine, and gamma-emitting radionuclides). Samples of atmospheric tritium are also collected monthly at selected perimeter stations.

4.7.2.2 Nonradiological Monitoring Network. The perimeter ambient air monitoring network for K-25, which was upgraded in 1986, consists of five stations that monitor airborne particulate contaminants such as nickel, lead, and chromium. In 1988, two additional ambient air monitoring stations were installed at the K-25 Site. These stations measure polychlorinated biphenyls, furans, dioxins, and hexachlorobenzene that may accidentally be released due to the Toxic Substance Control Act incinerator (located in the K-25 area).

4.7.3 Air Releases

4.7.3.1 Radiological Emissions. Table 4.7-1 presents the radioactive emissions to the atmosphere from each of the three ORR areas (ORNL, K-25, and Y-12) during 1992.

Table 4.7-1. Radioactive atmospheric emissions (curies/yr) from the ORR during 1992.

Isotope	ORNL	K-25	Y-12
Hydrogen-3 (Tritium)	2.14×10^3	0.0×10^0	0.0×10^0
Beryllium-7	8.91×10^{-6}	0.0×10^0	0.0×10^0
Potassium-40	0.0×10^0	1.01×10^{-3}	0.0×10^0
Cobalt-57	0.0×10^0	0.0×10^0	0.0×10^0
Cobalt-60	2.97×10^{-5}	0.0×10^0	0.0×10^0
Bromine-82	1.02×10^{-5}	0.0×10^0	0.0×10^0
Krypton-83m	7.32×10^1	0.0×10^0	0.0×10^0
Krypton-85	0.0×10^0	0.0×10^0	0.0×10^0
Krypton-85m	1.73×10^2	0.0×10^0	0.0×10^0
Krypton-87	3.50×10^2	0.0×10^0	0.0×10^0
Krypton-88	4.94×10^2	0.0×10^0	0.0×10^0
Krypton-89	6.27×10^2	0.0×10^0	0.0×10^0
Strontium-90	1.19×10^{-4}	0.0×10^0	0.0×10^0
Niobium-95	0.0×10^0	0.0×10^0	0.0×10^0
Technetium-97	0.0×10^0	6.10×10^{-2}	0.0×10^0
Ruthenium-106	0.0×10^0	4.36×10^{-4}	0.0×10^0
Iodine-129	2.70×10^{-4}	0.0×10^0	0.0×10^0
Iodine-131	1.25×10^{-1}	0.0×10^0	0.0×10^0
Iodine-132	1.36×10^0	0.0×10^0	0.0×10^0
Iodine-133	6.48×10^{-1}	0.0×10^0	0.0×10^0
Iodine-134	2.05×10^{-2}	0.0×10^0	0.0×10^0
Iodine-135	1.22×10^0	0.0×10^0	0.0×10^0
Xenon-133	8.81×10^2	0.0×10^0	0.0×10^0
Xenon-133m	2.74×10	0.0×10^0	0.0×10^0
Xenon-135	2.82×10	0.0×10^0	0.0×10^0
Xenon-135m	1.55×10^2	0.0×10^0	0.0×10^0
Xenon-138	8.50×10^2	0.0×10^0	0.0×10^0
Cesium-134	6.03×10^{-7}	0.0×10^0	0.0×10^0
Cesium-137	6.13×10^{-4}	8.16×10^{-5}	0.0×10^0
Cesium-138	0.0×10^0	0.0×10^0	0.0×10^0
Barium-137	3.84×10^{-4}	0.0×10^0	0.0×10^0
Barium-137m	6.13×10^{-4}	8.16×10^{-5}	0.0×10^0
Barium-140	1.00×10^{-4}	0.0×10^0	0.0×10^0
Lanthanum-140	1.39×10^{-6}	0.0×10^0	0.0×10^0

Table 4.7-1. (continued).

Isotope	ORNL	K-25	Y-12
Cerium-144	0.0×10^{0}	1.23×10^{-6}	0.0×10^{0}
Europium-152	1.86×10^{-12}	0.0×10^{0}	0.0×10^{0}
Europium-154	5.87×10^{-6}	0.0×10^{0}	0.0×10^{0}
Europium-155	3.02×10^{-6}	0.0×10^{0}	0.0×10^{0}
Osmium-191	2.27×10^{-2}	0.0×10^{0}	0.0×10^{0}
Gold-194	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}
Lead-212	1.56×10^{0}	0.0×10^{0}	0.0×10^{0}
Thorium-228	9.52×10^{-6}	1.54×10^{-3}	0.0×10^{0}
Thorium-230	6.49×10^{-7}	7.41×10^{-4}	0.0×10^{0}
Thorium-232	1.86×10^{-7}	2.96×10^{-5}	0.0×10^{0}
Thorium-234	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}
Protactinium-234m	0.0×10^{0}	4.07×10^{-1}	0.0×10^{0}
Uranium-234	2.24×10^{-5}	2.55×10^{-2}	4.70×10^{-2}
Uranium-235	4.79×10^{-7}	1.12×10^{-3}	1.49×10^{-3}
Uranium-236	0.0×10^{0}	0.0×10^{0}	1.86×10^{-4}
Uranium-238	7.57×10^{-7}	3.74×10^{-2}	4.11×10^{-3}
Neptunium-237	0.0×10^{0}	1.10×10^{-4}	0.0×10^{0}
Plutonium-238	7.40×10^{-6}	6.02×10^{-4}	0.0×10^{0}
Plutonium-239	2.06×10^{-5}	1.12×10^{-4}	0.0×10^{0}
Americium-241	1.37×10^{-5}	0.0×10^{0}	0.0×10^{0}
Curium-244	2.05×10^{-4}	0.0×10^{0}	0.0×10^{0}

4.7.3.2 Nonradiological Emissions. Table 4.7-2 presents the nonradiological emissions to the atmosphere from each of the three ORR areas during 1992.

4.7.4 Air Quality

4.7.4.1 Radiological. A summary of ORR airborne radionuclide emissions for 1992 is presented in Table 4.7-1. The GENII environmental transport and dose assessment model was used to calculate the effective dose equivalent resulting from these radionuclide emissions. These results are summarized in Table 4.7-3. The maximum effective dose equivalent at the ORR boundary is 3.3 millirem. This is 33 percent of the corresponding National Emissions Standard for Hazardous Air Pollutants. The collective effective dose equivalents to the estimated population of 910,000 persons within 80 kilometers (50 miles) of the proposed SNF facility is 52 person-rem. This dose is 0.019 percent of the natural background radiation affecting this population. Background radiation doses are presented in Figure 4.7-2.

4.7.4.2 Nonradiological. The ORR is located in Anderson and Roane Counties, in the Eastern Tennessee-Southwestern Virginia Interstate Air Quality Control Region 207. As of 1993, the areas within this Air Quality Control Region were designated as attainment with respect to all National Ambient Air Quality Standards (CFR 1993a).

One Prevention of Significant Deterioration ambient air quality Class I area can be found in the vicinity of ORR. That is the Great Smoky Mountains National Park, located approximately 48 kilometers (30 miles) southeast of ORR. Since the promulgation of the Prevention of Significant Deterioration regulations, no such permits have been required for any emissions source at the ORR.

Ambient air quality within and near the ORR is monitored for total suspended particulates, particulate matter less than 10 microns in diameter (PM_{10}), fluorides, lead, and sulfur dioxide, which was monitored until August 1990 (MMES 1993a). Ambient air quality monitoring data collected at the ORR are summarized in Table 4.7-4.

Table 4.7-2. Nonradiological emissions at ORR (kg/yr).[a]

Pollutant	Y-12	ORNL	K-25
Carbon monoxide	36,807	45,872	12,119
Nitrogen dioxide	648,746	201,090	20,065
Particulates	1,576	5,599	1,137
Sulfur dioxide	268,894	703,419	302
Volatile organic compounds	1,582	1,068	1,011
Chlorine	91	b	1,567
Hydrochloric acid	6,959	b	42
Methanol	26,407	b	b
Nitric acid	9,491	30	b
Perchloroethylene	12,245	b	b
Sulfuric acid	2,424	0	130
Hydrogen fluoride	73	b	b
Mercury	0.01	b	b
Trichloroethane	745	b	b

a. Source: MMES (1993a).

b. No source indicated.

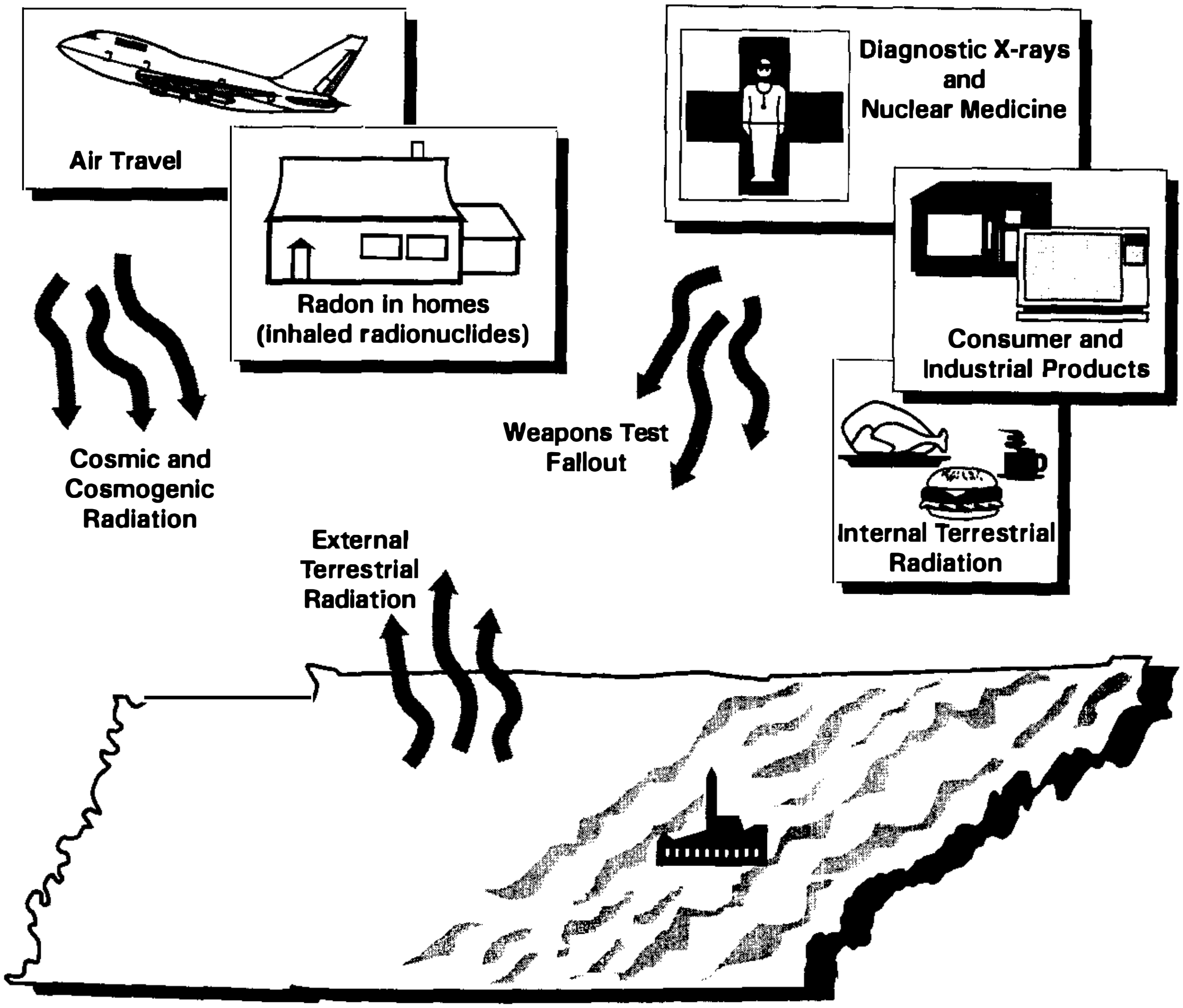
Table 4.7-3. Summary of effective dose equivalents to the public from ORR operations during 1992.[a]

	Maximum exposed individual dose[b]	Collective dose to the population within 80 km of ORR sources[c]
Dose	3.3 mrem	52 person-rem
National Emission Standards for Hazardous Air Pollutants standard	10 mrem per year	--
Percentage of National Emission Standards for Hazardous Air Pollutants	33	--
Natural background dose	295 mrem per year	279,000 person-rem per year
Percentage of natural background dose	1.1	0.019

a. Sources: MMES (1993a); PNL (1988).

b. The maximum boundary dose is to the hypothetical individual who remains in the open continuously during the year at the ORR boundary.

c. Based on estimated population of 910,000 persons within 80 kilometers of the proposed SNF facility site location in 1995.



Natural Background Radiation[a]	millirem per years[b]
Cosmic and cosmogenic radiation	27
External terrestrial radiation	28
Internal terrestrial radiation	40
Radon in homes (inhaled)	200
Other Background Radiation[a]	
Diagnostic X-rays and nuclear medicine	53
Weapons test fallout	<1
Air travel	1
Consumer and industrial products	10
Total	371

[a] From EPA 1981; NCRP 1987; Value for radon is an average for the United States.
[b] Committed effective dose equivalent.

Figure 4.7-2. Sources of radiation exposure, unrelated to Oak Ridge Reservation operations, to individuals in the vicinity of ORR.

Table 4.7-4. Comparison of baseline concentrations with most stringent applicable regulations and guidelines at the ORR.

Criteria pollutant	Averaging time	Most stringent regulation or guideline (μg/m³)	Maximum[a] background concentration (μg/m³)	Maximum existing site contribution (μg/m³)	Total existing maximum concentration (μg/m³)
Carbon monoxide	8-hour	10,000	b	6.9	6.9
	1-hour	40,000	b	24.1	24.1
Nitrogen dioxide	Annual	100	b	2.1	2.1
Lead	Calendar quarter	1.5	b	c	c
Particulate matter less than 10 microns in diameter	Annual	50	8	4.0[d]	12.0
	24-hour	150	54	43.9[d]	97.9
Sulfur dioxide	Annual	80	27	2.3	29.3
	24-hour	365	146	31.8	177.8
	3-hour	1,300	321	80.5	401.5
Total suspended particulates[f]	Annual	50	32	4.0	36.0
	24-hour	150	73	43.9	116.9
Hydrogen	30-day	1.2	0.06	c	0.06
Fluoride	7-day	1.6	0.03	c	0.03
Hydrogen fluorides (as fluorides)	24-hour	2.9	b	c	c
	8-hour	3.7	b	c	c
Hazardous[e] air pollutants					
Chlorine	8-hour	150	b	0	c
Selenium	8-hour	20	b	c	c
Mercury	8-hour	0.5	b	c	c
Chromium	8-hour	5	b	c	c
Chrome	8-hour	5	b	c	c

a. Ambient air quality data (MMES 1992a, 1991a).

b. Not monitored.

c. Not estimated because the potential release is negligible.

d. It is conservatively assumed that data for particulate matter less than 10 microns in diameter (PM_{10}) are total suspended particulates data.

e. State standard.

f. State guideline.

Table 4.7-4 presents the effects of site emissions on local ambient air quality. Concentrations of pollutants obtained from ambient air quality monitoring data are added to pollutant concentrations determined from air dispersion modeling using site-specific emission rates. The resulting sum is used to compare total concentrations to applicable Federal and state criteria pollutant and hazardous/toxic air pollutant guidelines and regulations. All pollutant concentrations of existing emissions at the ORR are below applicable regulations.

4.8 Water Resources

4.8.1 Surface Water

The hydrologic system on the ORR is controlled by the Clinch River (MMES 1994a). The Clinch River flows about 350 miles (560 kilometers) from its headwaters in southwest Virginia, near Tazewell, to its confluence with the Tennessee River at Kingston, Tennessee. Its drainage area is about 4,410 square miles (11,340 square kilometers) (Boyle et al. 1982). All water that drains from the ORR enters the Clinch River and subsequently the Tennessee River.

Flow in the Clinch-Tennessee River system is regulated by multipurpose dams of the Tennessee Valley Authority (TVA). Three dams operated by the TVA control the flow of the Clinch River. Norris Dam, approximately 31 miles (50 kilometers) upstream of the ORR, was constructed to provide flood control and low-flow regulation. Melton Hill Dam, south of the ORNL site, controls the flow of the Clinch River near the ORR. Its primary function is power generation. Flood control is a secondary function. Watts Bar Dam, also used for power generation, is located on the Tennessee River and influences the lower reaches of the Clinch River by creating backwaters that can extend as far upstream as Melton Hill Dam (Oakes et al. 1987).

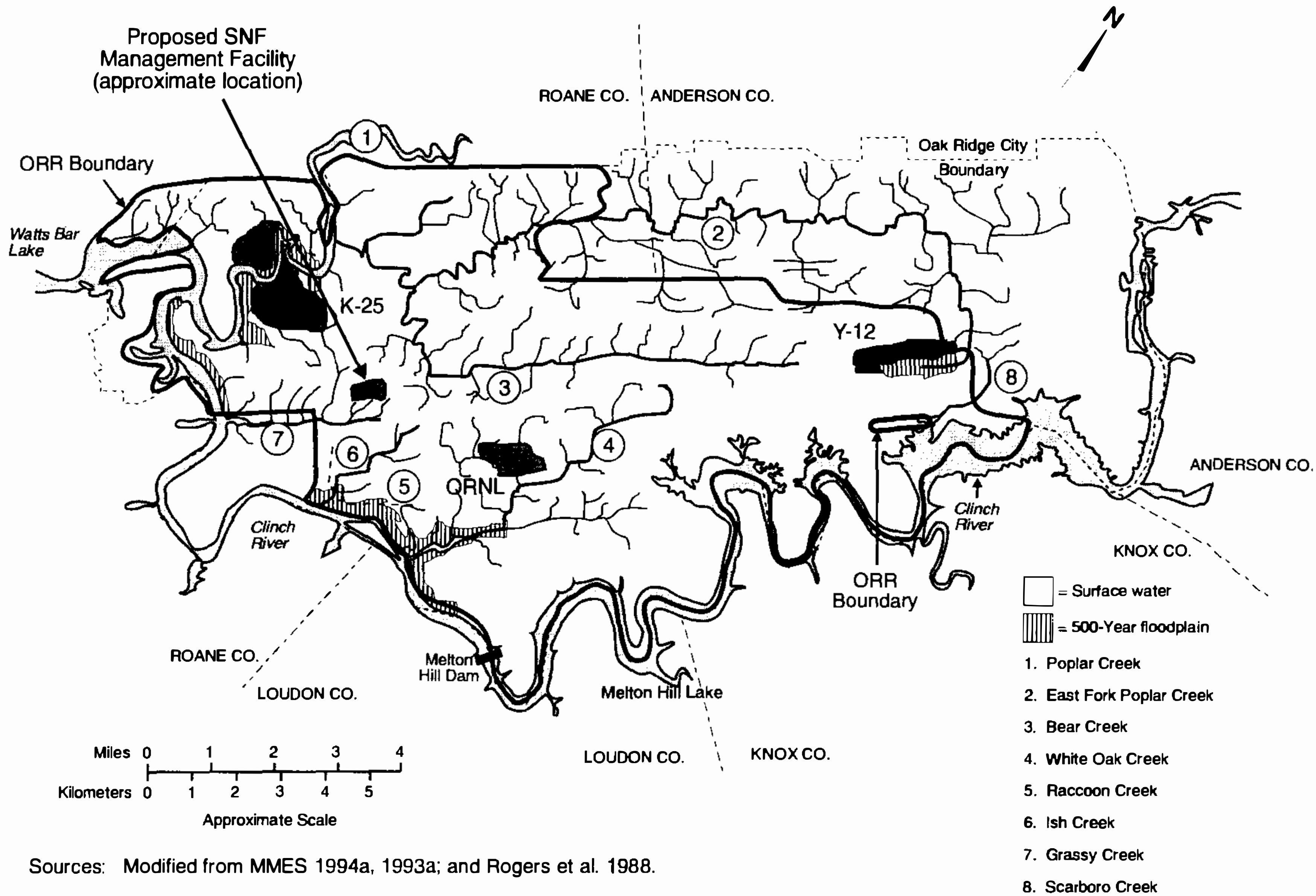
Heavy precipitation in the area causes localized flooding, primarily in the City of Oak Ridge (MMES 1994a) and along the Clinch River. A flood analysis was prepared by the TVA for the ORR (TVA 1991). This analysis provides flood elevations for flooding events in the Clinch River and major tributaries on the ORR. Flooding events analyzed ranged from the 25-year flood (a flood with a 1 in 25 chance of being equaled or exceeded in any given year) to probable maximum flooding events. Approximate 500-year floodplains (1 in 500 chance in any given year) are shown on Figure 4.8-1. Site-specific surveys should he performed to more accurately determine locations of flooding elevations.

The average discharge from Melton Hill Dam between 1963 and 1979 was 5,300 cubic feet (150 cubic meters) per second (Boyle et al. 1982). The average summer (June-September) discharge for the same period was 4,730 cubic feet (134 cubic meters) per second. However, power is generated at Melton Hill Dam to help meet peak loads and, as a result, flow in the Clinch River is pulsed. Periods of no flow at the dam can be followed by periods of flow of up to 20,000 cubic feet (560 cubic meters) per second. Variations in the flow of the Clinch River affect the flow of the tributaries on the ORR. For example, during peak periods of power generation at Melton Hill Dam, flow from White Oak Creek can be blocked or even reversed. The 1992 minimum monthly release at the Melton Hill Dam occurred in May and was 3.5 billion cubic feet (100 million cubic meters) (MMES 1994a).

The ORR is drained by a network of tributaries of the Clinch River (Figure 4.8-1). A statewide stream classification system based on water quality, water use, and resident aquatic biota designates most streams on the ORR for fish and aquatic life, irrigation, and livestock watering (MMES 1992a). For each designated classification, specific water quality criteria are applied, forming the basis for facility-specific National Pollutant Discharge Elimination System permits. No rivers designated as wild and scenic occur on the ORR.

Stream flow on the ORR varies primarily with seasonal precipitation (MMES 1994a). Precipitation varies throughout the year, with the winter months and July experiencing the highest rainfall. Five-year cycles of wet and dry seasons are also evident. Precipitation is lost through evaporation, vegetation uptake. runoff to streams, and to groundwater recharge through the soil.

The drainage pattern on the ORR is a weakly developed "trellis" pattern (Lee and Ketelle 1987). The majority of the small streams are located in the northeast-southwest-trending valleys. Some streams flow across the ridges through water gaps that may have formed due to the presence of structural features (Golder Associates 1988). Karst topography also affects the



Sources: Modified from MMES 1994a, 1993a; and Rogers et al. 1988.

Figure 4.8-1. Locations of the Clinch River and tributaries on the Oak Ridge Reservation.

appearance of surface drainage patterns, primarily because of the presence of sinkholes in areas underlain by the Knox Group.

A number of wetlands occur on the ORR (MMES 1994a). Wetlands are surface features periodically saturated with or covered by water, and have hydric soils and hydrophytic plants. With regards to water resources issues, wetlands absorb flood waters and improve groundwater quality. Characteristic wetlands of the ORR region include forested wetlands along creeks, wet meadows and marshes associated with streams and seeps, and emergent communities in shallow embayments and ponds.

The abundance of limestone and dolomite is reflected by the presence of calcium bicarbonate in the surface waters at the ORR. Water hardness is typically moderate, and the concentrations of total dissolved solids normally range between 100 and 250 milligrams per liter (Rogers et al. 1988).

Measurements of surface water quality and flow are made at a number of sampling stations on and around the ORR. Reference surface waters, ORR surface waters receiving effluents, off-reservation surface waters, and effluents are all sampled and analyzed as part of the surface water monitoring program. Water samples are collected and analyzed for radiological and nonradiological content, and the results are reported yearly in publicly available environmental reports (e.g., MMES 1993a; 1992a; 1991a).

Although bedrock characteristics differ somewhat among the watersheds of these streams, most of the observed differences in water quality are attributed to different contaminant loadings (Rogers et al. 1988). Both wastewater discharges and the groundwater transport of contaminants from waste disposal sites affect water quality in ORR streams. Consequently, a number of surface streams have been contaminated by activities at the ORR (DOE 1992c). In the past, contaminants have been directly released to surface waters on the ORR. Indirect releases via shallow groundwater discharge to surface water streams have occurred in the past and continue to date. For example, activities at the ORNL have contaminated reaches of the White Oak Creek system and Melton Branch with radionuclides, metals, and other hazardous chemicals. The stream channel of Upper East Fork Poplar Creek in the Y-12 Plant area has been contaminated from past activities at the Y-12 Plant. Activities at the Y-12 Plant have also contaminated surface water and groundwater in the Bear Creek Valley with nitrates, volatile organics, radionuclides, and metals beyond the ORR boundary. Operations at the Y-12 Plant have also contaminated Lower East Fork Poplar Creek beyond the ORR boundary with mercury, other metals, organics, and radionuclides. Ultimately, contaminants from all these streams have been discharged to the Clinch River, where sediment contamination is a primary concern.

All effluent discharges to streams are required to meet specified National Pollution Discharge Elimination System permit limits (MMES 1994a). For example, the quality of water in East Fork Poplar Creek partially reflects the influence of the Y-12 Plant and the City of Oak Ridge municipal wastewater treatment facility. Each of the ORR installations has a National Pollution Discharge Elimination System permit. In 1992, more than 400 National Pollution Discharge Elimination System stations were sampled, requiring more than 65,000 water analyses. Significant reductions in the number of noncompliances for the ORR between 1991 to 1992 were engineered especially with respect to the Y-12 Plant. The K-25 Site was in 99.9 percent compliance with discharge limits. The Y-12 Plant was in 99.5 percent compliance with discharge limits. The ORNL was in 99 percent compliance with discharge limits. Table 4.8-1 lists the National Pollution Discharge Elimination System noncompliances by installation and discharge point. At the Y-12 Plant, ORNL, and the K-25 Site, radiological effluents were well within limits at all effluent monitoring locations (MMES 1993a).

Water quality in the Clinch River is affected by ORR activities, by contaminants introduced upstream from the ORR, and by flow regulation at the Tennessee Valley Authority dams. Stream impoundment has resulted in a rise in water temperatures, sediment retention, and contaminant adsorption. Several institutions routinely monitor water quality in the Clinch River. Both the Tennessee Valley Authority and the U.S. Geological Survey monitor just below Melton Hill Dam. The Tennessee Department of Environment and Conservation maintains a monitoring station on the Clinch River about 2 miles (3.2 kilometers) below the mouth of Poplar Creek and the K-25 Site (Rogers et al. 1988).

The Clinch River supplies most of the water to the ORR, the City of Oak Ridge, and other cities along the river (MMES 1994a). Major surface water uses in the Oak Ridge area include

Table 4.8-1. 1992 National Pollutant Discharge Elimination System noncompliance at the ORR.[a]

Installation	Discharge point	Parameter	Percent compliance	Number of samples
Y-12	302 (Rogers Quarry)	pH	99	53
	501 (Central Pollution Control Facility [CPCF-1])	Total toxic organics	91	23
	502 (West End Treatment Facility)	Total suspended solids	98	54
	503 (Steam Plant Wastewater Treatment Facility)	Iron, total	99	158
		Oil and grease	99	157
	Category IV outfalls (untreated process wastewaters)	pH	95	107
	506 (9204-3 sump pump oil)	Oil and grease	98	53
		pH	98	53
	512 (Groundwater Treatment Facility)	Polychlorinated biphenyls	97	37
	Creek Outfalls	Visual	not applicable	22[a]
ORNL	X01 (Sewage Treatment Plant)	Oil and grease	99	157
		Total suspended solids	96	157
	X02 (Coal Yard Runoff Treatment Facility)	Oil and grease	94	34
	Category I outfalls	Oil and grease	33	3
	Category II outfalls	Oil and grease	87	166
		Total suspended solids	91	166
	Cooling systems	Chlorine, total residual	98	45
		Copper, total	98	45
		Zinc, total	98	45
K-25	001 (K-1700 discharge)	Aluminum	96	not available (4)[b]
		Oil and grease	99	not available (1)[b]
	005 (K-1203 sanitary treatment facility)	Chlorine, residual	99	not available (1)[b]
		Fecal coliform, No./100 milliliter	99	not available (2)[b]
		Settleable solids, milliliter/liter	99	not available (1)[b]
	006 (K-1007-B holding pond)	Chemical Oxygen Demand	99	not available (1)[b]
	007 (K-901-A holding pond)	Chromium, total	98	not available (1)[b]
		Suspended solids	98	not available (2)[b]
		Dissolved oxygen	98	not available (6)[b]
	Storm drain	Unpermitted discharge	not applicable	4[b]

a. Source: MMES (1993a).

b. Number of noncompliances.

withdrawals for industrial and public water supplies, commercial and recreational navigation, and other recreational activities such as fishing, boating, and swimming. Five public water supplies are located downstream of the ORR (MMES 1994a). The two nearest are the K-25 Site water treatment plant and the Kingston water treatment plant. These are located 2.5 miles (4 kilometers) above and 21 miles (34 kilometers) below the mouth of Poplar Creek, respectively.

4.8.2 Groundwater

Groundwater beneath the ORR is heavily influenced by the site geologic structure (Solomon et al. 1992). Geologic units of the ORR are assigned to two broad hydrologic groups: (1) the Knox aquifer, formed by the Knox Group and the Maynardville Limestone (carbonate rocks), in which flow is dominated by solution conduits and which stores and transmits relatively large volumes of water; and (2) the ORR aquitards, made up of all other geologic units of the ORR (sandstones, siltstones, and shales), in which flow is controlled by fractures. These aquitards may store fairly large volumes of water, but they transmit only limited amounts.

The hydrologic groups are divided into the near-surface stormflow zone, the vadose zone, the groundwater zone, and the aquiclude (Solomon et al. 1992). Flow in the 3- to 7-foot-deep (1- to 2-meter) deep stormflow zone accounts for approximately 90 percent of the water moving laterally through the subsurface. The stormflow zone can transmit some water laterally to surface streams at approximately 39 feet (12 meters) per hour through large pores; however, less than 1 percent of the total void volume of the zone is large pores. Most water mass resides and migrates through smaller pores in the stormwater zone at rates 10 to 100 times slower. Advective-diffusive exchange between pores substantially reduces contaminant migration rates. A vadose zone between the stormflow and groundwater zones exists at the ORR except where the water table is at the land surface, such as along perennial stream channels. The vadose zone is thickest beneath ridges and thinnest or non-existent in valleys. Most groundwater movement through the vadose zone occurs vertically during precipitation events and occurs along discrete features such as fractures in the bedrock. Measurements of permeability, recharge, and conductivity vary considerably by locality in the vadose zone. Generally, conductivity is less than an inch (on the order of millimeters to centimeters) per day. The groundwater zone is the continuously saturated area in which the remaining 10 percent of lateral sub-surface water movement occurs. Very little water movement occurs in the deep aquiclude layer.

The Knox aquifer is the only true aquifer of the ORR and is the primary source of sustained natural flow in perennial streams such as Upper White Oak Creek, East Fork Poplar Creek, and Bear Creek (Solomon et al. 1992). In some places the Knox aquifer can supply large quantities of water to wells. Flow volumes are significantly larger than in the aquitards, and flow paths are deeper. The potential groundwater flow path length in the Knox aquifer is also substantially greater than in the aquitards--on the order of a few miles or kilometers. The one strongly suspected instance of groundwater flow across the ORR boundary occurs along the northeastern portion of Chestnut Ridge, where water in the Knox aquifer travels along a geological strike northeastward from the Y-12 Plant accross the ORR boundary. In March 1994, DOE announced that elevated levels of four industrial solvents (carbon tetrachloride, chloroform, tetrachloroethylene, and trichloroethylene) had been found in groundwater wells in the Knox aquifer, 2,500 feet east of the Y-12 Plant in the Union Vally Industrial Park (Bowdle 1994). The same solvents are found in groundwater monitoring wells at the Y-12 Plant. DOE is currently investigating the size and direction of the solvent plume. No proposed SNF management facilities would be sited in areas overlying the Knox aquifer.

Virtually all mobile water in the aquitards is discharged to local streams within the ORR. Flow in the ORR aquitards is shallow; about 98 percent occurs at depths of less than 100 feet (30 meters) (Solomon et al. 1992). Water in the aquitards travels through the uppermost part of the groundwater zone along flow paths of up to 1,000 feet (300 meters) in length before being discharged to local surface waters. Groundwater flow volume decreases and solute residence times increase sharply with depth. Mean solute transport rate in the stormflow zone is on the order of meters per hour, but in the intermediate and deep intervals of the groundwater zone, representative transport rates are as low as a few centimeters per year. Additionally, the mobility of most contaminants on the ORR is greatly reduced by sorption onto subsurface solids. Residence times of solutes near the water table in the aquitards range from a few days to a few years. In the intermediate and deep intervals, estimates of residence times range from hundreds to tens of thousands of years. Most groundwater flow in the aquitards occurs through a few widely spaced (23-164 feet [7-50 meters]) permeable regions.

Water in the aquitards is at best a marginal resource (Solomon et al. 1992). A typical well yields under 0.25 gallon per minute (0.02 liter per second). In many places, wells are incapable of producing enough water to support a typical household.

Background groundwater quality at the ORR is generally good in the surficial aquifer zones and poor (because of high total dissolved solids) in the bedrock aquifer at depths greater than 1,000 feet (300 meters) (DOE 1993a). Water in the surficial aquifer is typically a nearly neutral to moderately alkaline calcium bicarbonate type. Transport processes in the subsurface (including diffusion from fractures to the rock matrix, sorption, and exchange) have resulted in an accumulation of contaminants downgradient of the sources (Solomon et al. 1992).

Contaminated sites in need of environmental restoration include past-practice waste disposal sites, waste storage tanks, spill sites, and contaminated inactive facilities (DOE 1993a). Principal groundwater contaminants that exceed applicable standards at the Y-12 Plant include volatile organics, nitrates, heavy metals, and radioactivity (MMES 1993a). 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 (920 meters) southwest of the source. Nitrate is relatively mobile in groundwater and may therefore define the maximum horizontal migration of contamination. At the ORNL, 20 waste area groupings 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 also 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.

In 1989, the Oak Ridge National Laboratory implemented an off-site residential drinking water quality monitoring program (MMES 1993a). The program objective is to document groundwater quality near the ORR and to monitor the potential impact of ORR operations on groundwater quality. Parameters monitored under the program include volatile organics, metals, anions, and various radioactive parameters. Radionuclides and organics have been detected in some of the off-site monitoring wells, however, concentrations have been below drinking water standards. Fluoride has been detected at concentrations exceeding drinking water standards in one of the off-site wells. The high fluoride concentrations and accompanying high pH are most likely attributed to natural chemical reactions in the substrate. No sources or flow paths have been identified for the other constituents detected.

Although surface water sources provide the main portion of potable water supplies in the area, groundwater does provide for some domestic, municipal, farm, irrigation, and industrial use (MMES 1993a). Single-family wells are common in areas not served by public water supplies (MMES 1992a). However, because of the abundance of surface water and its proximity to the points of use, almost no groundwater is used at the ORR (DOE 1993a). Only one supply well exists on the reservation; it provides a supplemental supply to an aquatics laboratory.

All aquifers at the ORR are classified as Class II (DOE 1993a). Class II groundwaters are current and potential sources of drinking water and those waters having other beneficial uses. There are no sole-source aquifers beneath the ORR (DOE 1993a). Water rights are not an issue in the region.

4.9 Ecological Resources

Land for the ORR was primarily in agricultural use at the time of acquisition by the DOE's predecessor agencies. Clearings for orchards and pastures were on some of the upper slopes, rocky areas, and ridgetops; tillage crops were raised on the lower slopes and bottomland. Severe soil erosion also occurred in some areas. Except on very steep slopes, most of the forests had been cut for timber, though not necessarily cleared for agricultural uses. Natural plant communities have since reestablished themselves on most of the ORR, although many areas are maintained as pine plantations or nonforested areas (ORNL 1988). Plant communities at the ORR are characteristic of the intermountain regions of central and southern Appalachia. Approximately 10 percent of the ORR has been developed since it was withdrawn from public access; the remainder of the site has reverted to or been planted with natural vegetation (MMES 1989).

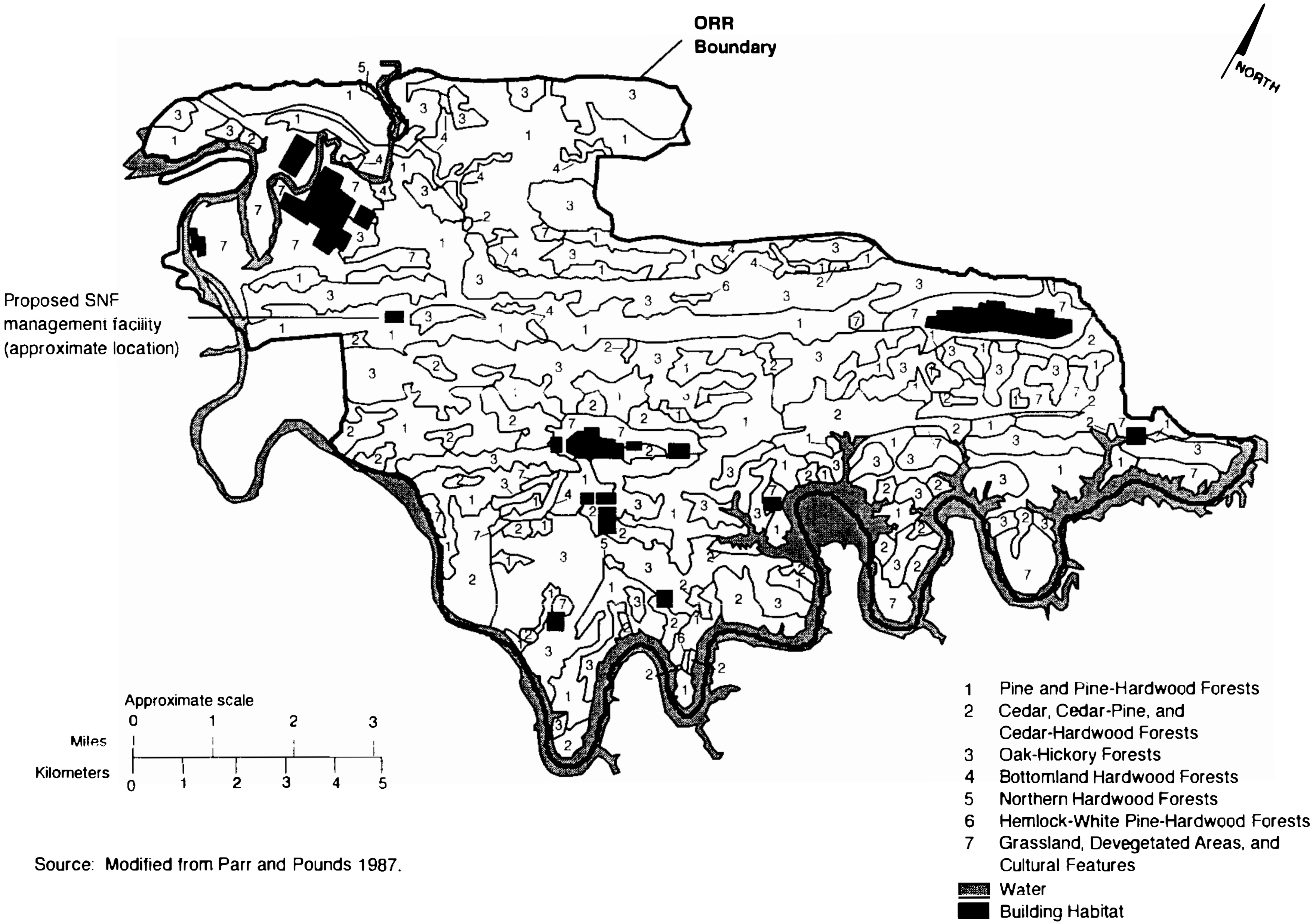
Biotic media, such as fish and deer, that may be affected by the releases or that might provide pathways of exposure to people are included in the environmental surveillance programs at the ORR. Bluegill (*Lepomis macrochirus*) and whitetail deer (*Odocoileus virginianus*) are routinely analyzed for radionuclide contamination. In 1992, the maximum doses to man projected from actual measurements were within the applicable regulatory requirements (see Section 4.12.4 and 4.12.5) (MMES 1993a).

The following describes biotic rcsources at the ORR, including terrestrial resources, wetlands, aquatic resources, and threatened and endangered species. Within each biotic resource area, the discussion focuses first on the ORR as a whole and then on the proposed site.

4.9.1 Terrestrial Resources

The vegetation of the ORR has heen categorized into seven plant communities (Figure 4.9-1) (Parr and Pounds 1987). The pine and pine-hardwood forest is one of the most extensive plant communities on the ORR. Important species of this community type include loblolly pine (*Pinus taeda*), shortleaf pine (*Pinus echinata*), and Virginia pine (*Pinus virginiana*) (Parr and Pounds 1987). Another abundant plant community is the oak-hickory forest, which is commonly found on ridges throughout the ORR. Northern hardwood forest and hemlock-white pine-hardwood forest are the rarest plant community types on the ORR. Currently, timber on the ORR is managed by thinning young stands and harvesting mature stands. Timber is also sold when an area is to he cleared for development (Bradburn 1994). A total of 899 species, subspecies, and varieties of plants have been identified on the ORR (Mann et al. 1985; Cunningham and Pounds 1991).

Thirty areas on the ORR that are representative of the vegetational communities of the southern Appalachian region or that possess unique biotic features have been designated by DOE as National Environmental Research Park Reference Areas (Pounds et al. 1993). Several of these areas are wetlands.



Source: Modified from Parr and Pounds 1987.

Figure 4.9-1. Oak Ridge Reservation plant communities.

The ORR provides habitat for a large number of animal species. Twenty-six species of amphibians, 33 species of reptiles, 169 species of birds, and 39 species of mammals have been recorded (Parr and Evans 1992). Habitats dominated by hardwood trees support the greatest number of wildlife species, followed in order by wetlands, old fields, and pine plantations (ORNL 1988).

Game animals present on the ORR include the whitetail deer, which has been hunted on the reservation since 1985 (MMES 1992b). Animals commonly found on the ORR include the American toad (*Bufo americanus*), eastern garter snake (*Thamnophis sirtalis*), Carolina chickadee (*Parus carolinensis*), northern cardinal (*Cardinalis cardinalis*), white-footed mouse (*Peromyscus leucopus*), and raccoon (*Procyon lotor*). Raptors, such as the red-shouldered hawk (*Buteo lineatus*) and great horned owl (*Bubo virginianus*), and carnivores, such as the gray fox (*Urocyon cinereoargenteus*) and mink (*Mustela vison*), are ecologically important groups on the ORR (Loar et al. 1981).

The surrounding countryside has much greater proportions of cultivated fields, pastures, and residential areas than the ORR, and much more fragmented forest cover. Because of the greater continuity of forests and a lack of human disturbance over much of the ORR, wildlife species that are affected by forest fragmentation offsite may find an abundance of suitable habitat on the ORR. Thus, the ORR may serve as a refuge for wildlife and as a source of wildlife migration (ORNL 1988).

Vegetative communities of the West Bear Creek site are typical of the ORR as a whole, composed of second-growth oak-hickory forest and mixed pine-hardwood forest. There are some loblolly pine plantations adjacent to the northern edge of the powerline right-of-way and between the right-of-way and Bear Creek Road (Rosensteel 1994). There are no National Environmental Research Park Reference Areas on the SNF site. Fauna of the site would also be similar to those expected throughout the ORR.

4.9.2 Wetlands

Wetlands on ORR have recently been evaluated based on National Wetland Inventory maps and field surveys of vegetation (Cunningham and Pounds 1991). Soils and hydrology were not specifically considered in this survey. Wetlands on the ORR include emergent, scrub/shrub, and forested wetland located in embayments of the Melton Hill and Watts Bar Reservoirs that border ORR; along all the major streams, including East Fork Poplar Creek, Poplar Creek, Bear Creek, and their tributaries; in old farm ponds; and around groundwater seeps.

Several well-developed emergent communities greater than 1 acre (0.004 square-kilometers) occur in shallow embayments of the reservoirs. The emergent communities typically grade into marshy areas adjoining forested wetlands. Most forested wetland sites are typically less than 1 acre, although forested wetlands greater than 1 acre are found along the East Fork Poplar Creek and the Clinch River near Gallahar Bridge. Ponds on the ORR vary in size and support diverse flora and fauna. Other wetland areas exist along utility rights-of-way, especially in Bear Creek and Melton Valleys (Cunningham and Pounds 1991).

Originating on the lower slopes of Pine Ridge are several headwater tributary systems of Grassy Creek that flow from north to south across the West Bear Creek site. The stream valleys contain forested wetlands. A powerline right-of-way crosses the stream bottoms, where the vegetation is dominated by wetland scrubs and herbaceous species, of which a portion adjacent to the west boundary has been designated a National Environmental Research Park Natural Area for the protection of state-listed rare plant species.

4.9.3 Aquatic Ecology

Aquatic habitats on or adjacent to the ORR range from small, free-flowing streams in undisturbed watersheds to larger streams with altered flow patterns because of dam construction. These aquatic habitats include tailwaters, impoundments, reservoir embayments, and large and small perennial streams.

Sixty-four fish species have been collected on or adjacent to the ORR. The minnow family has the largest number of species and is numerically dominant in most streams (ORNL 1988). Representative fish species of the Clinch River in the vicinity of the ORR are shad (*Dorosoma sp.*), herring (*Alosa sp.*), common carp (*Cyprinus carpio*), catfish (*Ictalurus sp.*), bluegill, crappie (*Pomoxis sp.*), and drum (*Aplodinotus sp.*) (Loar et al. 1981). Important fish species taken commercially in the ORR area are common carp and catfish. Recreational species include crappie, bass (*Micropterus sp.*), sauger (*Stizostedion canadense*), sunfish (*Lepomis sp.*), and catfish (Rector 1994).

Results from the ORNL monitoring program indicate varying degrees of impact on the benthic communities of the small perennial streams resulting from past waste disposal practices. Portions of these streams are dominated by pollutant-tolerant insect species (Loar 1992).

Portions of certain streams on the ORR have been designated by DOE as National Environmental Research Park Aquatic Natural or Reference Areas. These areas generally represent nonimpacted streams or reaches of streams and are used primarily for reference areas as part of the biological monitoring and abatement programs or environmental remediation efforts at ORR facilities. There are presently eight Aquatic Natural Areas and nine Aquatic Reference Areas (Pounds et al. 1993). Many of the Aquatic Natural Area streams contain the Tennessee dace, a species listed as in need of management by the State of Tennessee.

The aquatic resources occurring in the area of the West Bear Creek site are limited to several headwater tributary systems of Grassy Creek originating on the lower slopes of Pine Ridge and flowing from north to south across or adjacent to the site. Fifteen fish species have been recorded in Grassy Creek.

A National Environmental Research Park Aquatic Reference Area is located along Grassy Creek and its tributaries, one of which runs through the eastern portion of the proposed site. Grassy Creek has a diverse assemblage of invertebrates and fish species for a stream its size. The ORR uses Grassy Creek as a reference area for studies of other streams affected by site development (Pounds et al. 1993).

4.9.4 Threatened and Endangered Species

Federally and state-listed threatened, endangered, or other special-status species designated by the Endangered Species Act and/or the state's Nongame and Endangered Species and the Rare Plant Protection and Conservation Laws that have a reasonable potential for occurrence on the ORR are listed in Table 4.9-1. The table indicates that 25 of these species have recent records of occurrence on the ORR. The potential occurrence of the other 22 species listed is due to historical record, proximity to geographic ranges, and migratory nature of species. No critical habitat for threatened and endangered species, as defined in the Endangered Species Act (U.S. DOI 1992), exists on the ORR.

Although not all of the ORR has been surveyed for rare species, 33 different areas harboring rare plant species (federally or state-listed) have been designated as National Environmental Research Park Natural Areas by DOE (Pounds et al. 1993). The plant species listed in Table 4.9-1 are scattered among these Natural Areas but are not excluded from other areas on ORR. These Natural Areas are designated to provide protection for rare plant and animal species. The designated areas include river and creek bluffs, calcareous barrens, mesic forests, flood plains, and wetland cover classes.

No animal species listed by the Federal Government as threatened or endangered are known to reside on the ORR (Kroodsma 1987). The bald eagle (Federal, endangered) is a winter visitor to Watts Bar Lake and Melton Hill Lake. None of the species listed in Table 4.9-1 have been recorded on the proposed West Bear Creek Valley site. The purple fringeless orchid occurs in a Natural Area adjacent to the western border of the site (Pounds et al. 1993). Pink lady's-slippers are expected to occur throughout the Pine Ridge area (MMES 1992a). Preferred habitat within the site indicates a greater potential for occurrence of the barn owl, black vulture, Cooper's hawk, red-shouldered hawk, and sharp-shinned hawk. Surveys of the proposed site will be required to verify the presence of these and other plant and animal species.

Table 4.9-1. Federally and state-listed threatened, endangered, and other special-status species that potentially occur on or in the vicinity of the Oak Ridge Reservation.[a]

Common name	Scientific name	Status[b]	
		Federal	State
Plants			
Appalachian bugbane[c]	*Cimicifuga rubifolia*	C2	T
Butternut	*Juglans cinerea*	C2	T
Canada (wild yellow) lily[c]	*Lilium canadense*	NL	T
Carey's saxifrage[c]	*Saxifraga careyana*	NL	S
Fen orchid[c]	*Liparis loeselii*	NL	E
Ginseng[c]	*Panax quinquefolius*	NL	T
Golden seal[c]	*Hydrastis canadensis*	NL	T
Gravid sedge[c]	*Carex gravida*	NL	S
Lesser lady's tresses[c]	*Spiranthes ovalis*	NL	S
Michigan lily	*Lilium michiganense*	NL	T
Mountain witch alder[c]	*Fothergilla major*	NL	T
Northern bush honeysuckle[c]	*Diervilla lonicera*	NL	T
Nuttall waterweed[c]	*Elodea nuttallii*	NL	S
Pink lady's-slipper[c]	*Cypripedium acaule*	NL	E
Purple fringeless orchid[c]	*Platanthera peramoena*	NL	T
Spreading false foxglove[c]	*Aureolaria patula*	C1	T
Tall larkspur[c]	*Delphinium exaltatum*	C2	E
Tubercled rein-orchid[c]	*Platanthera flava* var. *herbiola*	NL	T
Virginia spiraea	*Spiraea virginiana*	T	E
Fish			
Flame chub	*Hemitremia flammea*	NL	D
Tennessee dace[c]	*Phoxinus tennesseensis*	NL	D
Amphibians			
Green salamander	*Aneides aeneus*	NL	D
Hellbender[c]	*Cryptobranchus alleganiensis*	C2	D
Tennessee cave salamander[d]	*Gyrinophilus palleucus*	C2	T
Reptiles			
Cumberland turtle	*Chrysemys scripta troosti*	NL	D
Eastern slender glass lizard	*Ophisaurus attenuatus longicaudus*	NL	D
Northern pine snake	*Pituophis melanoleucus*	C2	T
Six-lined racerunncr[d]	*Cnemidophorus sexlineatus*	NL	D
Birds			
Bachman's sparrow	*Aimophila aestivalis*	C2	E
Bald eagle[e]	*Haliaeetus leucocephalus*	E	E

Table 4.9-1. (continued).

Common name	Scientific name	Status[b] Federal	State
Birds (continued)			
Barn owl[c]	*Tyto alba*	NL	D
Bewick's wren	*Thyromanes bewickii altus*	C2	T
Black-crowned night heron[c]	*Nycticorax nycticorax*	NL	D
Black vulture[c]	*Coragyps atratus*	NL	D
Cooper's hawk[c]	*Accipiter cooperii*	NL	T
Grasshopper sparrow	*Ammodramus savannarum*	NL	T
Northern harrier	*Circus cyaneus*	NL	T
Osprey[c]	*Pandion haliaetus*	NL	E
Peregrine falcon	*Falco peregrinus*	E	E
Red-shouldered hawk[c]	*Buteo lineatus*	NL	D
Redheaded woodpecker	*Malanerpes erythrocephalus*	NL	D
Sharp-shinned hawk[c]	*Accipiter striatus*	NL	T
Mammals			
Eastern woodrat	*Neotoma floridana magister*	C2	D
Gray bat	*Myotis grisescens*	E	E
Indiana bat	*Myotis sodalis*	E	E
Smoky shrew	*Sorex fumeus*	NL	D
Southeastern shrew	*Sorex longirostris*	NL	D

a. Sources: Barclay (1990, 1992); Bay (1991); Cunningham et al. (1993); Hardy (1991), Hardy et al. (1992); Kitchings and Story (1984); Kroodsma (1987); ORNL (1981); ORNL (1988); TDEC (1992a, 1992b, 1992c, 1992d); TWRC (1991a, 1991b); U.S. DOI (1990, 1991, 1992).

b. Status codes:
C1 = Federal Candidate - Category 1 (probably appropriate to list)
C2 = Federal Candidate - Category 2 (possibly appropriate to list, more study required)
D = species deemed in need of management
E = endangered
NL = not listed
S = species of special concern
T = threatened, more study required

c. Recent record of species occurrence on the ORR.

d. Species collected on the ORR in 1964 (ORNL 1988).

e. Observed near ORR on Melton Hill and Watts Bar Lakes.

4.10 Noise

The major noise sources within the ORR occur primarily in developed operational areas and include various facilities, equipment, and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles). Major noise sources outside the operational areas consist primarily of vehicles and railroad operations. At the site boundary, away from most of these activities, noise from these sources would be barely distinguishable from background noise levels. Some disturbance of wildlife activities might occur on the ORR as a result of operational activities and construction activities.

Sound-level measurements have been made around the ORR in the process of testing sirens and preparing support documentation for the Atomic Vapor Laser Isotope Separation site (Cleaves 1991). The acoustic environment along the ORR site boundary in rural areas and at nearby residences away from traffic noise is typical of a rural location, with the average day-night sound level in the range of 35 to 50 decibels, A-weighted. Areas near the site within Oak Ridge are typical of a suburban area with the average day-night sound level in the range of 53 to 62 decibels, A-weighted (EPA 1974). The primary source of ORR noise at the site boundary and at residences near the site boundary is traffic, including trucks, private vehicles, and freight trains. During peak hours, plant vehicular traffic is a major contributor to traffic noise levels in the area. In addition, some noise due to air cargo and business travel via commercial air transport through the airport at Knoxville can be attributed to ORR operations. Section 4.11 (Traffic and Transportation) discusses vehicular, air, and rail transportation.

The State of Tennessee has not established specific numerical environmental noise standards applicable to the ORR. The City of Oak Ridge has specified allowable noise levels at property lines as shown in Table 4.10-1.

During a normal week, about 17,000 employees travel to the ORR each day in private vehicles from surrounding communities. In addition, both government-owned and private trucks pick up and deliver materials at the site. Based on the number of employees, it was estimated that about 33,000 vehicle trips are generated to and from the site each day; mostly on Tennessee

Table 4.10-1. City of Oak Ridge maximum allowable noise limits applicable to the ORR.[a]

Adjacent uses	Where measured	Maximum sound level (dBA)[b]
All residential districts	Common lot line	50
Neighborhood business district	Common lot line	55
General business district	Common lot line	60
Industrial district	Common lot line	65
Major streets	Street lot line	75
Secondary residential streets	Street lot line	60

a. Source: City of Oak Ridge (1984).

b. Decibels, A-weighted.

State Routes 58, 62, 95, and 162, which pass through the ORR and are open to the general public. Both government-owned and private trucks pick up and deliver materials at the site. The contribution of ORR operations to traffic volumes along these routes, especially during peak traffic periods, affects noise levels in the immediate vicinity of the ORR and through the City of Oak Ridge.

Use of the railroad branches from the CSX and the Norfolk Southern Corporation lines to deliver and pick up shipments at the ORR may cause some noise impacts along these routes. Twice a week service is scheduled to Y-12 from the CSX line. However, only 60 cars were delivered in 1993. Service to K-25 is provided as needed. Only three or four trains serviced K-25 in 1993. However, two or three trains per week may be required beginning in 1994 (Pearman 1994). Noise sources from rail transport include diesel engines, wheel-track contact, and whistle warnings at rail crossings.

4.11 Traffic and Transportation

Traffic congestion is measured by level of service. Level of service A represents free flow of traffic. Level of service B is in the range of stable flow, but the presence of other users in the traffic stream begins to be noticeable. Level of service C is in the range of stable flow, but marks the beginning of the range of flow in which the operation of individual users becomes significantly affected by interactions with others in the traffic stream. Level of service D represents high-density, but stable, flow. Level of service E represents operating conditions at or near the capacity level. Level of service F is used to define forced or breakdown flow. The calculated level of service are for discrete locations along a segment. Level of service will most likely be worse in urban areas and better in rural areas along the segment.

The Region of Influence for the ORR includes site roads and regional roads in Anderson, Blount, Knox, Loudon, and Roane counties. Regional and local transportation routes are presented in Figure 4.11-1 and Figure 2.1-2.

Primary roads on the ORR include Tennessee State Routes 95, 62, 162, and 170 (Bethel Valley Road), and Bear Creek Road. Except for Bear Creek Road, all are public roads. The remaining roads on the ORR are private. Interstate 75 and Tennessee State Routes 162, 62, and 61 form a loop around ORR. Bear Creek Road, Bethel Valley Road, Tennessee State Routes 62

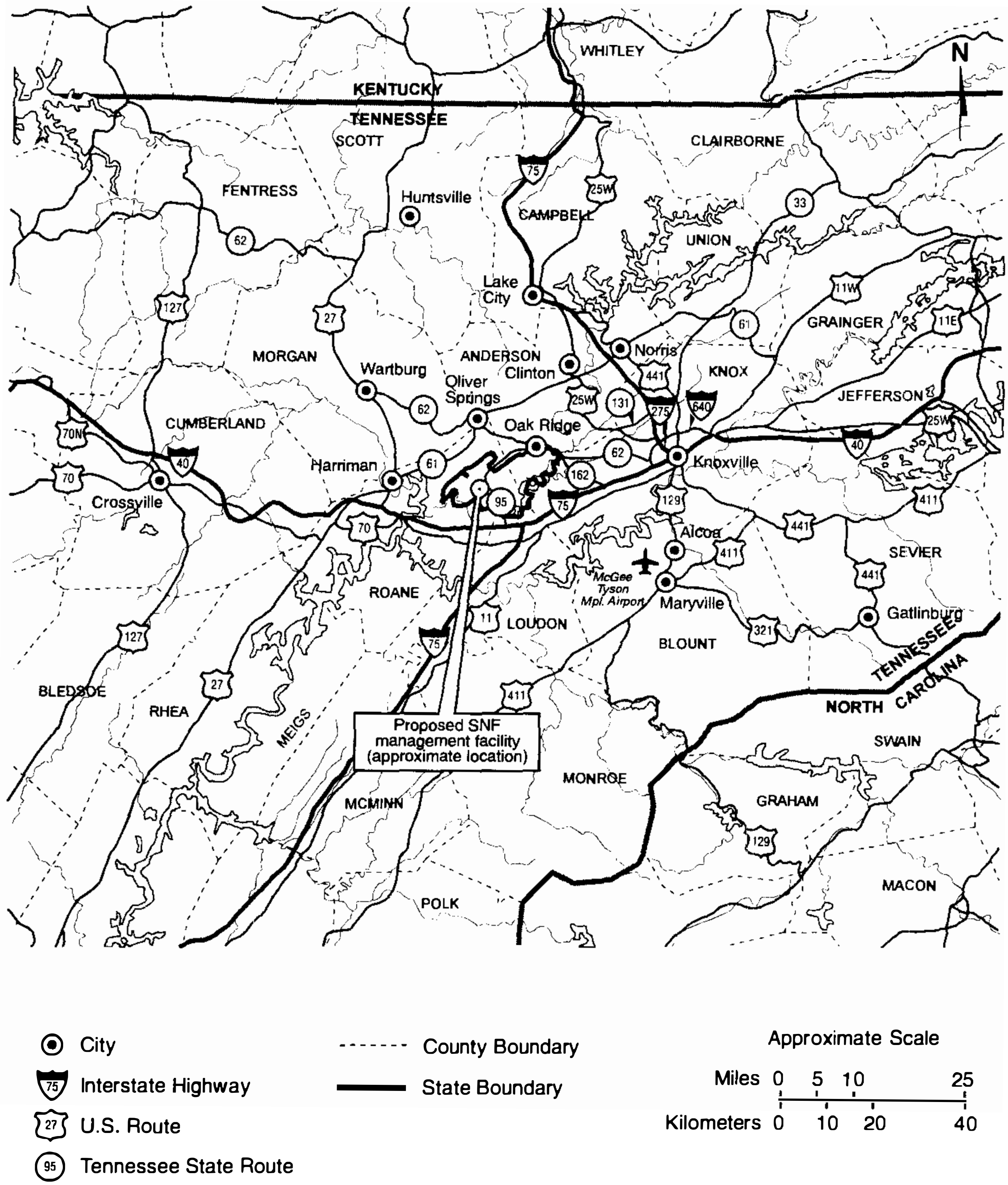


Figure 4.11-1. Oak Ridge Reservation regional transportation map.

and 95 experience high average traffic and peak hour volume. Other areas on the site that have traffic problems include Scarboro Road, security entrances, and intersections.

Current baseline traffic (i.e., 1995) along segments providing access to the ORR is projected to contribute to differing service level conditions (TDOT 1993). Tennessee State Route 61 would operate at level of service D between Interstate 75 at Norris and U.S. Route 25W at Clinton, and at level of service C between U.S. Route 25W at Clinton to Tennessee State Route 62 east of Oliver Springs. Tennessee State Routes 58 and 170 (providing access from the east), as well as Bear Creek Valley Road, would operate between level of service D and B. Tennessee State Routes 62 and 95 would operate at widely varying levels of service in the vicinity of ORR. Tennessee State Route 62 would operate at a level of service E between Tennessee State Route 95 at Oak Ridge and Tennessee State Route 170. Tennessee State Route 95 would operate at a level of service E between Tennessee State Route 61 and Tennessee State Route 62 at Oak Ridge.

Road reconstruction, widening, modification of interchanges, and new interchange construction projects are planned for segments of Bear Creek Valley Road, Scarboro Road, and Tennessee State Routes 58, 62, and 95 (Johnson, C. 1994; MMES 1991b).

Current baseline traffic along segments providing regional access to the ORR is projected to contribute to differing service level conditions. Interstate 40 passes within 5 miles (8 kilometers) to the south of the ORR. It has a level of service of A to B between U.S. Route 27 at Harriman to Interstate 75, which passes northeast about 11 miles (18 kilometers) and south about 3 miles (5 kilometers) of the ORR. U.S. Route 25W passes the ORR about 10 miles (16 kilometers) to the east and northeast. It has a level of service of D to E between Interstate 75 at Lake City to Tennessee State Route 131.

In 2001, when site-related impacts are at their highest along segments providing access to the ORR, background traffic is projected to contribute to differing service level conditions for local roads. Tennessee State Route 61 would operate at level of service D between Interstate 75 at Norris and U.S. Route 25W at Clinton and level of service C between U.S. Route 25W at Clinton to Tennessee State Route 62 east of Oliver Springs. Tennessee State Routes 58 and 170 as well as Bear Creek Valley Road would operate between level of service D and B. Tennessee State Routes 62 and 95 would operate at widely varying levels of service in the vicinity of the

ORR, with a level of service F between Tennessee State Route 95 at Oak Ridge and Tennessee State Route 162. U.S. Routes 11/70 would operate at level of service F between Tennessee State Route 131 and U.S. Routes 11E/11W Split. All other local roads operate at level of service E or better (University of Tennessee 1993). Interstate 40 has a level of service B to D between U.S. Route 27 at Harriman to Tennessee State Route 162.

The level of service was calculated using average daily traffic counts (TDOT 1990) and standard parameters (ITE 1991; TRB 1985; Rand McNally 1993).

No public transportation service exists in the City of Oak Ridge. Other modes of transportation within the Region of Influence include railways and waterways. Railroad service in the Region of Influence is provided by CSX Transportation and the Norfolk Southern Corporation. Two main lines serve the ORR. A CSX Transportation spur line serves the ORR site as well as the City of Oak Ridge. Waterborne transport in the Region of Influence is via the Clinch River, which provides an alternative mode of transportation to the Oak Ridge area. The Clinch River waterway has rarely been used for DOE business, and no designated port facilities exist for such purposes (Corps 1991).

McGhee Tyson Airport in Knoxville, 40 miles (64 kilometers) from the ORR, receives jet air passenger and cargo services from both national and international carriers. The closest air transportation facility to ORR is Atomic Airport in Oliver Springs. Numerous other private airports are located throughout the Region of Influence (DOT 1991).

4.12 Occupational and Public Health and Safety

The Department of Energy's Oak Ridge Reservation released chemicals and small quantities of radionuclides to the environment from operations at all facilities during 1992. These releases are quantified and characterized in detail in the Oak Ridge Environmental Report for 1992. This release information, along with estimates of the potential consequences resulting from these releases, is summarized in greater detail within sections 4.7, 5.7, 4.8, and 5.8 for the purpose of characterizing the existing radiation and chemical environment. The ORR baseline data presented within this section are expected to remain essentially constant between 1992 and 1995 (the year in which SNF operations are expected to commence).

Health effects from radiation are presented here as the risk of fatal cancer. This risk is in the ratio of the health risk estimator (risk of fatal cancer per rem of exposure). The value of this estimator for exposures to the public is 5×10^{-4} for fatal cancers. The corresponding estimator for exposures to workers is 4×10^{-4}.

4.12.1 Atmospheric Emissions and Doses

Table 4.7-1 in Section 4.7 illustrates the breakdown of radioactive emissions to the atmosphere from each of the three ORR operations areas (ORNL, K-25, and Y-12), during 1992. The calculated total dose of 3.3 millirem/year due to 1992 operations, to the maximally exposed individual at the site boundary, is well within the 10 millirem/year limit given in 40 CFR Part 61 (the U.S. Environmental Protection Agency's National Emission Standards for Hazardous Air Pollutants) (MMES 1993a).

The concentrations at the ORR boundary of all radionuclides released to the atmosphere from the three operations areas in 1992 were less than 1 percent of the DOE Derived Concentration Guide, which is based upon an exposure of 100 millirem; this equates to a dose of less than 1 millirem (MMES 1993a).

The associated isotopic gaseous release cancer risks are presented within Section 4.12.4.

Table 4.7-2 in Section 4.7 presents the chemical releases for 1992 in a fashion analogous to Table 4.7-1. All of these releases are within permitted levels. The associated chemical release cancer risks are presented within Section 4.12.6.

4.12.2 Groundwater/Surface Water Contamination and Doses

Referring to the various water contamination data presented in Section 4.8, it was found that a plausible 0.62 mrem/year of site operation could be incurred by a potential maximally exposed individual at the site boundary due to water ingestion, fish ingestion, and other associated factors (see Table 4.12-1) (MMES 1993a).

Additionally, a dose of 17 mrem/year of site operation could be incurred by this potential maximally exposed individual, due to external exposure from contaminated liquid effluents (see

Table 4.12-1. Summary of estimated radiation dose to public from 1992 operations at ORR.

Pathway	Location of maximally exposed individual	Committed effective dose equivalent to maximally exposed individual (mrem)	Collective committed effective dose equivalent (person-rem)[a]
Gaseous effluents	Nearest resident to		
Inhalation plus direct radiation from air, ground, and food chains	Y-12 Plant	2.7	29
	ORNL	0.06	2
	K-25 Site	0.53	21
	ORR	3.3	52
Liquid effluents			
Drinking water	Gallaher	0.2	0.85
Eating fish	Poplar Creek	0.4	1.0[b]
Other activities	Poplar Creek	0.02	
Direct radiation[b]	Clinch River shoreline	2	
	Poplar Creek (K-25 Site)	15	

a. Within 80 kilometers (50 miles) of the ORR.

b. Includes doses from all liquid pathways (MMES 1993a).

Table 4.12-1). Fifteen mrem/year of this dose would result from a hypothetical individual fishing for 250 hours/year along Poplar Creek near the K-25 storage areas (MMES 1993a).

The associated cancer risks related to these doses are presented in Section 4.12.4.

4.12.3 External Gamma Radiation

External gamma radiation measurements were made with thermoluminescent dosimeters at locations coinciding with the ambient air locations. The average external gamma radiation level at the ORR perimeter for 1992 was 7.6 microroentgens per hour. All of the measurements were well within the range of typical values for cities in the United States (MMES 1993a).

4.12.4 Radiation Dose and Health Effects Summary (Public and ORR Workers)

A summary of the effective dose equivalents to the hypothetical maximally exposed individual from the important pathways of exposure during 1992 is presented in Table 4.12-1. If the resident who receives the highest effective dose equivalent (3.3 millirem) from gaseous effluents also drank water from the Gallaher area (0.2 millirem), and went fishing at Poplar Creek (for 250 hours/year) near the K-25 site (15 millirem), that individual would receive a total effective dose equivalent of approximately 18.5 millirem, which is roughly 6.3 percent of the annual dose (295 millirem) from natural background radiation (see Figure 4.7-2). All of these doses are within the applicable regulatory requirements, (i.e., 4 millirem/year from the drinking water pathway, 10 millirem/year from the airborne release pathways, and 100 millirem/year total for all pathways) (MMES 1993a).

The risk of fatal cancer to the maximally exposed individual at the site boundary (due to atmospheric emissions only) is 1.7×10^{-6} per year of operation, and the corresponding (ingestion) risk to this maximally exposed individual from drinking water is 1.0×10^{-7} per year of operation. The risk of fatal cancer from direct radiation due to an individual's spending 250 hours/year fishing at Poplar Creek (K-25 Site) is 7.5×10^{-6} per year of exposure. A more realistic maximally exposed individual scenario from direct radiation, an individual spending 250 hours/year along the Clinch River shoreline near a field on which cesium-137 experiments were performed, yields an associated risk of 1×10^{-6}. The resulting risk to the maximally exposed individual is 9.2×10^{-6} per year of operation; over the 40-year SNF management facility lifetime this risk would be 3.7×10^{-4}.

Table 4.12-1 also includes the collective doses to the general population within 50 miles (80 kilometers) of the ORR. It was found that approximately 54 person-rem (which translates to an expected 0.027 fatal cancer) were received (from liquid and gaseous effluents) by this population from 1992 ORR operations. Thus, over a 40-year period, there would be approximately 1.1 fatal cancers expected.

Doses to onsite workers at the ORR have been reported by DOE for 1991 operations. Of the approximately 17,000 workers monitored, the maximally exposed individual was reported to receive 1 to 2 rem (assumed as 2 rem), which is well below the DOE guidelines of 5 rem (DOE 1992a). The average dose to workers at the site was 2.8 mrem/yr. The risk of fatal cancer to the average worker is 1.1×10^{-6} per year of operation; the risk to a worker who spent 40 years at ORR is approximately 4.5×10^{-5}. Additionally, the total collective (population) dose received by these workers was 48 person-rem, which corresponds to 0.019 fatal cancers per year of exposure. Over a 40-year period, there would be an expected 0.76 fatal cancer to this worker population.

4.12.5 Health Effects Studies

Two epidemiologic studies were conducted to determine whether the ORNL facility contributed to any excess cancers in the communities surrounding the facility. One study found no excess cancer mortality in the population living in counties surrounding ORNL when compared to the control populations located in other nearby counties and elsewhere in the United States (Jablon et al. 1991). The other found slight excess cancer incidences of several types in the counties near ORNL, but none of the excess risks were statistically significant (Sharpe 1992).

An Oak Ridge health assessment study is ongoing. This study will include a reconstruction of doses received by the public from historical releases of radioactivity from the reservation. To date, a Phase I report has been issued (Tennessee Department of Health and the Oak Ridge Health Agreement Steering Panel 1993).

Studies of workers at Oak Ridge National Laboratory (Jablon et al 1991; Wing et al. 1993) showed an excess of leukemia deaths among maintenance workers and engineers who had worked for more than 10 years, suggesting a possible excess attributed to exposures other than radiation. An increase of 2.68 percent in deaths from all causes and 4.94 percent for all cancers with every rem of cumulative dose exposure with a 20-year exposure lag was also reported. Excess cancer deaths were associated with working in radioisotope production and chemical operations but not with work in physics, engineering, or unknown job categories. Cancer mortality was also associated with exposure to beryllium, lead, and mercury.

In March 1990, the Secretary of Energy announced that DOE would turn over responsibility for analytical epidemiologic research on long-term health effects on workers at DOE facilities and surrounding communities to the Department of Health and Human Services, and directed that worker health and exposure data be released. A Memorandum of Agreement with the Department of Health and Human Services was signed in January 1991. The Department of Health and Human Services is now conducting the ongoing health effects research program. To develop a database on workers, DOE has initiated an Epidemiologic Surveillance Program and Health-Related Records Inventory.

4.12.6 Chemical Dose and Health Effects Summary

Table 4.7-2 in Section 4.7 presents the ORR chemical releases for 1992. Exposure to chemicals released from the ORR was compared with acceptable levels of exposure (no adverse effect from noncarcinogens) for the ingestion exposure pathway via drinking water and consumption of fish. Aluminum, nitrate, and polychlorinated biphenyls were measured above acceptable levels in upper Bear Creek; the ratios of their doses to acceptable doses were 3.4, 2.2, and 11.1, respectively. The only other chemical exposure attributable to ORR operations that was found to exceed acceptable levels was mercury. This noncarcinogen was found in fish caught from the Clinch River. The ratio of the mercury dose to acceptable dose levels was found to be 1.1 (MMES 1993a).

Because of concerns for possible contamination of the population by mercury, the Tennessee Department of Health and Environment conducted a pilot study in 1984. The study showed no difference in urine or hair mercury levels between individuals with potentially high mercury exposures (residence or activity in contaminated areas based on soil measurements or consumption of fish caught in the contaminated areas) and those with little potential exposure. Mercury levels in some soils measured as high as 2,000 parts per million. Analysis of a few soil samples showed that most of the mercury in the soil was inorganic, however, thereby lowering the probability of bioaccumulation and health effects. Planned occupational studies at the ORR include a 24-month clinical follow-up of 111 heavily exposed mercury workers (Wing et al. 1991).

4.13 Utilities and Energy

4.13.1 Water Consumption

Both the Clinch River and the Melton Hill Reservoir supply water to the ORR. Because they are a part of the TVA flood control system, they are capable of maintaining a constant volume of water well in excess of the demands of the ORR (MMES 1993a).

In 1995, water supply facilities at the ORR will have a capacity of approximately 1,761 liters per second (27,916 gallons per minute). In 1993, the average demand for water on the ORR water supply facilities was approximately 801 liters per second (12,708 gallons per minute) (Fritts 1994).

A pumping station near Y-12 on the Melton Hill Reservoir supplies untreated water to the DOE water treatment plant. After treatment, the water is stored in two reservoirs with a combined capacity of 26 million liters (7 million gallons). From the reservoirs, water is supplied by gravity flow to the Y-12 operations site, ORNL, the Scarboro Facility (which houses the Oak Ridge Institute of Science and Education's Energy/Environmental Systems Division), and the City of Oak Ridge (MMES 1994a).

A pumping station on the Clinch River provides water to the K-25 water system. After treatment, the water is stored in two water storage tanks on Pine Ridge. This system provides water to the K-25 Site, the Transportation Safeguards Facility, and the city's Clinch River Industrial Park (MMES 1994a).

The SNF facilities will be supplied with water from the K-25 water system. In 1995, the K-25 water system will have a capacity of approximately 184 liters per second (2,917 gallons per minute). In the years 1988 to 1994, K-25 water usage varied from a high of 97 liters per second (1,533 gallons per minute) in 1990 to a low of 78 liters per second (1.235 gallons per minute) in 1988. In 1994, the average demand was 84 liters per second (1,324 gallons per minute). Significant growth in water capacity or demand is not expected (Fritts 1994).

4.13.2 Electrical Consumption

The ORR electrical system is supplied power from four major power sources in the TVA system: Kingston Steam Plant, Bull Run Steam Plant, Wolf Creek Hydroelectric Plant, and Fort Loudon Hydroelectric Plant. The K-25 Power Operations Department manages and operates the electrical transmission and substation system of the ORR (MMES 1994a).

Three substations located at the K-25, Y-12, and ORNL sites comprise the ORR power system. The substations are tied together onsite by five DOE 161-kilovolt transmission lines. Power is supplied to ORR substations by six TVA electrical lines at 161 kilovolts, which is reduced to 13.8 kilovolts for distribution (MMES 1994a).

In 1995, the connected capacity of ORR facilities would be approximately 920 megavolt-amperes. From 1989 through 1993, the peak demand of electricity varied from a high of 116 megavolt-amperes in 1989 to a low of 98 megavolt-amperes in 1993 (Fritts 1994).

4.13.3 Fuel Consumption

The East Tennessee Natural Gas Company supplies natural gas to the ORR, transporting the gas from the supply areas through upstream pipelines and then through its own pipeline system for ultimate delivery to the ORR (MMES 1994a). By contract, ORR natural gas capacity is 7,600 decatherms. This amount can be increased if necessary. In 1994, the average daily usage of natural gas was 3,600 decatherms (Fritts 1994).

Coal is used to produce steam at ORNL and as a backup fuel at the Y-12 steam plant. Y-12 plans to use more coal in the future as a replacement for natural gas (Fritts 1994).

4.13.4 Wastewater Disposal

The ORR does not have a centralized sewage system for all facilities. The K-25 Site and ORNL have their own sewage systems, while Y-12 shares sewage lines with the City of Oak Ridge (MMES 1994a).

The sanitary sewage effluent from the Y-12 operations area flows to the Oak Ridge West End Treatment Plant. DOE maintains the sewage lines extending from Y-12 to the east end of the security road (Bear Creek Road). The City of Oak Ridge maintains the sewage lines from the end of the security road to the treatment plant on West Oak Ridge Turnpike (MMES 1994a).

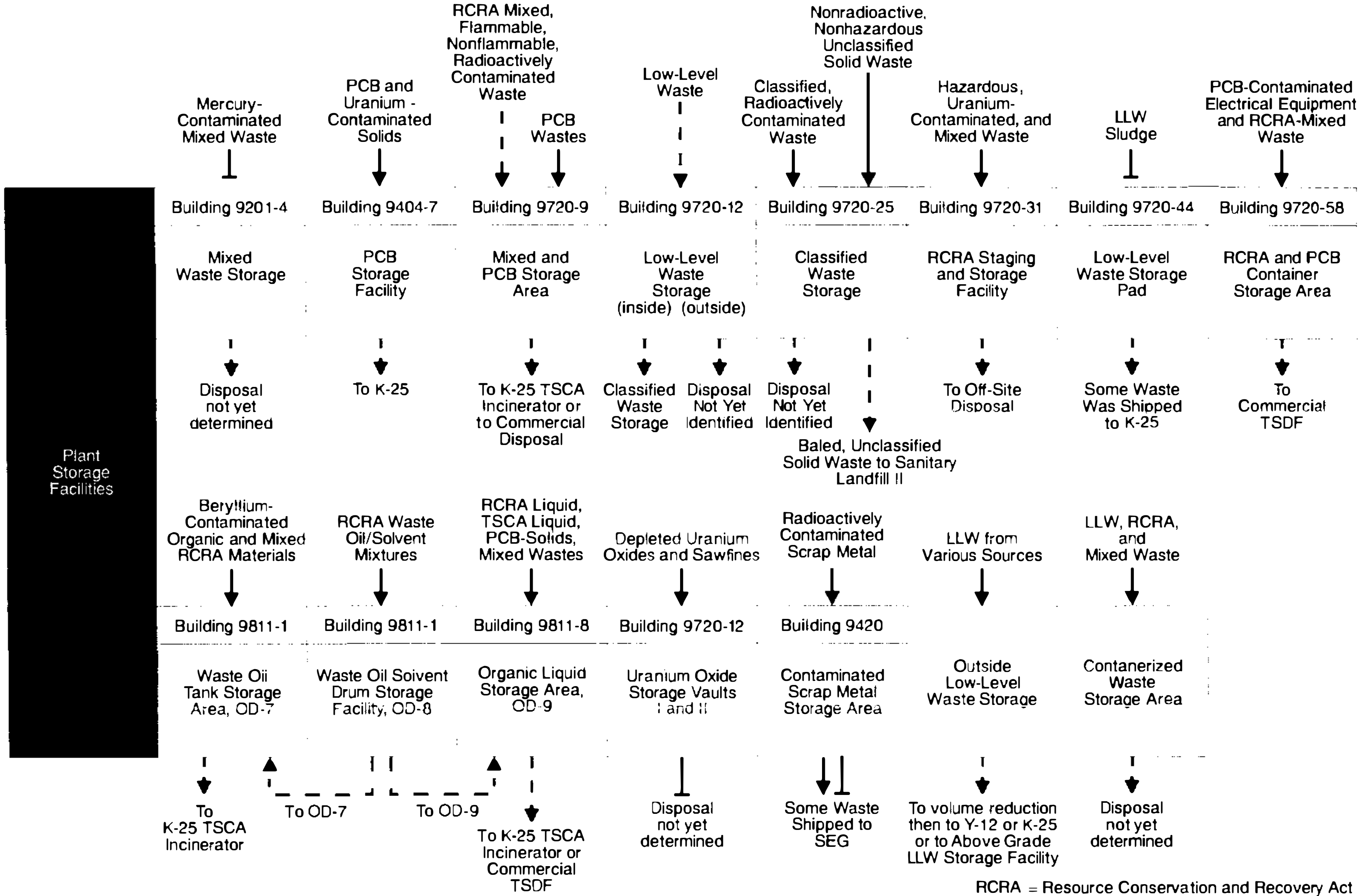
The sewage treatment plant for ORNL discharges treated effluent into White Oak Creek in full compliance with all permit requirements (MMES 1994a). There are no anticipated capacity problems with the K-25 sanitary sewage system, which is permitted by the National Pollution Discharge Elimination system (MMES 1994a).

The SNF management facility could use the K-25 sanitary sewer treatment system, located directly north of the proposed SNF site. The K-25 system has a capacity of 26 liters per second (417 gallons per minute). From 1988 to 1994, wastewater production peaked at 24 liters per second (378 gallons per minute) during wet conditions in 1994 (Fritts 1994). As an alternative, a new onsite sanitary sewage system and wastewater treatment plant might be required for the proposed SNF management facility.

4.14 Materials and Waste Management

This section describes the hazardous materials management (chemical raw materials), the waste categories, and the ongoing waste management activities, including onsite treatment, onsite storage, onsite waste disposal, and preparation for appropriate offsite disposal, for the three primary complexes within the ORR: the Y-12 Plant, the K-25 Site, and the ORNL (see Figure 2.1-2). Ongoing nuclear-related activities at the ORR have resulted in the generation of low-level, mixed low-level, hazardous, transuranic, spent nuclear fuel (see Chapter 2 for discussion), and industrial solid waste categories, which are discussed in this section. Section 4.8 discusses nonhazardous liquid waste treatment. A description of the Y-12 Plant, the K-25 Site, and ORNL waste categories and the waste management process unique to each of these complexes follows.

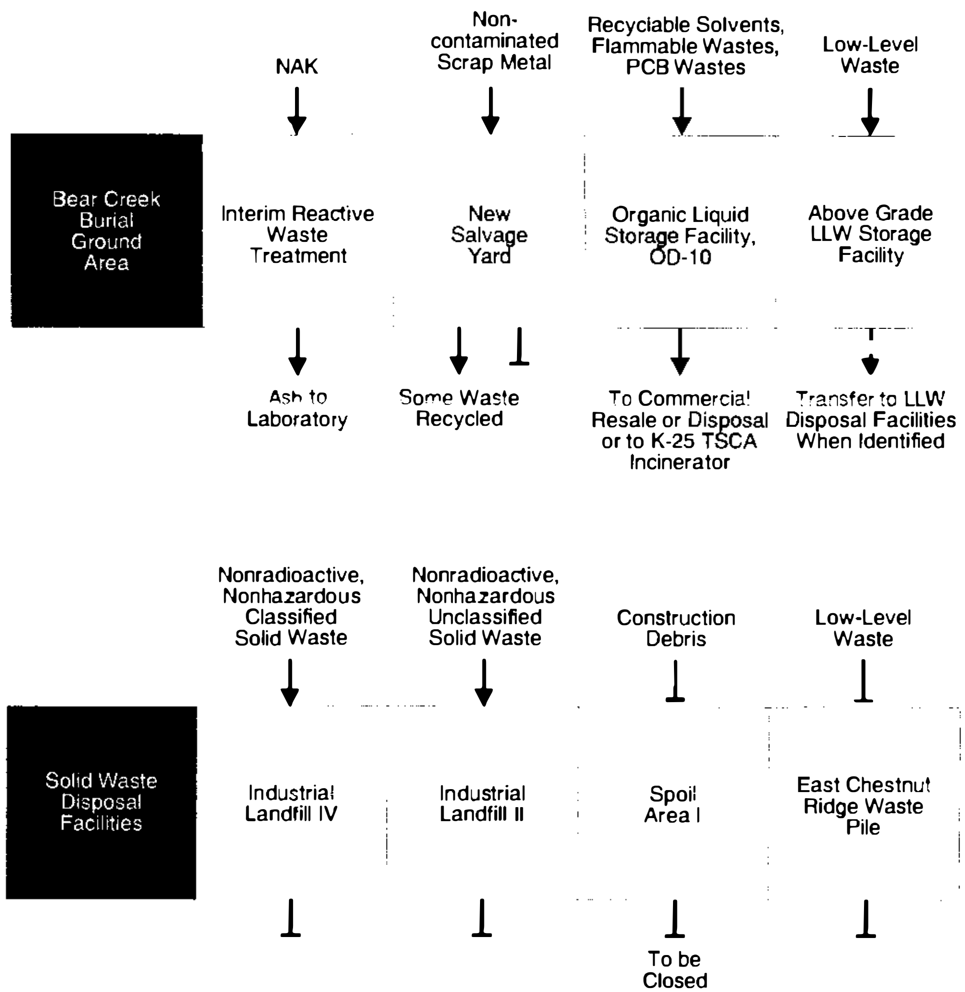
Facilities at the Y-12 Plant are being used to manage low-level radioactive, hazardous (Resource Conservation and Recovery Act hazardous/mixed polychlorinated biphenyl and polychlorinated biphenyl/uranium), and nonhazardous solid wastes. Figure 4.14-1 shows the waste management process at the Y-12 Plant.



Source: Modified from PAI Corporation 1993a

RCRA = Resource Conservation and Recovery Act
PCB = Polychrorinated Biphenyl
LLW = Low-level (radioactive) waste
TSDF = Treatment. Storage and Disposal Facility
TSCA = Toxic Substances Control Act
SEG = Scientific Ecology Group (contractor)
NAK = Sodium-Potassium

Figure 4.14-1. Flow diagram of Y-12 Plant storage and disposal units at ORR (Page 1 of 2).



RCRA = Resource Conservation and Recovery Act
PCB = Polychrorinated Biphenyl
LLW = Low-level (radioactive) waste
TSDF = Treatment, Storage and Disposal Facility
TSCA = Toxic Substances Control Act
SEG = Scientific Ecology Group (contractor)
NAK = Sodium-Potassium

Source: Modified from PAI Corporation 1993a

Figure 4.14-1. Flow diagram of Y-12 Plant storage and disposal units at ORR (page 2 of 2).

Facilities at the K-25 Site are being used to manage low-level radioactive, hazardous, and mixed wastes. Nonhazardous solid wastes are disposed at the Y-12 Plant Sanitary Landfill. Figure 4.14-2 shows the waste management process at the K-25 Site.

Facilities at the ORNL are being used to manage transuranic, low-level radioactive, hazardous, and mixed waste. Nonhazardous solid wastes are disposed at the Y-12 Plant Sanitary Landfill. Figure 4.14-3 shows the waste management process at the ORNL.

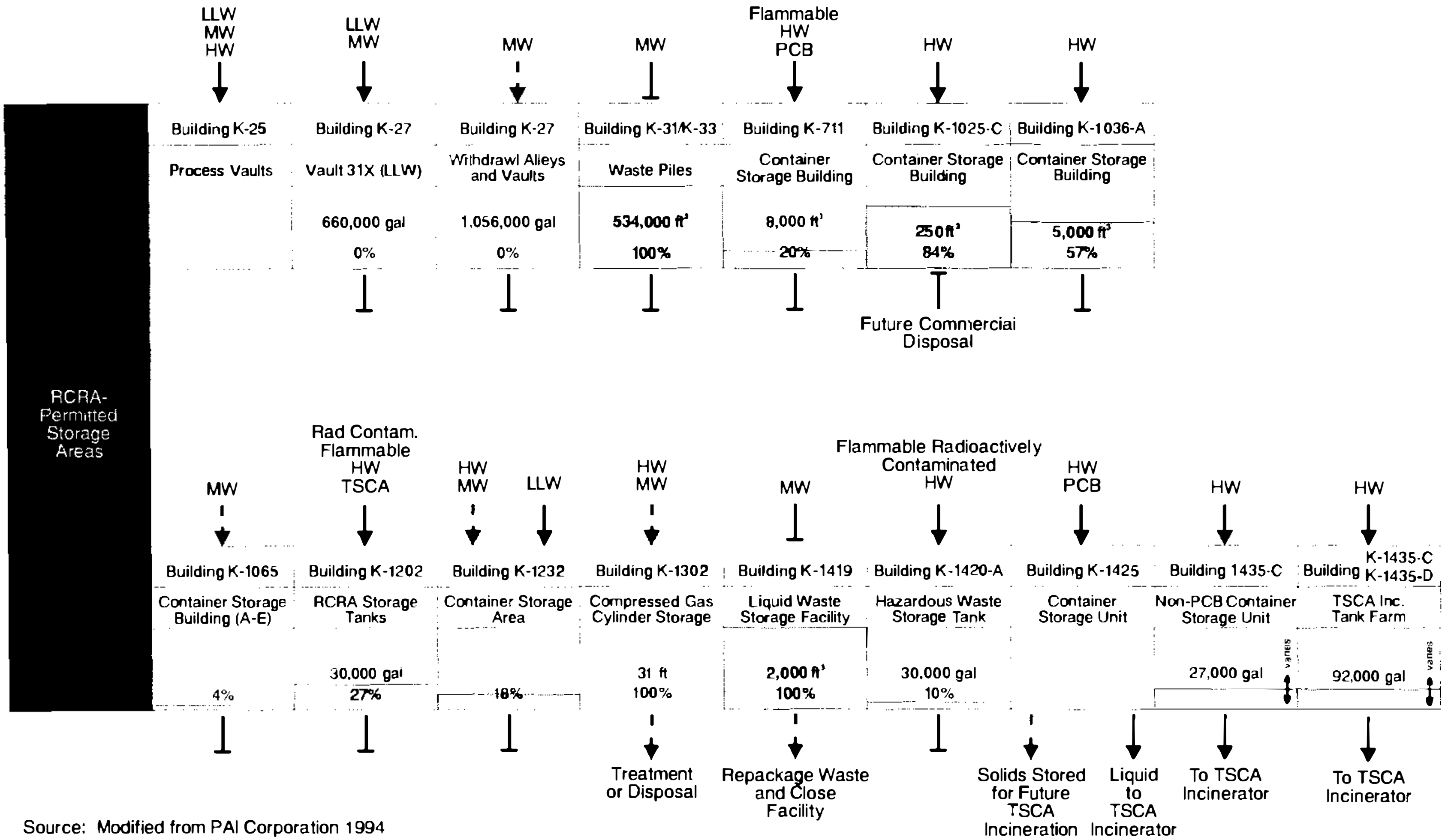
The overall ORR waste management activities, as well as details on the facilities used to manage wastes, are presented by waste category (transuranic, mixed low-level, low-level, hazardous, and industrial solid) in Sections 4.14.1 through 4.14.5 respectively. Note that the 1995 waste generation rates presented in tables associated with these sections are a representation of the annual generation rates for operations until the year 2035. Section 4.14.6 describes the management of the chemical raw materials used for ORR activities.

4.14.1 Transuranic Waste

The ORNL is the only complex at the ORR that generates and manages transuranic waste. Table 4.14-1 presents a summary of transuranic waste management activities projected for 1995, and details on the facilities used to manage transuranic wastes are presented in Table 4.14-2.

4.14.2 Mixed Low-Level Waste

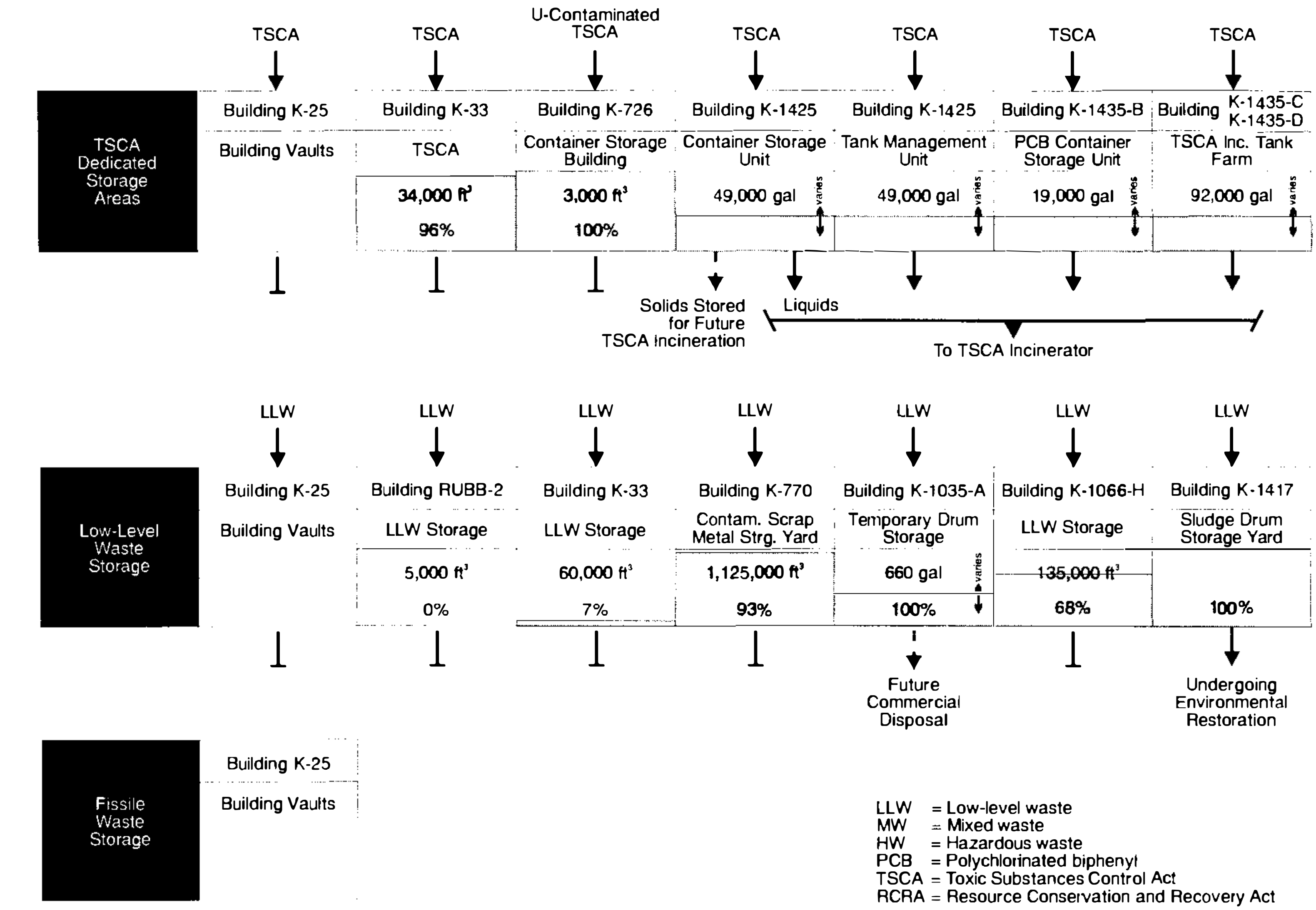
All three complexes at the ORR generate and manage mixed low-level wastes. The Y-12 Plant, K-25 Site, and the ORNL manage non-Resource Conservation and Recovery Act wastes (polychlorinated biphenyls, beryllium, and asbestos) contaminated by low-level radioactive materials as dangerous substances and include them with the Resource Conservation and Recovery Act-regulated radionuclide-contaminated materials as mixed wastes. Table 4.14-3 presents a summary of mixed low-level waste management activities projected for 1995, and details on the facilities used to manage mixed low-level waste are presented in Table 4.14-4.



Source: Modified from PAI Corporation 1994

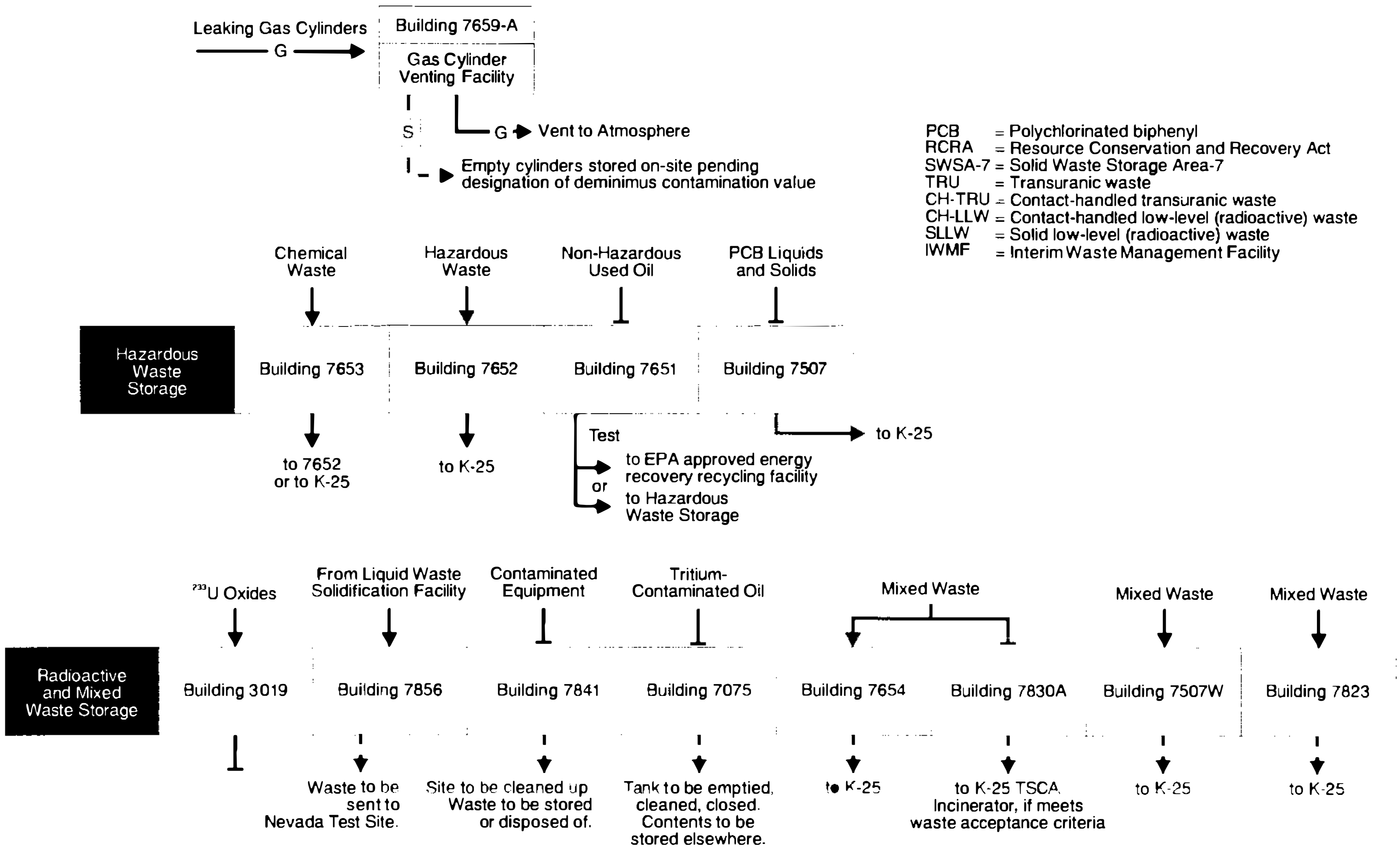
LLW = Low-level waste
MW = Mixed waste
HW = Hazardous waste
PCB = Polychlorinated biphenyl
TSCA = Toxic Substances Control Act
RCRA = Resource Conservation and Recovery Act

Figure 4.14-2. Flow diagram of K-25 waste storage units at ORR (Page 1 of 2).



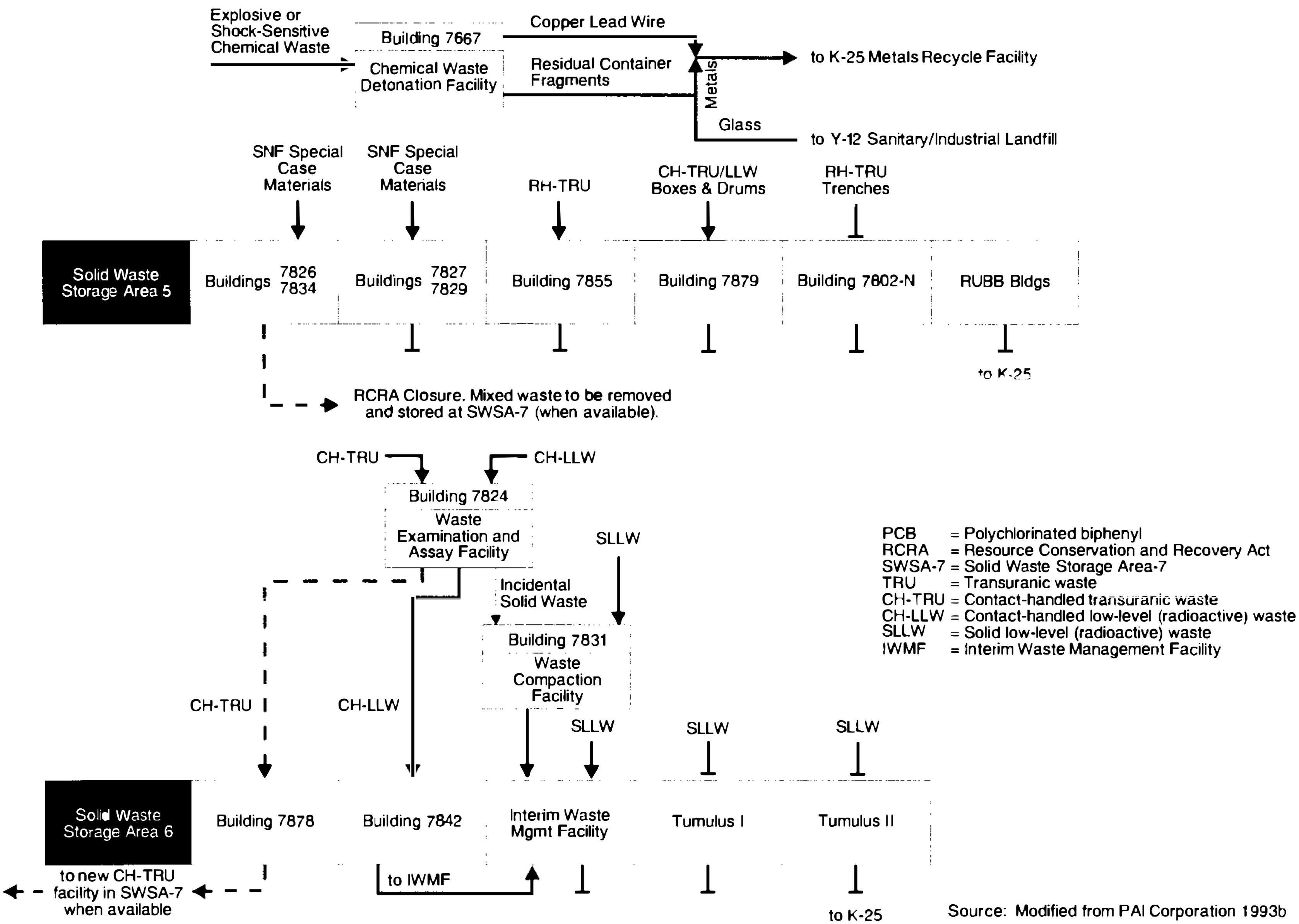
Source: Modified from PAI Corporation 1994

Figure 4.14-2. Flow diagram of K-25 waste storage units at ORR (Page 2 of 2).



Source: Modified from PAI Corporation 1993b

Figure 4.14-3. Flow diagrams of ORNL waste treatment units and storage and disposal units at ORR (Page 1 of 2).



Source: Modified from PAI Corporation 1993b

Figure 4.14-3. Flow diagrams of ORNL waste treatment units and storage and disposal units at ORR (Page 2 of 2).

Table 4.14-1. Projected 1995 transuranic waste management activities at the ORR (ORNL complex).[a]

Waste category	Generation rate[b]	Treatment method	Treatment capacity	Storage method	Storage capacity	Disposal method	Disposal capacity
Transuranic (Solid)							
Contact handled	10.7 m^3	None	Not available	Staged	611.7 m^3	WIPP[c], in future	To be determined
Remote handled	5.4 m^3	None	Not available	Shielded storage	221.7 m^3	WIPP[c], in future	To be determined

a. Sources: Snider (1993); Turner (1994).
b. 1991 data.
c. WIPP = Waste Isolation Pilot Plant

Table 4.14-2. Baseline transuranic waste management activities as of 1995 at the ORR (ORNL complex).[a,b]

Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
Transuranic	7802N	TRU[c] trenches	199 concrete casks	None
	7855	RH-TRU[d] waste storage facility	108 concrete casks	6 concrete casks
	7878	Interim storage facility	Not applicable (inspection facility)	Not applicable (inspection facility)
	7824	Waste examination and assay facility (dual use facility)	Not available	Not available
	7879	CH-TRU[e]/LLW[f] solids storage (dual storage facility)	372 m^2	Facility full

a. Sources: PAI Corporation (1993a); Turner (1994).
b. 1993 data.
c. TRU = Transuranic waste.
d. RH-TRU = Remote-handled transuranic waste.
e. CH-TRU = Contact-handled transuranic waste.
f. LLW = Low-level (radioactive) waste.

Table 4.14-3. Projected 1995 mixed low-level waste management activities at the ORR.[a]

Complex	Waste category	Generation rate	Treatment method	Treatment capacity	Storage method	Storage capacity	Disposal method	Disposal capacity
Y-12 Plant	Mixed solid[b]	242,869 kg[c] (573 m^3/yr)	None	N/A	Staged for shipment	1,730 yd^3 [d]	None, offsite to NTS pending	N/A
	Mixed liquid[b]	1,537,234 kg[e] (426,120 gal/yr)	Settlement and filtration	8,716 m^3 yr (2.3 million gal/yr)	Tanks	573 m^3 [f] (152,000 gal)	None, offsite to NTS pending	N/A
K-25 Site	Mixed liquid[g]	47,022.9 m^3 [h]	Settlement and filtration/ incineration	58,400,000 gal	Onsite	97.167 m^3 [i]	Not applicable	Not applicable
	Mixed solid[g]	535.2 m^3 [j]	Planned	Planned	Onsite	120,206 m^3	None	Not applicable
ORNL	Mixed liquid[g]	Not reported	Ion exchange	259,199.4 m^3	None	Not applicable	Not applicable	Not applicable
	Mixed solid[g]	48.9 m^3 [k]	Planned	Planned	Staged for shipment	22,000 gal [l]	None, offsite to NTS pending	Not applicable

a. Sources: Snider (1993); Brown (1994c).

b. 1992 data.

c. Includes 37,434 kg of contaminated (radionuclides) asbestos beryllium oxide waste and 28,948 kg of polychlorinated biphenyl/uranium waste.

d. RCRA/PCB Warehouse (Building 9720-9), RCRA and PCB Container Storage Area (Building 9720-58), Container Storage Facility (Building 9720-12) and PCB Drum Storage Facility (Building 9407-7).

e. Includes 13,152 kg of polychorinated biphenyl/uranium waste.

f. OD-9 and OD-10.

g. 1991 data.

h. TSCA (Toxic Substances Control Act) incinerator waste water.

i. Includes permitted container (solid/sludges/liquid wastes) and tank (liquids) storage capacity.

Table 4.14-3. (continued)

j. May include some polychlorinated biphenyl-tainted waste.

k. Includes polychlorinated biphenyl and asbestos waste.

l. Mixed Waste Drum Storage Pads - Bldg 7507 W, Part A permit, 22,000 gal.

Table 4.14-4. Baseline mixed low-level waste management activities as of 1995 at the ORR.[a]

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
Y-12 Plant	Mixed[b]	9201-4	Mixed waste storage area	350 55-gal drums	17 55-gal drums
		9404-7	PCB storage facility (dual storage/use)	See hazardous wastes	See hazardous waste
		9720-9	Mixed and PCB[c] storage area (dual storage/use)	See hazardous wastes	See hazardous waste
		9720-31	RCRA[d] staging and storage facility (dual storage/use)	See hazardous wastes	See hazardous waste
		9720-58	RCRA[d] and PCB[c] container storage area (dual storage/use)	See hazardous waste	See hazardous waste
		9811-1	Waste oil tank storage area, OD-7 (dual storage/use)	See hazardous waste	See hazardous waste
		9811-8	Waste oil solvent drum storage facility OD-8 (dual storage/use)	See hazardous waste	See hazardous waste
		9811-8	Organic liquid storage area, OD-9 (dual storage/use)	See hazardous waste	See hazardous waste
		None	Containerized waste storage area (dual storage/use)	See low-level waste	See low-level waste
K-25 Site[f]	Mixed[e]	K-1065A, B, C, D, E	Container storage	5097 m^3	970 m^3
		K-1419	Liquid waste storage facility	61 m^3	Facility full
		K-31	Waste piles (dual storage/use facility)	6623 m^3	Facility full
		K-33	Waste piles (dual storage/use facility)	8,506 m^3	Facility full
		K-27	Withdrawal alleys and vaults	2,640,000 gal	Future facility
		K-27	Vault 31X	660,000 gal	Future facility
ORNL	Mixed	7075	Used oil storage tank	4,200 gal	Tank full (undergoing RCRA[d] closure)
		7507W	Mixed waste storage facility	82 m^3	Facility full

Table 4.14-4. (continued)

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
		7654	Long term hazardous waste storage facility	62 m^3	Facility full
		7823	Mixed waste storage facility	390 m^3	117 m^2
		7830A	Waste storage tank	5,000 gal	Tank full

a. Sources: PAI Corporation (1993b); PAI Corporation (1994); Turner (1994).

b. 1993 data.

c. PCB = Polychlorinated biphenyl.

d. RCRA = Resource Conservation and Recovery Act.

e. 1994 data.

f. For additional mixed waste facilities see hazardous waste facilities at the K-25 Site (Table 4.14-8).

4.14.3 Low-Level Waste

The Y-12 Plant, K-25 Site, and the ORNL generate and manage low-level wastes. Table 4.14-5 presents a summary of low-level waste management activities projected for 1995, and details on the facilities used to manage low-level waste are presented in Table 4.14-6.

4.14.4 Hazardous Waste

All three complexes at the ORR generate and manage hazardous wastes. The Y-12 Plant, K-25 Site, and the ORNL manage non-Resource Conservation and Recovery Act wastes (asbestos, oils, and polychlorinated biphenyls) as dangerous substances and include them with the Resource Conservation and Recovery Act-regulated wastes as hazardous wastes. Table 4.14-7 presents a summary of mixed hazardous waste management activities projected for 1995, and details on the facilities used to manage hazardous waste are presented in Table 4.14-8.

4.14.5 Industrial Solid Waste

The K-25 Site and the ORNL industrial solid wastes are disposed of at the Y-12 Plant Sanitary Landfill (PAI Corporation 1994; PAI Corporation 1993a). Table 4.14-9 presents a summary of industrial solid waste management activities projected for 1995 at the Y-12 Plant, and details on the facilities used to manage industrial solid waste are presented in Table 4.14-10.

4.14.6 Hazardous Materials

The ORR uses a variety of chemical raw materials for activities associated with metal finishing/plating, uranium recovery, laboratory services, cooling tower operation, and facility cleaning/maintenance operations. Examples of chemicals used at the ORR include acids (hydrochloric, nitric), organics (methanol, perchloroethylene), and inorganics (hydrogen fluoride, chlorine). Currently, 309 specific chemicals and 20 chemical categories are being reviewed for possible reporting under the Superfund Amendments and Reauthorization Act Section 313 requirements. For 1992, the ORR reported 7 extremely hazardous substances and 39 hazardous chemicals for the Y-12 Plant; 5 extremely hazardous substances and 16 hazardous chemicals for the K-25 Site; and 20 extremely hazardous substances and hazardous chemicals for ORNL (MMES 1993a).

Table 4.14-5. Projected 1995 low-level waste management activities at the ORR.[a]

Complex	Waste category	Generation rate[b]	Treatment method	Treatment capacity	Storage method	Storage capacity	Disposal method	Disposal capacity
Y-12 Plant	Low-level solid[b]	1,438,680 kg[c] (5,793 m^3/yr)	Compaction/ incineration	Offsite	Stored onsite at Y-12 or K-25	See mixed solids	N/A[d]	N/A
	Low-level liquid[b]	565,929 kg (148,186 gal/yr)	Settlement and filtration	20,644m^3/yr[e] (5,400,000 gal/yr)	Stored onsite	See mixed liquids	N/A	N/A
K-25 Site	Low-level liquid[f]	Included in mixed	Settlement and filtration	See mixed liquid	None	Not applicable	Not applicable	Not applicable
	Low-level solid[f]	978.7 m^3 [g]	Compaction/ smelting	Offsite	Onsite	See mixed[b]	Planned onsite non-metallic Planned offsite metallic	Planned
ORNL	Low-level liquid[f]	2,064.4 m^3	Neutralization & precipitation	1.5292M m^3 [i]	Stored onsite in underground tanks	573.5 m^3	None	Not applicable
	Low-level solid[f]	130 m^3 [j]	Compaction	Offsite	Onsite	32,770.8 m^3[h]	Onsite burial	Not applicable

a. Sources: Snider (1993); Brown (1994c).

b. 1992 data.

c. Includes 649,429 kg of contaminated scrap metal.

d. N/A = not applicable.

e. West End Treatment Facility and Central Pollution Control Facility.

f. 1991 data.

g. Includes contaminated scrap metal.

h. Does not include 6.9 acre scrap metal storage site.

Table 4.14-5. (continued)

i. NPDES discharge limit for the ORNL Non-rad Wastewater Treatment Facility.

j. Includes scrap metal only. Does not include low-level radioactive waste solid sludge from Process Waste Treatment Facility, or from Sanitary Wastewater Treatment Plant.

k. Solid Waste Storage Area.

Table 4.14-6. Baseline low-level waste management activities as of 1995 at the ORR.[a]

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
Y-12 Plant	Low-level[b]	9720-12	Low-level waste storage		
			Indoor area	465 m^2	Not accepting waste
			Outside area	557 m^2	139 m^2
		9720-44	Low-level waste storage pad	Not reported	Not reported
		9825-1, 2	Uranium oxide storage vaults I and II	906 m^3 (each vault)	544 m^3 (each vault)
		None	Contaminated scrap metal storage area	Not reported	5% of area available
		None	Outside low-level waste storage	359 m^3	Not reported
		None	Above grade low-level waste storage facility	3,948 m^2	3,553 m^2
		9720-25	Classified waste storage facility	340 m^3	170 m^3
		None	Containerized waste storage area (dual use/storage)	2,323 m^2	929 m^2
K-25 Site	Low-level[c]	K-770	Contaminated scrap metal storage yard	31,857 m^3	2,230 m^3
		K-1035-A	Temporary drum storage	2.5 m^3	Varies
		K-1066-H	LLW[d] storage	3,830 m^3	627 m^3
		K-1417	Sludge-drum storage yard	8,846 m^3	Facility full
		RUBB-2	LLW[d] storage	138 m^3	83 m^3
		K-25	Process vaults (dual storage/use facility)	2,469 m^3	837 m^3
		K-33	Waste piles (dual storage/use facility)	961 m^3	24 m^3
		K-1232	Container storage area (dual storage/use facility)	42.5 m^3	34 m^3

Table 4.14-6. (continued)

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
ORNL	Low-level[b]	7831	Waste compaction facility	Not applicable (treatment facility)	Not applicable (treatment facility)
		7841	Contaminated equipment storage yard	Not reported	Scheduled to undergo closure under RCRA[e]
		7856	Cask storage site	Not reported	Not reported
		7823A, B, C, D, E	RUBB buildings	Not reported	Not reported
		7824	Waste examinations and assay facility, dual use facility	Not available	Not available
		7879	CH-TRU[f]/LLW[d] solids storage facility (dual storage facility)	372 m^2	Facility full
		7842	SWSA-6[g] staging and equipment building	297 m^2	Not applicable Facility is a staging area
		None	Tumulus I and II	Not reported	Facilities undergoing closure

a. Sources: PAI Corporation (1993b); PAI Corporation (1994); PAI Corporation (1993a); Turner (1994).

b. 1993 data.

c. 1994 data.

d. LLW = Low-level (radioactive) waste.

e. RCRA = Resource Conservation and Recovery Act.

f. CH-TRU = Contact-handled transuranic waste.

g. SWSA-6 = Solid Waste Storage Area - 6.

Table 4.14-7. Projected 1995 hazardous waste management activities at the ORR.[a]

Complex	Waste category	Generation rate	Treatment method	Treatment capacity	Storage method	Storage capacity	Disposal method	Disposal capacity
Y-12 Plant	Hazardous solid[b]	511,421 kg[c] (846 m^3/yr)	None	Not applicable	Staged for shipment	4,741 m^3 [d]	Offsite	Not applicable
	Hazardous liquid[b]	767,874 kg[e] (215,492 gal/yr)	Settlement and filtration	See low-level liquid	Tanks	670 yd^3 [f] (136,000 gal)	Offsite	Not applicable
K-25 Site	Hazardous liquid[g]	8,410.6 m^3 [h]	Neutralization/ precipitation	See mixed	Stored for processing	Not applicable	Planned offsite	Not applicable
	Hazardous solid[g]	680.5 m^3	Compaction for non-RCRA/TSCA[i] incineration	Offsite	Onsite	See mixed	Planned offsite	Not applicable
ORNL	Hazardous liquid[g]	0.8 m^3	Neutralization/ detonation	Not applicable	Tanks	588.7 m^3	Offsite	Not applicable
	Hazardous solid[g]	84.1 m^3 [j]	None	Not applicable	Staged for shipment	23,375 gal[k]	Planned onsite/offsite	Planned

a. Sources: Snider (1993); Brown (1994c).

b. 1992 data.

c. Includes 420,192 kg of uncontaminated (radionuclides) asbestos/beryllium oxide (BeO) waste and 42,434 kg of uncontaminated polychlorinated biphenyl waste.

d. Remaining West End Tank Farm sludge storage capacity.

e. Includes 55,624 kg of uncontaminated (radionuclides) polychlorinated biphenyl waste.

f. Liquid Organic Waste Storage Facility OD3, Building 9418-9, and OD9.

Table 4.14-7. (continued)

g. 1991 data.

h. Hydrogen softener blowdown from the steam plant.

i. RCRA = Resource Conservation and Recovery Act; TSCA = Toxic Substances Control Act.

j. Includes polychlorinated biphenyls and asbestos.

k. Hazardous Waste Storage Facility.

Table 4.14-8. Baseline hazardous waste management activities as of 1995 at the ORR.[a]

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
Y-12 Plant	Hazardous[b]	None	Interim reactive waste treatment area (open burning)	Not applicable	Not applicable
		9720-45	Organic liquid storage facility	Two 3,000-gal tanks Four 6,500-gal tanks 1,000, 55-gal drums	Variable
		9720-9	Mixed and PCB[c] storage area (dual storage/use)	311 m^3	62 m^3
		9720-31	RCRA[d] staging and storage facility (dual storage/use)	37,000 gallons	9,250 gallons
		9720-58	RCRA[d] and PCB[c] container storage area (dual storage/use)	Not reported	Not reported
		9811-1	Waste oil tank storage Area OD-7 (dual storage/use)	Two 30,000-gal tanks One 10,000-gal tank Two 3,000-gal tanks	38,000 gallons
		9811-8	Waste oil solvent drum storage facility, OD-8 (dual storage/use)	1,000 55-gal drums/containers	Not reported
		9811-8	Organic liquid storage area, OD-9 (dual storage/use)	Five 40,000-gal tanks Thirty-five 55-gal drums	50,480 gallons (projected to be used until the year 2010)
		9404-7	PCB[c] storage facility	334 m^2	84 m^2
		None	East Chestnut Ridge Waste Pile (dual use/storage facility)	Not reported	Not reported
K-25 Site	Hazardous/ mixed	K-25	Process vaults (dual storage/use facility)	6,810 m^3	1,282 m^3
		K-711	Container storage building (dual storage/use facility)	234 m^3	188 m^3
		K-1025C	Container storage (dual storage/use facility)	7 m^3	1 m^3
		K-1036A	Container storage facility (dual storage/use facility)	134 m^3	44 m^3

Table 4.14-8. (continued)

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
		K-1202	Storage tanks (dual storage/use facility)	108 m^3	76 m^3
		K-1302	Compressed gas cylinder storage (dual storage/use facility)	0.6 m^3	Facility full
		K-1420A	Hazardous waste storage tank (dual storage/use facility)	108 m^3	108 m^3
		K-1425	Container storage/tank management units (dual storage/use facility)	529 m^3	357 m^3
		K-726	Container storage building (dual storage/use facility)	86 m^3	Facility full
		K-33	TSCA[f] (dual storage/use facility)	961 m^3	24 m^3
	Hazardous[b]	7659-A	Gas cylinder venting facility	Not applicable (venting facility)	Not applicable
ORNL		7667	Chemical waste detonation facility	Not applicable (treatment facility)	Not applicable (treatment facility)
		7507	PCBs[g], liquids and solids storage facility	31 m^3	Facility full
		7651	Used oil storage facility	27 m^3	13 m^3
		7652	Hazardous waste storage facility	57 m^3	8.5 m^3
		7653	Chemical waste storage facility	60 55-gal drums	9 55-gal drums

a. Sources: PAI Corporation (1993b); PAI Corporation (1994); PAI Corporation (1993a).

b. 1993 data.

c. PCB = Polychlorinated biphenyl.

Table 4.14-8. (continued)

d. RCRA = Resource Conservation and Recovery Act.

e. 1994 data.

f. TSCA = Toxic Substances Control Act.

g. PCB = Polychlorinated biphenyl.

Table 4.14-9. Projected 1995 industrial solid waste management activities at the ORR.[a]

Complex	Waste category	Generation rate[b]	Treatment method	Treatment capacity	Storage method	Storage capacity	Disposal method	Disposal capacity
Y-12 Plant	Industrial solid[b]	5,554,873 kg (48,518 m^3/yr)	None	N/A	None	N/A	Landfill (onsite)	5.3522M[c] m^3[d]
K-25 Site	Industrial solid[e]	3,899.5 m^3	None	Not applicable	None	Not applicable	Y-12 landfill	5.3522M[c] m^3[f]
	Other solid[e]	5,046.4 m^3[g]	Compaction	Not applicable	None	Not applicable	Y-12 landfill	See industrial solid
ORNL	Industrial solid[e]	13 m^3	None	Not applicable	None	Not applicable	Y-12 landfill	5.3522M[c] m^3[f]
	Other solid[e]	30.6 m^3[h]	None	Not applicable	None	Not applicable	Y-12 landfill	See industrial solid

a. Sources: Snider (1993); Brown (1994c); PAI Corporation (1994); PAI Corporation (1993a).

b. 1992 data.

c. M = million

d. New sanitary landfill to open in 1994.

e. 1991 data.

f. Wastes are disposed of at the Y-12 Plant Sanitary Landfill.

g. Includes construction/demolition spoil and scrap metal.

h. Includes construction/demolition spoil; scrap metal estimates not available.

Table 4.14-10. Baseline industrial solid waste management activities as of 1995 at the ORR.[a,b]

Complex	Waste identification	Facility number	Facility description	Facility storage capacity	Available disposal space
Y-12 Plant	Industrial solid	None	New salvage yard	4,046.9 m^2	1,619 m^2
		None	Industrial landfill IV (classified waste landfill)	Not reported	Estimated useful life of the landfill is until the year 2034
		9983-44	Industrial landfill II	Storage capacity depleted	Storage capacity depleted
		None	Spoil Area 3 (construction debris)	Facility closed	Facility closed
		9720-25	Classified waste storage (dual use facility)	Not applicable (nonhazardous solid waste staging area)	Not applicable
K-25 Site	Industrial solid[c]				
ORNL	Industrial solid[c]				

a. Source: PAI Corporation (1993b).

b. 1993 data.

c. Wastes are disposed of at the Y-12 Plant Sanitary Landfill.

In addition, diesel fuel and gasoline, used to fuel site service and construction vehicles, are stored in bulk containers (55-gallon drums, aboveground storage tanks, and underground storage tanks).

The Y-12 Plant underground storage tank program includes seven in-service petroleum tanks. In addition, there are seven active petroleum underground storage tanks at the K-25 Site. At the ORNL there is one active underground storage tank containing heating oil and 22 active underground storage tanks that will be taken out of service or upgraded by 1998. The contents of these tanks was not reported (MMES 1993a).

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5. ENVIRONMENTAL CONSEQUENCES

5.1 Overview

This chapter describes the potential environmental consequences from the construction and operation of spent nuclear fuel (SNF) facilities at the Oak Ridge Reservation (ORR) under the Centralization and Regionalization Alternatives. Potential environmental consequences are assessed to the extent necessary to support a programmatic decision concerning the siting of the proposed SNF facilities. More detailed considerations of potential environmental consequences would be performed as necessary prior to initiating construction or operation of the facilities.

Impacts on the operation of the current facilities at ORR that create or store SNF are discussed in Chapter 3.

5.2 Land Use

The proposed site for SNF activities is in the eastern portion of the West Bear Creek Valley area, located in the western portion of the ORR. The SNF program's land requirements are assumed to be 90 acres (0.36 square kilometer), including all facilities and buffer areas. The majority of the land in the West Bear Creek Valley Area can be characterized as vacant, unused, and developable.

5.2.1 Centralization Alternative

Use of the West Bear Creek Valley area of the ORR for program activities would be consistent with the current land use and land use policies and plans for that area. The current land use designation for this area is Natural Areas, a generic category that includes all lands within the ORR not under any other specific land use designation (DOE 1993a). Use of this area for program activities would also be consistent with proposed future land uses as set forth in the ORR Site Development Plan (MMES 1989).

Future land uses proposed for the area of Roane County adjacent to the ORR near the proposed SNF site are low-density residential and public/semi-public uses (Roane County Regional Planning Commission 1992). These low intensity uses would be compatible with development in the western portion of the ORR.

Use of the West Bear Creek Valley site for the placement of SNF facilities may result in irreversible and irretrievable impacts to land use in that area by precluding all but waste management-type uses in the future. However, the placement of SNF facilities at this location would be consistent with U.S. Department of Energy's (DOE's) 1994 future land use plan, which designates the West Bear Creek Valley site for these uses (MMES 1989). Therefore, no mitigation measures are proposed.

5.2.2 Regionalization Alternative

As under the Centralization Alternative, land use impacts resulting from the Regionalization Alternative would not be expected to be significant. Impacts would be similar in character to those described for the Centralization Alternative.

5.3 Socioeconomics

Socioeconomics as addressed in this programmatic environmental impact statement (EIS) encompasses the interaction of economic, demographic, and social conditions. Economic consequences (e.g., technology requirements for operation of an SNF management facility) affect business activities, market structures, procurement methods, and dissemination of commodities within and between regions. Demographic consequences (e.g., in-migration of specialized human resources to support the SNF management program) affect size, distribution, and composition of the population, labor force, and the housing market in the regions. Social consequences (e.g., capacity modifications of public infrastructure to support SNF activity) affect the overall quality of life enjoyed by the residents of a community (Murdock and Leistritz 1979). These conditions are potentially affected either directly or indirectly by actions proposed under the DOE SNF Management Program.

The significance of actions and their intensity are relative to the affected region. A region can be described as a dynamic socioeconomic system, where physical and human resources, technology, social and economic institutions, and natural resources interrelate to create new products, processes, and services to meet consumer demands. The measure of a region's ability to support these demands depends on its ability to respond to changing economic, demographic, and social conditions.

Potential socioeconomic effects are addressed only to the extent that they are interrelated with the natural or physical environment (CFR 1993c). Direct effects include those impacts caused by the action and occurring at the same time and place. Indirect effects include those impacts caused by the action that are later in time or farther removed in distance, but are still reasonably foreseeable (i.e., offsite) (CFR 1993b).

Socioeconomic effects are quantified for regional economic activity and population. Potential impacts to individual communities such as public infrastructure and housing are discussed qualitatively to address programmatic issues.

Economic projections include direct and indirect jobs. Direct jobs are those jobs needed to construct or support operation of the SNF management complex at ORR. Indirect jobs are created throughout the regional economy within the Region of Influence as a result of procurement for materials, services, and other commodities; and induced effects from consumer spending. These direct and indirect impacts reflect both construction and operation phase demands that may occur concurrently or independently throughout the project planning period. Indirect jobs were projected using parameters from the U.S. Bureau of Economic Analysis Regional Input-Output Modeling System.

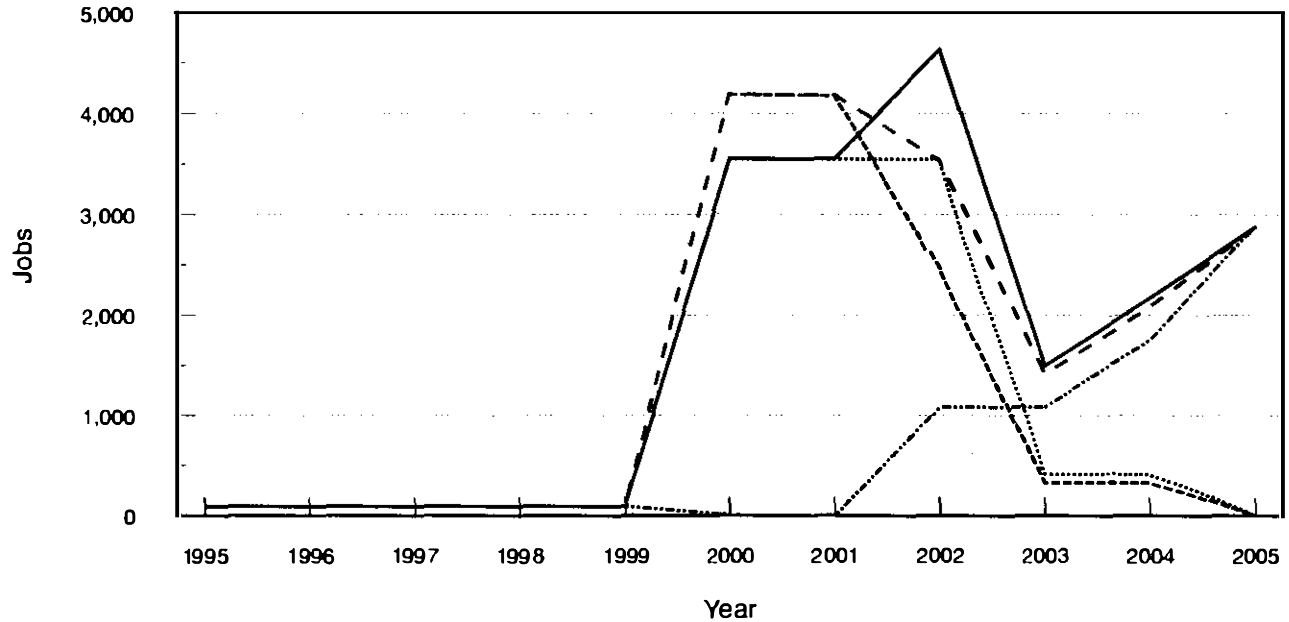
Two scenarios were analyzed to account for two potential distributions of the SNF facility construction efforts. The construction effort consists of fabricating various structures, each with its own construction labor need and a duration of either three or five years. The Peak Scenario accelerates the construction labor requirements into the first two years of construction. The Average Scenario averages the labor requirements of a structure for the duration of construction. The total construction effort for all structures, in labor years is the same for each scenario.

Therefore, for structures with a three year construction duration, the Peak Scenario has high labor needs for the first two years and then a substantial reduction for the third year, while the Average Scenario has a constant labor requirement for the three years. Likewise, for structures with a five year construction duration, the Peak Scenario has a high labor need for the first two years, then a lower need for the remaining three years, while the Average Scenario has a constant requirement for all five years. Because the total construction labor years for each structure is the same for both scenarios, the Average Scenario will have a lower requirement than the Peak Scenario in the first two years, then will have a higher requirement then the Peak Scenario in the remaining construction years.

Regional population projections reflect the potential change in population resulting from an increase in regional economic activity. Detailed assumptions regarding in-migration associated with SNF Management Program were not developed given the programmatic scope of the analysis. Potential in-migration effects resulting from direct job creation are presented qualitatively where appropriate.

5.3.1 Centralization Alternative

The upper and lower bounds of construction and operations related jobs generated from implementation of the Centralization Alternative from 1995 to 2005 are illustrated in Figure 5.3-1 and tabulated in Table 5.3-1. In the initial phases, the Centralization Alternative may create 90 jobs (25 direct, 65 indirect) beginning in 1995 and continuing through the year 1999 to support project planning, engineering design, and environmental permitting and compliance. Construction is expected to begin in the year 2000, requiring a total of 4,352 direct jobs (7,1232 indirect jobs). In that year and 2001, the Peak Scenario requires 1,587 construction laborers, while the Average Scenario needs 1,346. There is no operational labor required for this time period. In 2002 after two years of construction, the Peak Scenario decreases its construction labor requirements to 928 workers, while the Average Scenario maintains its 1,346 laborers. Additionally, 300 operational personnel are needed, raising the total of SNF workers to 1,228 for the Peak Scenario and 1,646 for the Average Scenario. By 2003, the buildings with three year construction durations have been completed; therefore, both the Peak and Average Scenario construction labor requirements decline to 125 and 157, respectively. Operation labor



1. Effects are direct and indirect.
2. Peak Scenario assumes construction labor peaks in the initial years of construction activity.
3. Average Scenario assumes construction labor is averaged throughout construction period.

= Total Employment - Average Scenario
= Total Employment - Peak Scenario
= Construction - Average Scenario
= Construction - Peak Scenario
= Operations

Figure 5.3-1. Total employment effects - ORR Centralization Alternative

Table 5.3-1. Socioeconomic effects - Centralization of SNF at Oak Ridge Reservation.

	Time period					
Years	1995-1999	2000, 2001	2002	2003	2004	2005 +
			Operations			
Direct jobs	25	0	300	300	487	800
Indirect jobs	65	0	780	780	1,265	2,079
Total jobs	90	0	1,080	1,080	1,752	2,879
			Construction			
Direct jobs						
Peak	0	1,587	928	125	125	0
Average	0	1,346	1,346	157	157	0
Indirect jobs						
Peak	0	2,597	1,519	205	205	0
Average	0	2,203	2,203	257	257	0
Total jobs						
Peak	0	4,184	2,447	330	330	0
Average	0	3,549	3,549	414	414	0
			Total			
Direct jobs						
Peak	25	1,587	1,228	425	612	800
Average	25	1,346	1,646	457	644	800
Indirect jobs						
Peak	65	2,597	2,299	984	1,470	2,079
Average	65	2,203	2,983	1,036	1,522	2,079
Total jobs						
Peak	90	4,184	3,527	1,408	2,082	2,879
Average	90	3,548	4,629	1,493	2,166	2,879
			Population Change			
Peak	82	4,366	(1,001)	(3,214)	1,022	2,011
Average	82	3,688	1,640	(4,759)	1,022	1,797

requirements remain at 300 workers. Total SNF labor requirements are 425 workers for the Peak Scenario and 457 for the Average Scenario. In 2004, construction labor needs for both scenarios remains at their previous level, but operational personnel increase. Total SNF labor requirements are 612 workers in the Peak Scenario and 644 workers in the Average Scenario. By 2005, all construction has been completed and operational personnel have increased to the full staff labor requirement of 800 workers.

The peak scenario reaches it maximum construction labor with 1,587 direct jobs (4,184 total jobs created) over a 2-year period from years 2000 through 2001. The average scenario would have its maximum construction labor with 1,346 direct jobs (3,549 total jobs created) from 2000 through 2002.

Ancillary operation (Table 5.3-1) activity associated with the Centralization Alternative will begin in the year 2002; the initial operations might create approximately 1,080 phase-related jobs (300 direct, 780 indirect). Additional operation activity would also begin, creating an additional 187 phase-related jobs (485 indirect jobs). The remaining operation activities are expected to start in 2005, after construction is finished, creating a total of 2,879 phase-related jobs (800 direct, 2,079 indirect), and the jobs will continue through 2035.

Regional businesses and the workforce will benefit from increased competition for contract procurements and jobs associated with SNF Centralization Alternative. Most of this activity is anticipated to be captured by Anderson, Knox, and Roane counties, with a small share occurring in Loudon County. The impact to the regional economy, however, only represents a portion of the total economic activity generated by the Centralization Alternative. For instance, specialized materials purchases and technology acquisition may occur outside Tennessee. The economic activity occurring outside the region might result in economic benefits for that region. This indirect effect is not captured by this analysis since it occurs outside of the Region of Influence as defined in Section 4.3.

Most of the population change in the Region of Influence above the baseline forecast will be driven by the in-migration of labor and households to support SNF management activities at

ORR. It is likely that most of the operation jobs will be filled by SNF personnel relocating from other DOE sites where SNF inventories were stored prior to shipments to ORR. These personnel would be familiar with the processes, technologies, and research involved with SNF operations elsewhere. Other operational jobs not associated with SNF management will probably be filled by the regional labor force. The regional labor force would be likely to fill the demand for construction jobs, except for specialized tasks.

To assess potential population and housing impacts, an in-migration rate per job was estimated using a ratio between forecasted employment and population figures (Table 4.3-1). This ratio was applied to the number of total (direct and indirect) jobs created by SNF management activities at ORR, giving the total estimated number of persons migrating into the Region of Influence per job created (Table 5.3-1).

With initial operation in 1995 under both scenarios, a total of 82 persons will migrate into the Region of Influence. The number of persons migrating into the Region of Influence would be at its largest when construction starts, for the years 2000 through 2001; (a total of 4,366 in-migrants for the peak scenario and 3,688 for the average scenario). For the years 2002 and 2003, after most of the construction has finished, people might migrate out of the Region of Influence. The number of in-migrants might increase as more of the SNF management operations start in the years 2004 and 2005. After the year 2005, in-migration due to SNF management activities would cease due to the fact that SNF management activities would not create any more jobs.

Assuming one housing unit per household, and an average family size of 2.6 persons per family (U.S. Department of Commerce 1991), the number of houses demanded in 1995, when preliminary operations start, might be 32. Between the year 2000 and 2002, a total of 1,679 housing units might be demanded. Even though this demand is only a temporary demand, the Region of Influence may have difficulty providing new housing during this time period. By the year 2003 and 2004, however, there might be a surplus of 1,236 housing units due to the phasing out of construction. In 2005, once SNF operational activities are under way, there will be a demand for 1,167 housing units associated with SNF management activities.

The greatest impact to the Region of Influence housing market may occur between the years 2000 and 2002, when construction starts. The demand for housing during the SNF facility construction period would be for transitional housing. While the population in the Region of Influence under baseline conditions has historically been growing and is projected to grow at less than 1 percent annually, recent vacancy rates for housing in the Region of Influence have been low (Census 1982, 1991). Therefore the in-migration associated with SNF construction might cause shortages in the housing market, and might cause shortages in construction supplies. However, due to decreasing employment levels on ORR between 1990 and 1999 (Section 4.3.1.5), additional housing units above the baseline may be available, thus reducing the potential strain on the housing market. Since construction will only be temporary, there may be excess capacity in the regional infrastructure when all SNF management operations begin in 2005.

5.3.1.1 Potential Public Service and Education Impacts. Given the population growth associated with the SNF Management Program, increases in capital expenditure may be required to meet the increased demand of housing utilities, including electricity generation, wastewater treatment, and water (see Section 5.13), transportation infrastructure (see Section 5.11), and education or service levels, assuming current conditions are constant through the analysis.

Assuming that the Centralization Alternative would be an addition to the ORR's current operations, security and fire protection on the site would need to be investigated at a minimum to determine whether or not current capacity could accommodate the requirements of the SNF Management Program.

5.3.2 Regionalization Alternative

Socioeconomic impacts resulting from the Regionalization Alternative are expected to be similar to the Centralization Alternative. The construction and operation cycles for each alternative would be the same; therefore, the same issues identified for the Centralization Alternative would apply. Labor requirements may be slightly reduced for the Regionalization Alternative. Although the volume of SNF stored would be less for the Regionalization Alternative, an economy of scale occurs for both alternatives, so that differences in labor and capital between the two alternatives would be minimized.

5.3.3 Mitigation Measures

5.3.3.1 Coordination with Local Jurisdictions. To reduce construction- and operation-related impacts, possible coordination with local communities could address potential impacts from increased labor and capital requirements. The knowledge of the extent and effect of growth due to SNF management activities could greatly enhance the ability of affected jurisdictions to plan effectively. Effective planning would address changes in levels of service for housing, infrastructure, utilities, transportation, and public services and finances.

5.3.3.2 Enhance Labor Force Availability. To alleviate potential impacts associated with the in-migration of labor, local labor force availability could be increased through various employment training and referral systems. The goal of these systems would be to reduce the potential for in-migration of labor to support SNF management activities.

5.4 Cultural and Paleontological Resources

5.4.1 Centralization Alternative

Under the Centralization Alternative, the proposed construction area for the SNF facilities is not expected to exceed 100 acres. There are no known historical, archeological, paleontological or Native American traditional sites in the proposed area (Fielder 1975). No impacts to cultural or paleontological resources are expected due to ground disturbance, noise, or air emissions during construction or operation of the SNF facilities. Consultation with the Tennessee State Historic Preservation Officer prior to project implementation is required by section 106 of the National Historic Preservation Act.

5.4.2 Regionalization Alternative

Under the Regionalization Alternative, the location of the SNF facilities would remain the same, but would be reduced in area. As with the Centralization Alternative, impacts are not anticipated.

5.5 Aesthetics and Scenic Resources

5.5.1 Centralization Alternative

When fully constructed and under operation, the proposed SNF facilities associated with the Centralization Alternative would consist of a series of buildings set within a 90-acre site. The maximum height of the buildings contained at the site would not exceed 42 feet above ground level, or two to three stories. The entrance to the site and security fencing will be visable to traffic on Bear Creek Road.

Since the buildings would be set into the south face of Pine Ridge, between Pine Ridge and Chestnut Ridge, the site would not be visible from areas outside the reservation, with the possible exception of a limited section of Gallaher Road on the west side of the Clinch River, looking east along Bear Creek Valley (TVA 1987). However, since the approximate distance from the boundary of the reservation to the proposed location is in excess of 2 miles, and includes hilly terrain and heavy vegetation, public views looking on to the site from off-site are not expected to be affected. Impacts to aesthetics and scenic resources on and off ORR are not anticipated.

5.5.2 Regionalization Alternative

Under the Regionalization Alternative, proposed SNF facilities are reduced in area and intensity of operations, and environmental effects to aesthetics and scenic resources would be less than those under the Centralization Alternative. Therefore, adverse environmental impacts from the Regionalization Alternative are also not anticipated.

5.6 Geologic Resources

This section describes any incremental or additional impacts on geology and geologic resources that might result from the construction and operation of the new facilities associated with the storage of SNF at the ORR.

For the most part, geologic impacts from construction activities would be limited to soil disturbance, although in some areas, ripping or blasting of limestone, dolomite, or chert layers might be required. Since no extensive or unique geologic or mineral resources are known to occur on the West Bear Creek Valley site, impacts to geologic resources would not be expected.

Because previously undisturbed areas would be used for new construction, some soil impacts from siting SNF facilities at the West Bear Creek Valley site would occur as a result of grading. Potential impacts from sediment runoff generated during construction activities would be minimized by implementation of soil erosion and sediment control measures. During operations, impacts to soil resources would be controlled by the planting or landscaping of land surfaces not covered by pavement and buildings.

Major seismic activity and associated mass movement and subsidence are unlikely to occur during the construction or operation phases, because although ground-shaking has occurred at the ORR due to earthquakes in other parts of the country, faults in the area have not been active since the late Paleozoic.

5.7 Air Resources

The proposed SNF management facility would be composed of a wet and dry storage facility and a technology development facility, with construction to take place in the calendar years 2000-2004. Air quality is assessed for construction and operation with regard to radiological and nonradiological air emissions. This section characterizes the impacts and expected air quality effects resulting from an SNF facility. This section also discusses the quantitative impacts under the Regionalization Alternative. The Centralization Alternative qualitative impacts are compared with the regionalization impacts in order to determine exceedances, if any, of existing local and Federal standards for both alternatives.

5.7.1 Releases

Emissions of radiological and nonradiological air pollutants might result from the construction and operation of a SNF management facility. These emissions might include airborne radionuclides, criteria pollutants, and hazardous air pollutants.

The impact of air emissions from construction activities might include criteria air pollutants of particulate matter (fugitive dust) primarily from the moving of soil, and exhaust emissions of particulate matter with an aerodynamic diameter equal to or less than 10 microns (PM_{10}); carbon monoxide; sulfur dioxide; volatile organic compounds; and nitrogen dioxide from earth-moving and equipment-handling machinery and equipment. During construction, a small increment in traffic volume above existing levels might result in a small increase in air pollutant emissions. (Section 5.11 discusses the level of traffic activity projected for the construction and operation phases of the SNF facility.)

During operations, the transport of SNF within the ORR from points of generation or storage sites to the disposal site would result in emissions of criteria air pollutants from various vehicles as well. Some emissions of air pollutants from worker vehicles would also occur both within and beyond the ORR.

5.7.1.1 Radiological Emissions. There are no expected contributions to radiological air emissions during the construction phases of the proposed SNF management facility. During operations, the facility would be expected to generate negligible radiological emissions. The potential radiological emissions associated with the proposed SNF management facility and those associated with the baseline are presented in Table 5.7-1 by isotope.

5.7.1.2 Nonradiological Emissions. The construction phase of the SNF facility for the Receipt/Storage Facility and Canning Factory is estimated to be complete in about 8-10 years. Short-term emissions, such as fugitive dust and heavy equipment exhaust emissions, would be generated temporarily, and would only affect receptors close to construction areas. Fugitive dust emissions would be minimized by watering. Under the operational phase of the SNF management facility, criteria and hazardous air pollutants might be emitted. Table 5.7-2 lists

Table 5.7-1. Isotopic release additions due to SNF management facility presence (Ci/yr) at ORR.[a]

	(Baseline) ORR	(SNF) ISF	ORR+ ISF
Hydrogen-3	2.1×10^{3}	7.9×10^{-1}	2.1×10^{3}
Beryllium-7	8.9×10^{-6}	0.0×10^{0}	8.9×10^{-6}
Carbon-14	0.0×10^{0}	1.2×10^{0}	1.2×10^{0}
Potassium-40	1.0×10^{-3}	0.0×10^{0}	1.0×10^{-3}
Manganese-54	0.0×10^{0}	2.2×10^{-8}	2.2×10^{-8}
Cobalt-60	3.0×10^{-5}	4.2×10^{-8}	3.0×10^{-5}
Bromine-82	1.0×10^{-5}	0.0×10^{0}	1.0×10^{-5}
Krypton-83M	7.3×10^{1}	0.0×10^{0}	7.3×10^{1}
Krypton-85	0.0×10^{0}	1.0×10^{4}	1.0×10^{4}
Krypton-85M	1.7×10^{2}	0.0×10^{0}	1.7×10^{2}
Krypton-87	3.5×10^{2}	0.0×10^{0}	3.5×10^{2}
Krypton-88	4.9×10^{2}	0.0×10^{0}	4.9×10^{2}
Krypton-89	6.3×10^{2}	0.0×10^{0}	6.3×10^{2}
Strontium-90	1.2×10^{-4}	3.3×10^{-6}	1.2×10^{-4}
Yttrium-90	1.2×10^{-4}	3.3×10^{-6}	1.2×10^{-4}
Technetium-99	6.1×10^{-2}	0.0×10^{0}	6.1×10^{-2}
Ruthenium-106	4.4×10^{-4}	1.1×10^{-5}	4.5×10^{-4}
Antimony-125	0.0×10^{0}	3.4×10^{-4}	3.4×10^{-4}
Iodine-129	3.1×10^{-4}	1.0×10^{-1}	1.0×10^{-1}
Iodine-131	1.2×10^{-1}	0.0×10^{0}	1.2×10^{-1}
Iodine-132	1.4×10^{0}	0.0×10^{0}	1.4×10^{0}
Iodine-133	6.5×10^{-1}	0.0×10^{0}	6.5×10^{-1}
Iodine-134	2.1×10^{-2}	0.0×10^{0}	2.1×10^{-2}
Iodine-135	1.2×10^{0}	0.0×10^{0}	1.2×10^{0}
Xenon-133	8.8×10^{2}	0.0×10^{0}	8.8×10^{2}
Xenon-133M	2.7×10^{1}	0.0×10^{0}	2.7×10^{1}
Xenon-135	2.8×10^{1}	0.0×10^{0}	2.8×10^{1}
Xenon-135M	1.6×10^{2}	0.0×10^{0}	1.6×10^{2}
Xenon-138	8.5×10^{2}	0.0×10^{0}	8.5×10^{2}
Cesium-134	6.3×10^{-7}	6.2×10^{-8}	6.9×10^{-7}
Cesium-137	7.0×10^{-4}	4.8×10^{-5}	7.5×10^{-4}
Cesium-144	1.2×10^{-6}	0.0×10^{0}	1.2×10^{-6}

Table 5.7-1. (continued).

	(Baseline) ORR	(SNF) ISF	ORR+ ISF
Barium-140	1.0×10^{-4}	0.0×10^{0}	1.0×10^{-4}
Lanthanum-140	1.4×10^{-6}	0.0×10^{0}	1.4×10^{-6}
Europium-152	4.4×10^{-11}	0.0×10^{0}	4.4×10^{-11}
Europium-154	5.9×10^{-6}	0.0×10^{0}	5.9×10^{-6}
Europium-155	3.0×10^{-6}	0.0×10^{0}	3.0×10^{-6}
Osmium-191	2.3×10^{-2}	0.0×10^{0}	2.3×10^{-2}
Lead-212	1.6×10^{0}	0.0×10^{0}	1.6×10^{0}
Thorium-228	1.5×10^{-3}	0.0×10^{0}	1.5×10^{-3}
Thorium-230	7.4×10^{-4}	0.0×10^{0}	7.4×10^{-4}
Thorium-232	3.0×10^{-5}	0.0×10^{0}	3.0×10^{-5}
Protactinium-234	1.2×10^{-3}	0.0×10^{0}	1.2×10^{-3}
Uranium-234	7.2×10^{-2}	0.0×10^{0}	7.2×10^{-2}
Uranium-235	2.6×10^{-3}	0.0×10^{0}	2.6×10^{-3}
Uranium-236	1.9×10^{-4}	0.0×10^{0}	1.9×10^{-4}
Uranium-238	4.1×10^{-2}	0.0×10^{0}	4.1×10^{-2}
Neptunium-237	1.1×10^{-4}	0.0×10^{0}	1.1×10^{-4}
Plutonium-238	6.1×10^{-4}	0.0×10^{0}	6.1×10^{-4}
Plutonium-239	1.3×10^{-4}	0.0×10^{0}	1.3×10^{-4}
Plutonium-240	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}
Americium-241	1.4×10^{-5}	0.0×10^{0}	1.4×10^{-5}
Curium-244	2.0×10^{-4}	0.0×10^{0}	2.0×10^{-4}

a. Source: Johnson, V. (1994).

Cm241 with 35 day half-life included with AM241 with 458 yr half-life.
Os194 with 8.0 yr half-life decays to Ir194 with 17.4 hr half-life, then to P1194 which is stable.
ISF: Interim Storage Facility.

Table 5.7-2. Total annual nonradioactive emissions for the SNF management facility at ORR.[a]

Criteria pollutants	Release rate (kg/yr)
Carbon monoxide	1.7×10^{3}
Particulate matter, PM_{10}[b]	1.0×10^{-3}
Nitrogen oxides	5.5×10^{3}
Sulfur dioxide	1.3×10^{2}
Lead	5.0×10^{-9}
Hazardous air pollutants	
Selenium compounds	1.6×10^{-4}
Mercury compounds	5.1×10^{-1}
Chlorine	3.5×10^{3}
Hydrogen fluoride	1.6×10^{1}
Cadmium compounds	2.9×10^{-7}
Cobalt, chromium, antimony, and nickel compounds	2.0×10^{-10}

a. Source: Johnson, V. (1994).

b. It is assumed that PM_{10} (particulate matter less than 10 microns in diameter) data are total suspended particulate data.

total expected annual emissions associated with the SNF storage facility. These nonradioactive emissions are primarily from the technology development facility and were estimated based on a previous design for a similar facility proposed at INEL.

5.7.2 Air Quality

5.7.2.1 Radiological. The GENII Environmental Transport and Dose Assessment Model, along with 1992 Y-12 west meteorological data and 1992 source terms (Table 5.7-1), was used to calculate the effective dose equivalent for the year 2005. A population of 988,754 persons within 80 kilometers (50 miles) is estimated. A radiation background level of 306 millirem per year is used.

Based on model results, 1 year of operation at the SNF management facility might result in a calculated dose of 9.5 millirem per year to the maximally exposed member of the public. This dose is below the National Emission Standards for Hazardous Air Pollutants limit of 10 millirem per year and is 3.1 percent of the natural background radiation received by the average person near the ORR.

The annual population dose from operation in the year 2005 was calculated to be 5.7×10^{1} person-rem. The population dose from operation of this option in 2005 is approximately 2.1×10^{-2} percent of the dose received by the surrounding population from natural background radiation.

Table 5.7-3 summarizes the effective dose equivalents for the maximum boundary dose and to the population with 80 kilometers (50 miles) of the proposed SNF facility. Compared to the background radiation, these increased doses are very small. The total doses are well within the regulatory limits.

5.7.2.2 Nonradiological. The Industrial Source Complex Short-Term Air Dispersion model was used with 1992 meteorological data from the Y-12 west meteorological monitoring station at ORR to determine pollutant concentrations resulting from the centralization portion of nonradiological emissions listed in Table 5.7-2. An emissions baseline was established to

Table 5.7-3. Summary of effective dose equivalents to the public from ORR operations and the proposed SNF management facility.

	Maximally exposed individual dose[a]	Collective dose to population within 80 km of ORR sources
Dose	9.5 mrem per year[b]	5.7×10^{1} [c]
Location	Site boundary 1.2 km SW of ORR storage facility	9.1×10^{5} people within 80 km of SNF storage facility
NESHAP[b] standard	10 mrem per year	—
Percentage of NESHAP	95	—
Natural background dose	306 mrem	2.79×10^{5} person-rem
Percentage of natural background dose	3.1	2.1×10^{-2}

a. The maximum boundary dose is the hypothetical individual exposed continuously during the year at ORR boundary located 1.2 km SW from the SNF site.

b. The SNF management facility contributes 6.2 mrem to this dose.

c. The SNF management facility contributes 5.2 person-rem to this dose.

NESHAP: National Emission Standards for Hazardous Air Pollutants.

km: kilometer

mrem: millirem

Note: Effective dose equivalents computed using GENII (PNL 1988).

characterize conditions at ORR using actual emission rates (MMES 1993a). It is also assumed that 1995 operations at the ORR will result in the same baseline nonradiological emissions as the 1992 operations at the ORR. The results of modeling are presented in Table 5.7-4, where the existing ORR site contribution concentration is compared to the existing DOE site contribution concentration plus the proposed SNF contribution. Table 5.7-5 presents the annual maximum concentration for hazardous air pollutants for offsite receptors. These concentrations are used in Section 5.12 for calculation of health effects. The increases in pollutant concentrations from the proposed action are negligible in magnitude. The concentrations of nonradiological air pollutants from operation of the SNF facilities, under that alternative, and from existing sources would remain within all applicable regulatory guidelines.

If a Regionalization Alternative SNF facility is operated at the ORR, the incremental contribution to maximum concentrations of pollutants would be less than for the Centralization Alternative. The concentrations of nonradiological air pollutants from operation of the SNF facilities, under this alternative, and from existing sources would remain within all regulatory guidelines.

5.8 Water Resources

Construction and operation of SNF management facilities could potentially affect water resources. Potential environmental impacts to surface water and groundwater resources during construction include depletion of water supplies, floodplain encroachment, and surface water sedimentation from erosion runoff occurring after land clearing. Potential normal operational impacts would include depletion of water supplies, and diminished water quality resulting from wastewater discharges from normal operations.

Impacts are analyzed for the Centralization Alternative, which would cause the most impacts to water resources at the ORR, if chosen. However, for the Centralization Alternative, no significant impacts are identified with respect to water resources issues. Therefore, no significant impacts are expected from the Regionalization Alternative as the Centralization Alternative is the bounding case.

Table 5.7-4. Comparison of baseline concentrations with most stringent applicable regulations and guidelines at ORR and proposed SNF management facility plus current operations.

Criteria pollutant	Averaging time	Most stringent regulation or guideline[a] (μg per m^3)	Total existing maximum concentration[b] (μg per m^3)	Total projected maximum concentration including SNF (μg per m^3)	Increase in maximum concentration (μg per m^3)
Carbon monoxide[c]	8-hour	10,000	6.9	6.9	0
	1-hour	40,000	24.1	33.5	9.4
Nitrogen dioxide	Annual	100	2.1	2.7	0.6
Lead	Calendar quarter	1.5	d	3.7×10^{-12}	3.7×10^{-12}
PM_{10}[e]	Annual	50	12.0	12.0	0
	24-hour	150	97.9	97.9	0
Sulfur dioxide	Annual	80	29.29	29.34	0.05
	24-hour	365	177.8	178.0	0.2
	3-hour	1,300	401.5	401.5	0
Total suspended particulates	Annual	50[a]	36.0	36.0	0
	24-hour	150[a]	116.9	116.9	0
Hydrogen fluoride (as fluorides)	30-day	1.2[a]	0.06	0.06	0
	7-day	1.6[a]	0.03	0.03	0
	24-hour	2.9[a]	d	f	f
	8-hour	3.7[a]	d	f	f
Hazardous air pollutants					
Selenium	8-hour	20	d	2.18×10^{-7}	2.18×10^{-7}
Mercury compounds	8-hour	0.5	d	2.18×10^{-3}	2.18×10^{-3}
Chlorine compounds	8-hour	150	d	1.52	1.52
Cadmium compounds	8-hour	5	d	1.81×10^{-9}	1.81×10^{-9}
Cobalt, chromium, antimony, and nickel compounds	8-hour	5	d	5.5×10^{-10}	5.5×10^{-10}

a. State standard.

b. Includes background concentration plus existing DOE facilities impact concentration. This is the baseline concentration.

c. Existing maximum and projected maximum did not occur in the same location.

d. Zero release (no sources indicated).

e. It is assumed that PM_{10} (particulate matter less than 10 microns in diameter) data are total suspended particulate data.

f. Not estimated because the potential release is negligible.

Table 5.7-5. Calculated annual maximum concentrations for hazardous air pollutants at ORR for offsite receptors.[a]

Hazardous air pollutant	Maximum average concentration($\mu g/m^3$)
Selenium compounds	8.85×10^{-8}
Mercury compounds	8.85×10^{-4}
Chlorine compounds	0.62
Hydrogen fluoride	1.53×10^{-3}
Cadmium compounds	7.35×10^{-10}
Cobalt, chromium, antimony and nickel compounds	2.21×10^{-10}

a. Offsite includes public access roads within the ORR. All impacts from proposed source only. No hazardous air pollutant emissions information available for existing sources.

5.8.1 Surface Water Quantity

The ORR currently receives its water supply from the Clinch River basin. Construction and operation of SNF management facilities would have very minimal impact on the quantity of water in the river and in local surface streams.

Construction of SNF management facilities would require some water consumption. However, the amount of water required would not significantly affect the Clinch River water level.

Stormwater runoff associated with both the construction and operation of SNF facilities is expected to have a negligible impact on surface water quantity. During construction, standard stormwater management techniques would be employed to attenuate runoff. A site drainage and stormwater management system consisting of perimeter drainage ditches and a retention pond would be included as part of SNF operations (Johnson, V. 1994). This system would provide for runoff and erosion control, which could otherwise affect receiving water courses or SNF operations.

As discussed in Section 4.8.1, analysis of available data indicates that the proposed SNF management facilities would be sited outside the 500-year floodplain. The SNF management facilities would be located and constructed to minimize any floodplain impact, as required by Executive Order 11988 (Floodplain Management) and DOE Orders. Site-specific surveys would be performed to more accurately determine precise locations of flooding elevations.

Operation of SNF management facilities would require approximately 9,863 gallons (37,335 liters) of water per day. This would mean that an additional 3.6 million gallons (13.6 million liters) of water would be used at the ORR per year. This figure is significantly less than the minimum monthly release for 1992 which was 3.5 billion cubic feet (100 million cubic meters) in May of that year (MMES 1993a). Therefore no impacts to water supply from SNF operations are expected.

Operation of SNF management facilities would involve the discharge of almost all water withdrawn, as very little would be consumed. A new onsite sanitary wastewater treatment plant would be required at the SNF facility. If all water withdrawn were to be treated and released at a constant rate over the course of a year, the increased flow from SNF operations would be approximately 0.13 gallon (0.5 liter) per second. Flow in Grassy Creek at its confluence with the Clinch River has been estimated at 20 gallons (80 liters) per second. Water discharge points and other appropriate mitigation measures would be selected in accordance with state and Federal requirements so as not to impact surface water quantity and flow in streams receiving discharges.

5.8.2 Surface Water Quality

During construction of SNF management facilities, 90 acres (36 hectares) would be disturbed, all in previously undisturbed areas. This would create the potential for increased sediment runoff into wetlands, adjacent to the site and along the downstream reaches of Grassy Creek as well as into Grassy Creek and its tributaries, which drain to the Clinch River. However, sediment runoff from construction activities would be controlled and minimized by implementing soil erosion control measures.

Under the Centralization Alternative, SNF management facilities would require a sanitary sewer system comprising a sewage treatment facility equipped with a sewage treatment and ejection pump system with a programmable controller and software. A pressurized sanitary sewer line would be provided that would run to a permitted stream discharge point (Johnson, V. 1994). This would accommodate the estimated 9,863 gallons (37,335 liters) per day of sanitary wastewater generated by SNF facilities and personnel, and would result in no appreciable impact to surface water quality. This system would be operated in accordance with State of Tennessee permitting requirements.

The proposed SNF management facilities are designed to have no liquid release of wastewater with hazardous chemical or radiological characteristics related to SNF management operations. These facilities would be constructed using state-of-the-art technologies, including secondary containment, and leak detection and water balance monitoring equipment. Therefore no environmental consequences related to surface water resources are anticipated from the normal operation of SNF management facilities.

A very low probability release scenario was evaluated to identify the potential environmental consequences of a liquid release to the environment under normal operating conditions. The release scenario was evaluated for information purposes only, as no normal operating releases are planned for the proposed facilities. The scenario evaluated consisted of a maximum potential liquid release to the environment under normal operating conditions such as an undetected secondary containment failure or piping leak. The scenario was developed using conservative estimates of the sensitivity of actual leak detection systems and operational source term data from similarly functioning facilities at the Idaho National Engineering Laboratory (INEL). The estimates for the hypothetical release included a point release of 5 gallons (19 liters) per day to the environment over the course of 1 month. The release volume and durations are considerably greater than existing leak detection system sensitivities, surveillance activities, and radiological surveys. Source terms were derived at the 95 percent confidence level from 8 years of operational data at the INEL Fluorinel and Storage Facility at the Idaho Chemical Processing Plant.

This release was assumed to occur at 40 feet (12 meters) below the land surface. This would be at either the depth of the vadose zone or the groundwater zone in most cases where SNF management facilities would be sited on the ORR. Any release to the vadose zone would migrate downward to the groundwater zone as described in Section 4.8.2. The upper layers of the groundwater zone in the ORR aquitards (where SNF management facilities would be sited) flow laterally to discharge points in nearby streams.

Most radiological constituents would be below drinking water standards at the point of release. Those radiological constituents above drinking water standards would be diluted in movements through the vadose zone, groundwater zone, and immediately upon entry into the receiving surface water body. Migration of contaminants through the vadose and groundwater zones would also be greatly reduced by sorption.

The short-term scenario evaluated would result in a long-term release of dilute contaminants to local streams and the Clinch River. Any release from the SNF management facilities would discharge to Grassy Creek through the subsurface. Although there are no continuous records of stream discharge for Grassy Creek, the average discharge of Grassy Creek to the Clinch River has been estimated at 20 gallons (80 liters) per second (Bailey and Lee 1991). The worst-case undetected release from the SNF facilities (5 gallons [19 liters] per day) would constitute less than 0.0003 percent of the estimated daily creek discharge to the Clinch River. Therefore, any hazardous constituents would be well below established standards at the confluence of Grassy Creek and the river. Even if a release were to occur during a period of low flow in Grassy Creek, the percentage would still be very small. Additionally, the 1992 minimum monthly release (in May) of 3.5 billion cubic feet (100 million cubic meters) at the Melton Hill Dam on the Clinch River averages to approximately 10,000 gallons (40,000 liters) per second (MMES 1994a). Therefore, no significant contaminant concentrations would be expected at the confluence of Grassy Creek and the Clinch River, or in the river itself.

5.8.3 Groundwater Quantity

No groundwater would be used for SNF management activities given the plentiful surface water supplies at the ORR. Therefore no impacts to groundwater quantity are expected.

5.8.4 Groundwater Quality

As previously mentioned in Section 5.8.2, the proposed SNF management facilities would be designed to have no liquid release to the environment of wastewater with hazardous chemical or radiological characteristics. However, for the purpose of this analysis, a conservative release scenario was analyzed.

As discussed in Section 4.8, virtually all mobile groundwater in the ORR aquitards is discharged to local streams through the upper layers of the groundwater zone. The deeper intervals of groundwater have extremely high residence times. Therefore, even the conservative scenario of a release to groundwater would have negligible impacts to these resources, and no significant impacts to offsite groundwater.

5.9 Ecological Resources

The Centralization and Regionalization Alternatives could affect ecological resources primarily through the alteration or loss of habitat. Potential impacts to terrestrial and aquatic resources and threatened and endangered species are described below for both alternatives.

Radiation doses received by terrestrial biota from SNF activities would be expected to be similar to those received by man. Although guidelines have not been established for acceptance limits for radiation exposure to species other than man, it is generally agreed that the limits established for humans are also conservative for other species (NRC 1979). Evidence indicates that no other living organisms have been identified that are likely to be significantly more radiosensitive than man (Casarett 1968; National Academy of Sciences 1972). Thus, so long as exposure limits protective of man are not exceeded, no significant radiological impact on populations of biota would be expected as a result of SNF activities at the West Bear Creek Site.

5.9.1 Centralization Alternative

Under this alternative, construction of the proposed SNF management facility would result in the disturbance of approximately 90 acres (0.36 square kilometers), or less than 1 percent of the ORR. It is assumed that the area to be disturbed includes construction laydown areas, grading, and new buildings, and that the access road or other rights-of-ways have not been included in total area to be disturbed. Vegetation within the area proposed for the SNF management facility would be destroyed during land clearing activities but may be mitigated by revegetating with native species where possible. Vegetation cover in this area is predominantly oak-hickory forest or pine and pine-hardwood forest. Both forest types are common on the ORR and within the region.

Construction of the proposed SNF management facility would have some adverse effects on animal populations. Less mobile animals, such as amphibians, reptiles, and small mammals, within the project area would be destroyed during land-clearing activities. Larger mammals and birds in construction and adjacent areas would be disturbed by construction activities and would move to nearby suitable habitat. The long-term survival of these animals would depend on whether the area to which they moved was at or below its carrying capacity. Areas that would be revegetated upon completion of construction would be of minimal value to most wildlife but may be repopulated by more tolerant species.

The Migratory Bird Treaty Act is primarily concerned with the destruction of migratory birds, as well as their eggs and nests. It may be necessary to survey construction sites for the nests of migratory birds prior to construction and/or avoid clearing operations during the breeding season.

Activities associated with operation, such as noise, increased human presence and traffic, and night lighting could affect wildlife living immediately adjacent to the site. While these disturbances may cause some sensitive species to move from the area, most animals should be able to adjust.

Construction of the proposed SNF management facility would likely displace the forested wetlands adjacent to tributaries of Grassy Creek flowing through the proposed site. This unavoidable displacement of wetlands would be accomplished in accordance with the U.S. Army Corps of Engineers and Tennessee Water Quality Control Administration requirements. The potential also exists to disturb wetlands further down stream through erosion and sedimentation. Such impacts would be controlled through implementation of a soil erosion and sediment control plan. Construction-related discharges to Grassy Creek would be relatively low and have negligible impacts to wetlands associated with the creek. No impacts to wetlands are anticipated during facility operations.

Construction of the proposed SNF management facility would require the rechanneling of tributaries to Grassy Creek that cross the proposed site and, thus, the loss of this aquatic habitat. In addition, soil erosion due to construction could cause water quality changes (primarily sediment loading) to Grassy Creek and its tributaries. These impacts could be minimized by implementation of soil erosion and sediment control measures. No operational impacts to aquatic resources are anticipated. It is assumed that the proposed project will have a water retention pond and a sewage lagoon area within the security fence that may provide minimal habitat for amphibians in the area.

No federally listed species are expected to be affected by construction and operation of the SNF management facility. Site surveys will be required to verify the presence of state-listed or other special status species. Land clearing activities may destroy protected plant species, such as purple fringeless orchid and pink lady's-slippers, that may occur within the site. State-listed species including the Cooper's, sharp-shinned, and red-shouldered hawks, the barn owl, and the black vulture, which potentially occur in the area, could be impacted by project activities. Approximately 90 acres (36 hectares) of potential nesting and foraging habitat would be lost as a result of construction activities. Because this type of habitat is abundant in the area, the loss is not expected to affect the viability of populations of these species. However, appropriate steps would be taken to prevent nest disturbance. The DOE would consult with the Tennessee Department of Environment and Conservation as appropriate to avoid or mitigate imminent impacts to state-listed species.

5.9.2 Regionalization Alternative

Impacts under this alternative are expected to be generally the same as under the Centralization Alternative. The major difference between the two is the total area to be disturbed. The Regionalization Alternative is expected to have fewer buildings required and, therefore, fewer acres to be disturbed.

5.10 Noise

As discussed in Section 4.10, noises generated on the ORR do not propagate offsite at levels that impact the general population. Thus, ORR noise impacts for both the Centralization and Regionalization Alternatives are those resulting from the transportation of personnel and materials to and from the site that affect the nearby communities, and those resulting from onsite sources that may affect some wildlife near these sources. The effect of noise on wildlife near SNF management facilities under the Centralization or Regionalization Alternatives would be addressed in a project-specific environmental assessments.

The transportation noises are a function of the size of the work force (e.g., an increase in the size of the work force would result in increased employee traffic and corresponding increases in deliveries by truck and rail, and a decreased work force would result in decreased employee traffic and corresponding decreases in deliveries). This analysis of traffic noise took into account noise from the major roadways that provide access to the ORR. Vehicles used to transport employees and personnel on roadways would be the principal sources of community noise impacts near the ORR from the Centralization and Regionalization Alternatives.

This analysis used the day-night average sound level to assess community noise as suggested by the U.S. Environmental Protection Agency (EPA 1974, 1982) and the Federal Interagency Committee on Noise (FICON 1992). The change in day-night average sound level from the baseline noise level for each alternative was estimated based on the projected change in employment and traffic levels from the baseline levels. The baseline levels are those for 1995. The combination of construction and operation employment was considered. A change in noise level below 3 decibels would not be expected to result in a change in community reaction (FICON 1992).

Under the Centralization Alternative the projected ORR work force might increase by about 9 percent in the years 2000 to 2002, during the peak construction period, and might decrease thereafter (Section 5.3). There would be a corresponding increase in private vehicle and truck trips to the site. The day-night average sound level at 15 meters (50 feet) from the roads that provide access to the ORR would be expected to increase by less than 1 decibel. No change is expected in the community reaction to noise along these routes. No mitigation efforts are necessary.

Under the Regionalization Alternative tbe traffic noise impacts would be the same as for the Centralization Alternative.

5.11 Traffic and Transportation

5.11.1 Centralization Alternative

The proposed SNF management activities would involve a small increase in the number of employees commuting to the ORR and the transportation of SNF and hazardous chemicals onsite. This section summarizes the potential transportation impacts due to the proposed SNF facilities on the ORR.

5.11.1.1 Level of Service. Levels of service were calculated for construction and operation of the SNF facility at the ORR. The maximum reasonably foreseeable scenario for operations occurs when the projected combined employees and population are at the highest level. This occurs in 2001, when there are 4,184 employees and a projected population in the Region of Influence of 528,800. The Region of Influence includes Anderson, Blount, Knox, Loudon, and Roane counties. This is the region from which employees can be expected to commute. The employees and population associated with the proposed action generate direct trips in the Region of Influence. These trips to the site are distributed to the Region of Influence road network according to percentages based on a traffic flow to the site from where employees historically have lived. Increase in baseline population and indirect site-related employees will generate indirect traffic trips in the Region of Influence. These trips are distributed based on the current average daily traffic per present population in the region of influence for a given segment. Direct and indirect average daily traffic is added and a new level of service is determined. Construction and operation employees contribute little to the future traffic because they represent such a small percentage of the Region of Influence population growth.

The following segment has a poorer level of service due to site-related impacts over the future baseline. Tennessee State Route 61 between Interstate 75 at Norris and 25W at Clinton will worsen to a level of service of E while Tennessee State Route 62 between Interstate 75 at Knoxville and US 441/TN 33 at Knoxville will worsen to a level of service of F. There are no other site-related impacts on any other segment.

Road reconstruction, widening, modification of interchanges, and new interchange construction projects are planned for segments of Bear Creek Valley Road, Scarboro Road, and Tennessee State Routes 58, 62, and 95 (Johnson, C. 1994; MMES 1991b).

Possible mitigation of impacts on local and regional roads having level of service of F could include adding lanes or employing traffic demand management.

The generic facility design would require rail access for Naval fuel delivery. This would create impacts that would be evaluated in detail if the site were selected for the SNF facility.

5.11.1.2 Transportation of Hazardous Chemicals. The hazardous chemicals required and hazardous waste generated by the proposed SNF facility operation are assumed to be transported by truck. The onsite transportation impacts for these hazardous chemicals and wastes shipments are calculated based on the assumptions that (a) they do not have any incident free impacts, (b) the material would not leak during transport, (c) only risk is due to traffic fatalities, and (d) the material spill of entire contents is bound by the risk evaluated for the Expended Core Facility considered under facility accidents.

The total distance for onsite shipment of these hazardous chemicals is assumed to be the maximum site boundary distance from the proposed SNF facility to the nearest highway. Based on the unit risk factor (Cashwell et al. 1986) and occupational and nonoccupational fatalities considering a rural setting, the onsite transportation risks are calculated, assuming 10 annual shipments.

The maximum one-way distance from the site to the ORR gate by which trucks would deliver hazardous waste is 16 kilometers (10 miles). Based on 1.5×10^{-8} accident occupational fatalities per kilometer per shipment, 1.92×10^{-4} accident occupational fatalities are estimated over a 40-year period. Based on 5.3×10^{-8} accident non-occupational fatalities per kilometer per shipment, 6.8×10^{-4} accident non-occupational fatalities are estimated for a 40-year period.

5.11.1.3 Transportation of Radioactive SNF. The definition of offsite transportation includes transportation of radioactive material from the shipping facility to the storage facility at the receiving site; therefore this local transportation does not separately address the onsite transportation impacts due to radioactive materials shipment except for handling at the storage facility. Based on current inventories and expected future generation, DOE estimates approximately 480 spent nuclear shipments over 40 years (1995-2035) from the High Flux Isotope Reactor. The distance between the High Flux Isotope Reactor and the proposed SNF management facility at ORR is about 6 miles (9.75 km). Incident-free onsite radiological transportation impacts from the estimated 480 shipments were calculated for transportation crew members (occupational) and general population. Occupational dose of 0.34 person-rem over 40 years was calculated based on a unit risk factor of 7.16 x 10^{-5} person-rem per kilometer (Appendix I). This dose results in 1.36 x 10^{-4} fatal cancers. The general population dose of 8.56 x 10^{-3} person-rem over 40 years was calculated based on a unit risk factor of 1.83 x 10^{-6} person-rem per kilometer (Appendix I). This dose results in 4.28 x 10^{-6} fatal cancers.

5.11.2 Regionalization Alternative

The impacts due to the Regionalization Alternative would be less than those described for the Centralization Alternative.

5.12 Occupational and Public Health and Safety

5.12.1 Centralization Alternative

This section evaluates the impacts to human health resulting from both contaminated emissions and direct exposures associated with the proposed SNF management facility under the Centralization Alternative. Based on current inventories and expected future generation, DOE estimates approximately 480 spent nuclear shipments over 40 years (1995 - 2035) from the High Flux Isotope Reactor. The distance between the High Flux Isotope Reactor and the proposed SNF management facility at ORR is about 6 miles (9.75 km). Incident-free onsite radiological transportation impacts from the estimated 480 shipments were calculated for transportation crew members (occupational) and general population. Occupational dose of 0.34 person-rem over 40 years was calculated based on a unit risk factor of 7.16 x 10^{-5} person-rem per kilometer (Appendix I). This dose results in 1.36 x 10^{-4} fatal cancers. The general population dose of 8.56 x 10^{-3} person-rem over 40 years was calculated based on a unit risk factor of 1.83 x 10^{-6} person-rem per kilometer (Appendix I). This dose results in 4.28 x 10^{-6} fatal cancers.

5.12.1.1 Radiological Dose and Cancer Impacts. Computation and modeling (see Table 5.7-1) have shown that the dose rate (due to atmospheric effluents only) to the maximally exposed individual, conservatively taken to be at the site boundary of the ORR (without the presence of the interim storage facility), is 3.3 millirem per year of site operation with an associated risk of fatal cancer of 1.7×10^{-6} to this maximally exposed individual. It has also been established (see Section 4.12.4) that liquid effluents may present an additional plausible dose rate of 15.2 millirem per year of site operation (MMES 1993a) to a potential maximally exposed individual at the site boundary (due to both water consumption [0.2 millirem] and exposure from liquid material [15 millirem]), yielding a corresponding risk of 7.6×10^{-6} per year of operation. Subsequently, an additional 6.2 millirem per year to the postulated maximally exposed individual at the site boundary has been tabulated due to the presence of interim storage facility gaseous effluents (no radioactive liquid effluents are expected from the interim storage facility). Thus, if the spent fuel were brought to the ORR, it could result in a total cumulative dose rate (ORR + interim storage facility) to the maximally exposed individual at the site boundary of 24.7 millirem per year of site operation (see Table 5.12-1), with an associated total risk from ORR operations of 1.2×10^{-5} for fatal cancer; the resulting increase in risk to this individual from ORR operations with SNF management included is 34 percent. The total dose (24.7 millirem) to the maximally exposed individual is well within all applicable DOE limits (i.e., 4 millirem per year from the drinking water pathway, 10 millirem per year from the airborne release pathways, and 100 millirem per year total for all pathways). Table 5.12-1 shows the relationship among the various sources of radiation doses to the maximally exposed individual. The risks are presented there for both 1 and 40 years of exposure. The latter values are approximate and correspond to the operating lifetime of the SNF facility.

The annual population dose (80-kilometer [50-mile] radius) from total site operations (without the interim storage facility) is 54 person-rem, resulting in an increase of fatal cancer of 0.027. The increase in annual population dose from SNF operations is 5 person-rem, resulting in an increase of 2.5×10^{-3} for fatal cancer.

Over 40 years the increase in fatal cancers from SNF operations is 0.10. The increase of 9 percent in fatal cancers to the population from site operations with SNF results in an increase from 0.019 to 0.021 percent in the comparison of the dose received from ORR to that received from background. Table 5.12-1 also includes a summary of these population health impacts.

Table 5.12-1. Critical Interim Storage Facility impacts on radiation dose and cancer risks at ORR.

	Dose rate to the maximally exposed individual (mrem per yr)	Associated fatal cancer risk (yr of operation)[a]	Associated facility lifetime fatal cancer risk (40 years)[a]	Population dose from total site operations (person-rem per yr)	Associated total cancer increase (person per yr of operation)	Associated facility lifetime fatal cancer increase (person per 40 years)
Natural background	295	1.5×10^{-4}	5.9×10^{-3}	279,000	140	5,580
Public						
Baseline site operations	18.5	9.2×10^{-6}	3.7×10^{-4}	54	0.027	1.1
SNF operations	6.2	3.1×10^{-6}	1.2×10^{-4}	5.2	2.5×10^{-3}	0.10
Baseline & SNF	24.7	1.2×10^{-5}	4.9×10^{-4}	59	0.030	1.2
Percent increase SNF over baseline	34	34	34	9	9	9
Workers						
Baseline site operations	2.8[b]	1.1×10^{-6}	4.5×10^{-5}	48	0.019	0.76
SNF operations	40[b]	1.6×10^{-5}	6.4×10^{-4}	32	0.013	0.40[a]

a. Facility lifetime fatal cancer risk accounts for time-varying number of workers.
b. Dose rate to an average worker.

It has been assumed that the additional doses to SNF workers (due to interim storage facility operations) will be similar in nature to those for major DOE facility Waste Processing/Management personnel. Hence, by examining the dose data from 1989, 1990, and 1991 for Richland, INEL, and Savannah River Site and assuming that the nuclear activity of the SNF would remain fairly constant until it is dealt with at the interim storage facility, it may be asserted that a maximally exposed interim storage facility worker could plausibly receive an additional (above background) annual dose of 3 rem from normal operations; this is equivalent to a risk of 1.2×10^{-3} for fatal cancer per year of operation. However, the average calculated dose (incurred in 1989, 1990, and 1991) to SNF workers was approximately 40 millirem per year; this is equivalent to a risk of 1.6×10^{-5} for fatal cancer per year of operation, and to an approximate risk of 6.4×10^{-4} to a worker who is present during the entire 40-year facility lifetime.

An excess of 0.013 fatal cancer among all SNF facility workers is projected from peak annual operations; exposures to radiation over the lifetime of SNF operations could result in an excess of 0.40 fatal cancer. The maximum health effects due to radiological doses to a noninvolved worker, i.e., an ORR worker at a faciity other than SNF, would be on the order of 1 percent of the occupational exposure to an SNF worker based on analyses for the SRS and INEL sites. Table 5.12-1 includes a summary of the doses and fatal cancer risks to SNF workers.

5.12.1.2 Chemical Exposure Health Impacts. The calculated atmospheric maximum concentrations of hazardous chemicals (at the site boundary) for the proposed action are presented in Table 5.7-5 in Section 5.7. The maximum concentrations at the site boundary reflect an exposure to a maximally exposed individual, whereas the maximum onsite concentrations reflect an exposure to a worker. Of the potential hazardous chemicals identified for the proposed action, cadmium, nickel and chromium VI (chrome) are carcinogens for which a total cancer risk is calculated. The remaining seven chemicals are noncarcinogens for which a hazard index is calculated. A hazard index value of greater than 1 serves as an indicator for potential adverse health effects.

The offsite concentrations in Table 5.7-5 represent values at public access roads within the reservation. However, a maximally exposed individual is assumed to be unable to take up residence on these roads, but instead takes up residence along the reservation fence line. The concentrations at the fence line are 62 percent of those listed as offsite. On the other hand, the concentrations at the roads, being the highest listed within the fence line, are used here to represent maximum concentrations for ORR workers.

Based on the maximum hazardous chemical concentrations at the site boundary, the lifetime fatal cancer risk and hazard index to the maximally exposed member of the public are 2.5×10^{-12} and 1.2×10^{-2}, respectively. Based on the maximum concentrations onsite, the lifetime fatal cancer risk and hazard index to a worker are 4.0×10^{-12} and 1.9×10^{-2}, respectively. This indicates that there will be virtually no health impacts from nonradiological releases.

5.12.1.3 Labor and Construction Health Risks. There are expected to be 25,212 total occupational/total labor worker-years for the 40-year duration of the interim storage facility. Hence, over the 40-year interim storage facility life span, it is estimated that 807 total injuries/illnesses and 0.81 fatality to DOE and contractor personnel would result. The expected 4,352 total construction worker-years for the 40-year duration of the interim storage facility results in 270 total injuries/illnesses and 0.48 fatality to DOE and contractor personnel.

5.12.2 Regionalization Alternative

Although the Regionalization Alternative is not explicitly analyzed, its impacts will be less than those from the Centralization Alternative.

5.13 Utilities and Energy

Direct changes in utility demand as a result of the Centralization and Regionalization Alternatives were compared against the current capacity and peak demand for each utility resource. Impacts to provision of a utility are considered to occur if the current demand, average annual demand, or peak demand for a utility is equal to or exceeds the current available capacity within the designated Region of Influence. For the purpose of analysis, the Region of Influence for each resource area is defined as the area served by the utility provider responsible for meeting the service demands of the ORR.

5.13.1 Centralization Alternative

5.13.1.1 Water Consumption. For the Centralization Alternative, approximately 0.43 liter per second (6.85 gallons per minute) of water is required to operate all the modules within the facility (Harr 1994). The K-25 plant, which would provide water to the site, has a capacity of 184 liters per second (2,917 gallons per minute) (Fritts 1994).

The proposed SNF management facilities would require approximately 0.2 percent of the K-25 plant's water capacity. The K-25 plant would operate at 53 percent of its capacity when the SNF facilities' water requirements are combined with the 1990 peak water usage of 97 liters per second (1,533 gallons per minute).

5.13.1.2 Electrical Consumption. The proposed SNF management facilities under the Centralization Alternative would require approximately 23,000 megawatt hours of electricity per year or approximately 2.63 megavolt-amperes average demand (Harr 1994). This represents 0.3 percent of ORR's 920 megavolt-ampere connected capacity. Thirty-one percent of the connected capacity of ORR would be utilized when the peak electric requirement of 285 megavolt-amperes was combined with the electrical requirements of the Centralization Alternative.

5.13.1.3 Fuel Consumption. Energy requirements for the proposed SNF management facilities under the Centralization Alternative were calculated assuming that electrical power purchased from a utility provider was the primary source of energy; however, fossil fuels may be used to power backup generators and during construction. The amount of fuel required for these operations would be small and should not substantially increase ORR fuel requirements.

5.13.1.4 Wastewater Disposal. Under the Centralization Alternative, approximately 0.43 liter per second (6.85 gallons per minute) of wastewater would be generated (Harr 1994). A new onsite sanitary sewage system and wastewater treatment plant might be required at the SNF facility. If a new system is not built, and sanitary sewage and wastewater are treated at K-25, this addition would represent approximately 2 percent of the K-25 sanitary sewer treatment system capacity of 26 liters per second (417 gallons per minute). Ninety-four percent of the wastewater capacity of the K-25 sanitary sewer treatment system would be utilized when the peak wastewater production of 24 liters per second (378 gallons per minute) was combined with the wastewater production of the SNF management facilities.

5.13.2 Regionalization Alternative

5.13.2.1 Water Consumption. The proposed SNF management facilities under the Regionalization Alternative would require less water than the facilities under the Centralization Alternative; therefore, the impacts would be less.

5.13.2.2 Electrical Consumption. The proposed SNF management facilities under the Regionalization Alternative would require less electricity than the facilities under the Centralization Alternative; therefore, the impacts would be less.

5.13.2.3 Fuel Consumption. Energy requirements for the proposed SNF management facilities under the Regionalization Alternative were calculated assuming that electrical power purchased from a utility provider was the primary source of energy; however, fossil fuels may be used to power backup generators and during construction activities. The amount of fuel required for these operations would be small and should not substantially increase ORR fuel requirements.

5.13.2.4 Wastewater Disposal. The proposed SNF management facilities under the Regionalization Alternative would produce less wastewater than the Centralization Alternative; therefore, the impacts would be less.

5.14 Materials and Waste Management

This section discusses the potential environmental consequences of the Centralization and Regionalization Alternatives for the management of chemical raw materials and transuranic, low-level radioactive, and hazardous waste at the ORR. Nonhazardous (sanitary) wastes are discussed in Section 5.8. Section 4.14 describes the waste categories and outlines the ongoing waste management activities for the ORR. These waste management activities include onsite and offsite waste treatment, onsite and offsite waste disposal, and onsite waste storage. Section 4.14 also describes the chemical raw material management activities for the ORR.

5.14.1 Methodology

This analysis considers the impact of the Centralization and Regionalization Alternatives on current waste management activities at the ORR (baseline conditions). In addition to requiring land area for SNF management, both alternatives would generate transuranic, low-level radioactive, hazardous, and nonhazardous wastes. Neither alternative is projected to generate mixed wastes or high-level wastes. This analysis is based on a comparison of the projected amounts of waste generated by the Centralization and Regionalization Alternatives versus the current waste generation rates and storage capacity at the ORR.

5.14.2 Materials and Waste Management

SNF management activities would require the use of chemicals, and it is conservatively assumed that all chemical raw materials used within the proposed SNF management facility would become hazardous wastes. The proposed SNF management facility would contribute transuranic, solid low-level, and sanitary (sewage) wastes. Table 5.14-1 presents the estimated waste generations by waste classification for each of the two alternatives (Centralization and Regionalization) and by each of two storage options (wet storage, dry storage).

5.14.2.1 Centralization Alternative. Under the Centralization Alternative, all DOE SNF (including Naval and domestic and foreign research reactors) will be transferred to and managed at the ORR.

5.14.2.2 Wet Storage Option. The wet storage option would generate transuranic, low-level, hazardous, and sanitary wastes. The effect that the projected amounts of each of these wastes would have on the ORR waste management is discussed below.

5.14.2.2.1 Transuranic Waste—Over a period of 40 years of operation the projected amount of transuranic waste generated due to the recovery and purification of transuranic products would be 644 cubic meters (22,750 cubic feet). The current storage capacity at the ORR (ORNL) is 833.4 cubic meters (295,000 cubic feet). ORNL will continue to generate transuranic waste, and disposal is eventually planned for the Waste Isolation Pilot Plant unit. If the Waste Isolation Pilot Plant unit does not come on line, the ORR transuranic waste storage

Table 5.14-1. Ten-year cumulative estimated waste generation for SNF alternatives at the ORR (m^3).[a]

Alternative/ storage option	Time period			
	1995-2004	2005-2014	2015-2024	2025-2034
Centralization Alternative				
Wet storage option				
Transuranic waste	161	161	161	161
Low-level waste	1,950	1,950	1,950	1,950
Hazardous waste	74	74	74	74
Sanitary waste (sewage)	1.2×10^5	1.2×10^5	1.2×10^5	1.2×10^5
Dry storage option				
Low-level waste	76	76	76	76
Sanitary waste (sewage)	1.9×10^4	1.9×10^4	1.9×10^4	1.9×10^4
Regionalization Alternative				
Wet storage option				
Transuranic waste	<161	<161	<161	<161
Low-level waste	<1,950	<1,950	<1,950	<1,950
Hazardous waste	<74	<74	<74	<74
Sanitary waste (sewage)	$<1.2 \times 10^5$	$<1.2 \times 10^5$	$<1.2 \times 10^5$	$<1.2 \times 10^5$
Dry storage option				
Low-level waste	<76	<76	<76	<76
Sanitary waste (sewage)	$<1.9 \times 10^4$	$<1.9 \times 10^4$	$<1.9 \times 10^4$	$<1.9 \times 10^4$

a. Source: Harr (1994).

capacity may have to be expanded to accommodate transuranic waste generated at the SNF facility.

5.14.2.2.2 Low-Level Waste—The wet storage option would generate liquid low-level waste as a result of its interim storage in water. Over a period of 40 years of operation, an estimated 7,800 cubic meters (over 2 million gallons) of low-level liquid waste might be generated. The total ORR (Y-12, K-25, ORNL) storage capacity for liquid low-level wastes is about 98,300 cubic meters (about 26 million gallons) (see Tables 4.14-1, 4.14-3, and 4.14-5). Impacts would be small.

5.14.2.2.3 Hazardous Wastes—Installation of the proposed SNF management facility would require additional management of hazardous wastes, including the placement of satellite storage areas within the SNF complex and more frequent offsite shipments of hazardous wastes. It is estimated that the wet storage option will generate approximately 7.4 cubic meters (261 cubic feet) of waste annually. Currently ORR manages about 10,000 cubic meters (about 353,000 cubic feet) of hazardous waste annually (see Tables 4.14-1, 4.14-3, and 4.14-5); therefore, the impact of SNF generated hazardous waste on the management of hazardous waste at the ORR would be minimal.

5.14.2.2.4 Sanitary Waste—Sanitary wastes are covered in Section 5.8.

5.14.2.3 Dry Storage Option. The dry storage option would generate low-level waste and sanitary waste. The effects that the projected amounts of each of these wastes would have on the ORR waste management is discussed below.

5.14.2.3.1 Low-Level Waste—The low-level radioactive contaminated waste stream would result from wastes generated during decontamination operations. Over a period of 40 years of operation, an estimated 304 cubic meters (10,700 cubic feet) of low-level waste might be generated. As reported in Section 5.14.2.2.2 the total ORR storage capacity for liquid low-level waste is about 98,300 cubic meters (about 26 million gallons). Impacts from SNF operations on low-level waste management would be minimal.

5.14.2.3.2 Sanitary Waste—Sanitary wastes are covered in Section 5.8.

5.14.2.2 Regionalization Alternative. Under the Regionalization Alternative, the ORR would be the alternate site for the SRS. This alternative would generate less waste from the SNF complex than the Centralization Alternative since it is the alternative that stores less SNF. For either the wet storage or dry storage option, the waste generated would be less than those presented for the Centralization Alternative. Therefore, Table 5.14-1 presents tbe estimated waste generation for the SNF for the Regionalization Alternative as less than those generated for the Centralization Alternative. The impacts presented for each of the waste categories for its two options (wet storage, dry storage) for the Centralization Alternative apply to the Regionalization Alternative as well.

5.15 Facility Accidents

A potential exists for accidents at facilities associated witb the handling, inspection, and storage of spent nuclear fuel at the ORR. Accidents can be categorized into events that are abnormal (for example, minor spills), events a facility was designed to withstand, and events a facility is not designed to withstand. These categories are termed *abnormal*, *design basis*, and *beyond design basis* accidents, respectively. Summarized here are consequences of possible facility accidents for a member of the public at the nearest site boundary and at the nearest road, for the collective population within 80 kilometers (50 miles), for workers, and for the environment. See Section 5.11 for a summary of the assessment of transportation accidents.

A review of the historical record of accidents at the ORR is summarized in the following section. Methods used to assess potential future events are summarized in Section 5.15.2. Evaluations of accident impacts by alternative are summarized in Sections 5.15.3 through 5.15.7. A summary comparison of accident impacts by alternative is given in Section 3.2. Additional supporting documentation for the accident impacts is given in a separate report (HNUS 1995).

This section examines the various activities that have been performed to assess the potential for accidents and their consequences for workers and the public for each alternative. A set of potential reasonably foreseeable accidents over the 40-year period are described which envelop all accidents. Secondary impacts of accidents pertaining to cultural resources, economics, land use, endangered species, water resources, and ecology are also addressed. This section also addresses emergency preparedness plans that have been established to mitigate the primary and secondary effects of accidents.

5.15.1 Historical SNF Accidents at ORR

The records of unusual events, including accidents, at the ORR have been reviewed to determine whether there have been any accidents with offsite impacts. The results indicate that there have been no accidents at the ORR associated with SNF that have had significant offsite consequences for the general public.

5.15.2 Methodology

5.15.2.1 Existing Facilities.

5.15.2.1.1 Assumptions and Approach—The potential accidents associated with the existing SNF management facilities and operations were screened to determine which ones to include in the accident analysis for the No Action Alternative. Source terms were developed for each accident analysis. The GENII code (PNL 1988) was used to estimate accident consequences for the general public and for individuals onsite or at the site boundary based on both 50 percent and 95 percent meteorology. Accident consequences and risk are described in terms of dose, cancer fatalities, and total health detriments for workers, an individual at the site boundary, and the public residing as far as 80 kilometers (50 miles) from the proposed SNF management facility.

5.15.2.1.2 Accident Screening—The potential accidents associated with the existing SNF management facilities and operations were screened to determine which ones to include in the accident analysis for the No Action Alternative. Initiating events were reviewed including natural phenomena (earthquakes, tornadoes, etc.), human initiated events (human error), equipment failures, fires, explosions, airplane crashes, and terrorism. One reference design basis fuel handling accident was selected for detailed analysis.

The dam in the High Flux Isotope Reactor fuel pool is removed and stored within the pool during refueling operations. The reference design basis fuel handling accident postulated that during refueling operations, the dam falls and damages all the 62 spent fuel cores, including the most recently discharged core, located in the pool. The fission products from all 62 spent fuel cores are released to the water in the pool (ORNL 1992b).

A beyond design basis tornado accident was considered that resulted in collapse of the High Flux Isotope Reactor bay roof and the roof's major structural member falls into the fuel pool and damages all the 62 spent fuel cores located in the pool. The fission products from all 62 spent fuel cores are released to the water in the pool (Flanagan 1994).

Additional beyond design basis accidents initiated by an airplane crash were postulated for the High Flux Isotope Reactor and Bulk Shielding Reactor but were screened out because the probability of an airplane crash into the fuel pool was estimated to be less than 1.0×10^{-7} per year.

The consequences of postulated operational and reference design basis accidents for the existing facilities are enveloped by the accident consequences presented in Subsection 5.15.4 for the Centralization Alternative.

5.15.2.2 New Facilities. In the absence of suitable design details for new SNF management facilities during this stage of the SNF Management Program upon which to base an accident analysis, the approach makes use of accident scenarios and associated data that have been analyzed and documented for similar facilities. They include spent nuclear fuel facilities at INEL, Hanford, Savannah River Site, and Naval sites.

5.15.2.2.1 Assumptions and Approach—A number of postulated accidents for the similar facilities have been selected to serve as a common basis for estimating accident consequences for workers and the public at the ORR site. Although the accident scenarios, source terms, and related assumptions are common for both sites, the estimated consequences are unique to the ORR site because of site differences in modeling parameters pertaining to distances to site boundaries and population centers, population distributions, and meteorology. The GENII code was used to estimate accident consequences for the general public and for individuals onsite or at the site boundary based on both 50 percent and 95 percent meteorology. Accident consequences and risk are described in terms of dose, cancer fatalities, and total health detriments for workers, an individual at the site boundary, a transient individual at the nearest public access, and the public residing as far as 80 kilometers (50 miles) from the proposed SNF facility. The estimated frequency of each selected accident is based on the reference source documentation.

The probability of an airplane crash into the new SNF management facility is considered small because there are no nearby airports with large aircraft activity. The probability is expected to be in the 1×10^{-6} to 1×10^{-8} per year range. For calculational purposes the probability of this accident is conservatively estimated at 1×10^{-6} per year. Potential accidents initiated by an airplane crash into the SNF management facilities and the estimated consequences have been analyzed.

The secondary impacts of accidental releases of radioactive and hazardous materials are also addressed in a qualitative manner. Secondary impacts pertain to effects of accidents on land use, endangered species, water resources, cultural resources, and ecology.

5.15.2.2.2 Accident Screening—The potential accidents associated with existing SNF management facilities and operations were screened to determine which ones to include in the accident analysis for the ORR. The source documentation for this purpose was primarily Appendices A, B, C, and D of Volume 1 of this EIS. The source documentation describes potential accidents for existing and planned SNF management facilities that were selected by a screening process. Initiating events were reviewed including natural phenomena (earthquakes, tornadoes, etc.), human initiated events (human error), equipment failures, fires, explosions, airplane crashes, and terrorism. Accidents associated with the Expended Core Facility operations at the ORR, were analyzed separately and the results are documented in Appendix D of this EIS. For the ORR the maximum reasonably foreseeable criticality and nonradiological accidents are associated with the Expended Core Facility. The potential for a criticality exists while the fuel is in dry storage, during handling, and in the wet storage pool. Although the probability of any criticality is very low, a hypothetical criticality of 1×10^{19} fissions was postulated in the Expended Core Facility wet pool as a basis for estimating the maximum reasonably foreseeable consequences of a criticality.

The selected accidents include beyond reference design basis events to reflect the magnitude of accident consequences that envelop all other accidents that have a reasonable probability of occurrence. They also include other accidents with lower consequences and typically higher probabilities of occurrence to show a range of accident types and consequences.

The accidents included in this set are reasonably foreseeable, meaning that there are one or more sequences of events that will lead to their occurrence and the sequence with the lowest probability of occurrence is greater than 1×10^{-7} per year. Accidents falling outside of this envelope, such as a meteorite impact, have been judged unreasonable because the probability of occurrence in less than 1×10^{-7} per year.

5.15.2.2.3 Accident Prevention and Mitigation — Under the Centralization and Regionalization alternatives, the SNF management facilities at the ORR will be of new design and construction and incorporate the latest technology for safety. The accidents postulated for the SNF management facilities are based on operations and safety analyses that have been performed at similar facilities. One of the major design goals for the SNF management facilities is to achieve a reduced risk to facility personnel and to public health and safety relative to that associated with similar functions at the existing SNF management facilities. Significant changes exist between design criteria and safety standards for the new SNF management facilities and those for the current facilities, thus reducing total risk. These changes include design to current DOE structural and safety criteria and to planned throughput and storage capacity.

The new SNF management facilities would be designed to comply with current Federal, state, and local laws, DOE Orders, and industrial codes and standards. This would provide facilities that are highly resistant to the effects of severe natural phenomena, including earthquake, flood, tornado, high wind, as well as credible events as appropriate to the site, such as fire and explosions, and man-made threats to its continuing structural integrity for containing materials.

Emergency preparedness plans have also been prepared for existing facilities and will be revised for new facilities to lower the potential consequences of an accident to workers and the public. All workers receive evacuation training to ensure timely and orderly personnel movement away from high-risk areas. Plans and arrangements with local authorities are also in place to evacuate the general public that may be at risk of exposure to hazardous materials that are accidentally released.

5.15.3 No Action Alternative

There is a potential for the accidental release of radioactive substances during various stages of SNF handling operations and storage. The operations begin with discharge of SNF from the reactor during refueling operations. The discharged SNF is placed in the fuel pool for cooling and short term storage. After an adequate cooldown period, SNF is removed from the pool and transported offsite for long term storage. Accidents that may occur during these handling operations and storage may involve the release of radioactive material to air or water pathways. The cause of accidents may be due to internal initiators, such as operator error, equipment failure, and terrorism, or external initiators, such as an earthquake.

In the event that SNF can not be transported offsite for long term storage, reactor operations will cease when the fuel pool is full. Presently the SNF stored in the ORR fuel pools is sound and has not deteriorated. If the existing SNF were to remain in the ORR fuel pools for an extended period of time and deterioration of the aluminum fuel cladding occurred, there are no existing facilities at the ORR to characterize the SNF.

5.15.3.1 Radiological Impacts. The potential accidents associated with the existing SNF management facilities and operations were screened to determine which ones to include in the accident analysis for the No Action Alternative. One reference design basis accident and one beyond design basis accident were selected for detailed analysis. Although other accidents may occur, their estimated consequences are bounded by this beyond design basis accident or their probability of occurrence is less than 1.0×10^{-7}per year. If these accidents were to occur, the dose and risk to the onsite worker and the general population are shown in Tables 5.15-1 and 5.15-2 for 95 percent and 50 percent meteorology respectively. Similarly, cancer fatalities are shown in Tables 5.15-3 and 5.15-4, and the health effects are shown in Tables 5.15-5 and 5.15-6.

5.15.3.1.1 Reference Design Basis Accident—The dam that separates the High Flux Isotope Reactor pool from the clean center pool during normal reactor operation is moved to a position between the east and center clean pools prior to defueling the reactor. The dam is lifted approximately 3 feet above the water over its slot between the reactor and center pools, then moved with the crane across the center clean pool, and then lowered into its slot between the east and center pools. During this movement, and when the dam is being moved back, the fuel in the center pool is subjected to the possibility of dropping the dam and mechanically

Table 5.15-1. Summary of No Action Alternative accident analysis dose and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEI[a] (rem)	NPAI[b]	Worker[d] (rem)	Population (person-rem)	MEI (rem/yr)	NPAI	Worker (rem/yr)	Population (person-rem/yr)
Dropped dam	1.0×10^{-4} [e]	3.7×10^{-1} [c]	6.2×10^{-1}	2.3×10^{-2}	3.5×10^{3} [c]	3.7×10^{-5}	6.2×10^{-5}	2.3×10^{-6}	3.5×10^{-1}
Beyond design basis tornado	1.9×10^{-7}	4.9×10^{0} [d]	7.5×10^{1}	2.6×10^{1}	4.5×10^{4} [d]	9.3×10^{-7}	1.4×10^{-5}	4.9×10^{-6}	8.6×10^{-3}

a. Maximum exposed individual (MEI).

b. Nearest public access individual (NPAI) - Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation, external, and ingestion pathways.

d. Radiation exposure received from inhalation and external pathways.

e. The value is expected to be in the 1.0×10^{-4} to 1.0×10^{-6} range. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

Table 5.15-2. Summary of No Action Alternative accident analysis dose and risk estimates for the Oak Ridge Site at 50 percent meteorology.

		50 percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEI[a] (rem)	NPAI[b]	Worker[d] (rem)	Population (person-rem)	MEI (rem/yr)	NPAI	Worker (rem/yr)	Population (person-rem/yr)
Dropped dam	1.0×10^{-4} [e]	8.6×10^{-2} [c]	1.9×10^{-1}	5.7×10^{-3}	1.2×10^{3} [c]	8.6×10^{-6}	1.9×10^{-5}	5.7×10^{-7}	1.2×10^{-1}
Beyond design basis tornado	1.9×10^{-7}	9.5×10^{-1} [d]	1.9×10^{1}	4.0×10^{0}	7.2×10^{3} [d]	1.8×10^{-7}	3.6×10^{-6}	7.6×10^{-7}	1.4×10^{-3}

a. Maximum exposed individual (MEI).

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation, external, and ingestion pathways.

d. Radiation exposure received from inhalation and external pathways.

e. The value is expected to be in the 1.0×10^{-4} to 1.0×10^{-6} range. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

Table 5.15-3. Summary of No Action Alternative accident analysis cancer fatality and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
		Cancer fatalities				Cancer fatality risk (cancer fatalities/year)			
Accident scenario	Frequency (per year)	MEI[a]	NPAI[b]	Worker[d]	Population	MEI	NPAI	Worker	Population
Dropped dam	1.0×10^{-4} [e]	1.8×10^{-4} [c]	3.1×10^{-4}	9.2×10^{-6}	1.7×10^{0} [c]	1.8×10^{-8}	3.1×10^{-8}	9.2×10^{-10}	1.7×10^{-4}
Beyond design basis tornado	1.9×10^{-7}	2.5×10^{-3} [d]	7.5×10^{-2}	2.0×10^{-2}	2.3×10^{1} [d]	4.8×10^{-10}	1.4×10^{-8}	3.8×10^{-9}	4.4×10^{-6}

a. Maximum exposed individual (MEI).

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation, external, and ingestion pathways.

d. Radiation exposure received from inhalation and external pathways.

e. The value is expected to be in the 1.0×10^{-4} to 1.0×10^{-6} range. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

Table 5.15-4. Summary of No Action Alternative accident cancer fatality and risk estimates for the Oak Ridge Site at 50 percent meteorology.

Accident scenario	Frequency (per year)	50 percent meteorology: Cancer fatalities				Cancer fatality risk (cancer fatalities/year)			
		MEI[a]	NPAI[b]	Worker[d]	Population	MEI	NPAI	Worker	Population
Dropped dam	1.0×10^{-4} [e]	4.3×10^{-5} [c]	9.5×10^{-5}	2.3×10^{-6}	6.2×10^{-1} [c]	4.3×10^{-9}	9.5×10^{-9}	2.3×10^{-10}	6.2×10^{-5}
Beyond design basis tornado	1.9×10^{-7}	4.8×10^{-4} [d]	9.5×10^{-3}	1.6×10^{-3}	3.6×10^{0} [d]	9.1×10^{-11}	1.8×10^{-9}	3.0×10^{-10}	6.8×10^{-7}

a. Maximum exposed individual (MEI).

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation, external, and ingestion pathways.

d. Radiation exposure received from inhalation and external pathways.

e. The value is expected to be in the 1.0×10^{-4} to 1.0×10^{-6} range. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

Table 5.15-5. Summary of No Action Alternative accident analysis health effects and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
		Total health detriments[a]				Total health detriment risk (detriments/year)			
Accident scenario	Frequency (per year)	MEI[b]	NPAI[c]	Worker[e]	Population	MEI	NPAI	Worker	Population
Dropped dam	1.0×10^{-4} [f]	2.7×10^{-4} [d]	4.6×10^{-4}	1.3×10^{-5}	2.5×10^{0} [d]	2.7×10^{-8}	4.6×10^{-8}	1.3×10^{-9}	2.5×10^{-4}
Beyond design basis tornado	1.9×10^{-7}	3.6×10^{-3} [e]	1.1×10^{-1}	2.9×10^{-2}	3.3×10^{1} [e]	6.8×10^{-10}	2.1×10^{-8}	5.5×10^{-9}	6.3×10^{-6}

a. The estimated number of cancer fatalities, cancer nonfatalities, and genetic defects resulting from the radiation exposure.

b. Maximum exposed individual (MEI).

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. Radiation exposure received from inhalation and external pathways.

f. The value is expected to be in the 1.0×10^{-4} to 1.0×10^{-6} range. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

Table 5.15-6. Summary of No Action Alternative accident analysis health effects and risk estimates for the Oak Ridge Site at 50 percent meteorology.

Accident scenario	Frequency (per year)	50 percent meteorology							
		Total health detriments[a]				Total health detriment risk (detriments/year)			
		MEI[b]	NPAI[c]	Worker[e]	Population	MEI	NPAI	Worker	Population
Dropped dam	1.0×10^{-4} [f]	6.3×10^{-5} [d]	1.4×10^{-4}	3.2×10^{-6}	9.0×10^{-1} [d]	6.3×10^{-9}	1.4×10^{-8}	3.2×10^{-10}	9.0×10^{-5}
Beyond design basis tornado	1.9×10^{-7}	6.9×10^{-4} [e]	1.4×10^{-2}	2.2×10^{-3}	5.3×10^{0} [e]	1.3×10^{-10}	2.7×10^{-9}	4.2×10^{-10}	1.0×10^{-6}

a. The estimated number of cancer fatalities, cancer nonfatalities, and genetic defects resulting from the radiation exposure.

b. Maximum exposed individual (MEI).

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. Radiation exposure received from inhalation and external pathways.

f. The value is expected to be in the 1.0×10^{-4} to 1.0×10^{-6} range. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

damaging the fuel. There is also a possibility that the dam could somehow be dropped as it is being lowered into (or raised from) its place between the clean pools and then fall in a way that would damage the fuel in either pool. The reference design basis fuel handling accident postulated that during refueling operations, the dam falls and damages all the 62 spent fuel cores, including the most recently discharged core, located in the pool. The fission products from all 62 spent fuel cores are assumed to be instantaneously released into the water in the pool. The analysis assumed that the pool area exhaust system was operational, it carried off all evaporated fission products, it filtered the stream, and it released the remaining fission products up the stack. The source term released up the stack is shown in Table 5.15-7. The frequency of occurrence for this accident is in the range of 1.0×10^{-4} to 1.0×10^{-6} per year (ORNL 1992b).

5.15.3.1.2 Beyond Design Basis Accident—The beyond design basis accident postulated that a beyond design basis tornado with wind speeds of approximately 300 mph struck the High Flux Isotope Reactor reactor bay. The reactor bay roof collapses and the major structural member in the roof falls into the fuel pool and damages all the 62 spent fuel cores, including the most recently discharged core, located in the pool. The fission products from all 62 spent fuel cores are assumed to be instantaneously released into the water in the pool. The analysis assumed that all evaporated fission products are released directly to the environment at ground level. The source term is similar to the reference design basis accident source term present in Table 5.15-7 except that no credit was taken for filtration of the iodine evaporated from the pool. The iodine released in the beyond design basis source term is 100 times greater than the iodine released in the reference design basis accident source term (Flanagan 1994).

The annual return frequency of a tornado with wind speeds of approximately 300 mph at ORR is 1.4×10^{-5}. The conditional probability for collapse of the reactor bay roof during a 300 mph tornado is 0.46. The ratio of the spent fuel area to the reactor bay floor area (i.e., the probability that the falling structural member will fall into the spent fuel area of the fuel pool) is 0.03. The frequency of occurrence for this beyond design basis accident is 1.9×10^{-7} per year (Flanagan 1994).

Due to the dose consequences associated with the postulated accident, protective actions were assumed for the offsite population. The analysis took no credit for evacuation of the public from the affected area. However, credit was taken for removing contaminated food from the general public.

Table 5.15-7. Estimated radionuclide releases for the High Flux Isotope Reactor fuel pool dam drop accident at ORR.

	Release Duration	
Isotope	0-2 hr Curies	0-30 day Curies
Hydrogen-3 (Tritium)	3.5×10^{2}	3.5×10^{2}
Krypton-83m	1.9×10^{2}	1.9×10^{2}
Krypton-85	1.0×10^{4}	1.0×10^{4}
Krypton-85m	3.6×10^{3}	3.6×10^{3}
Krypton-87	4.2×10^{-1}	4.2×10^{-1}
Krypton-88	1.1×10^{3}	1.1×10^{3}
Iodine-151	3.8×10^{0}	1.5×10^{1}
Iodine-132	5.0×10^{0}	5.1×10^{0}
Iodine-133	4.7×10^{0}	6.2×10^{0}
Iodine-134	2.2×10^{-7}	2.2×10^{-7}
Iodine-135	7.4×10^{-1}	8.1×10^{-1}
Xenon-131m	2.3×10^{3}	2.3×10^{3}
Xenon-133	8.7×10^{5}	8.7×10^{5}
Xenon-133m	2.5×10^{4}	2.5×10^{4}
Xenon-135	1.7×10^{5}	1.7×10^{5}
Xenon-135m	1.2×10^{3}	1.2×10^{3}

Source: ORNL 1992b

5.15.3.2 Nonradiological Hazards. The two bounding accidents involving nonradiological hazards postulated for the Centralization Alternative in subsection 5.15.4.2 are assumed to be bounding for the No Action Alternative. SNF operations under the No Action Alternative should not introduce any nonradiological hazards unique to the ORR SNF facilities.

5.15.4 Centralization Alternative

There is a potential for the accidental release of radioactive substances during various stages of SNF handling operations and storage. The operations at the new SNF management facilities begin with the receipt of an SNF shipment by truck or rail carrier, followed by the unloading of the shipping cask from the transport vehicle. If the SNF requires cooling, the cask is placed into an unloading pool where the SNF is withdrawn from the cask, moved to a temporary wet storage basin, and placed into a fuel rack. Some SNF that does not require cooling will be handled in a special cell where it will undergo canning and/or characterization. SNF that does not have to be cooled and does not require canning and/or characterization will be loaded into a dry storage canister within a transfer cask and transported to modular above-grade dry storage. Accidents that may occur during these handling operations and storage at the existing or new SNF management facilities may involve the release of radioactive material to air or water pathways. The cause of accidents may be due to internal initiators, such as operator error, terrorism, and equipment failure, or external initiators, such as an airplane crash into a facility.

5.15.4.1 Radiological Impacts. The accidents described below have been chosen to envelop the consequences of potential accidents for the proposed new SNF management facilities at the ORR. Although other accidents may occur, their estimated consequences are bounded by the accidents in the envelope or their probability of occurrence is less than 1 x 10^{-7} per year. If these accidents were to occur, the dose and risk would be as shown in Tables 5.15-8 and 5.15-9 for 95 percent and 50 percent meteorology respectively. These doses are in addition to the average natural background radiation exposure of 360 millirem per year. Similarly, cancer fatalities are shown in Tables 5.15-10 and 5.15-11, and the health effects are shown in Tables 5.15-12 and 5.15-13.

5.15.4.1.1 Fuel Assembly Breach—Physical damage and breach of a fuel assembly could accidentally occur from dropping, objects falling on the assembly, or cutting into the fuel

Table 5.15-8. Summary of the Centralization Alternative accident analysis dose and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEI[a] (rem)	NPAI[b] (rem)	Worker[c] (rem)	Population[d] (person-rem)	MEI (rem/year)	NPAI (rem/year)	Worker (rem/year)	Population (person-rem/year)
Fuel assembly breach	1.6×10^{-1} [e]	1.2×10^{-2}	3.8×10^{-3}	1.5×10^{-3}	2.1×10^{1}	1.9×10^{-3}	6.1×10^{-4}	2.4×10^{-4}	3.4×10^{0}
Dropped fuel cask	1.0×10^{-4} [f]	7.8×10^{0}	1.2×10^{1}	4.7×10^{0}	1.9×10^{4}	7.8×10^{-4}	1.2×10^{-3}	4.7×10^{-4}	1.9×10^{0}
Severe impact and fire	1.0×10^{-6} [g]	5.6×10^{1}	8.8×10^{0}	3.4×10^{0}	1.0×10^{5}	5.6×10^{-5}	8.8×10^{-6}	3.4×10^{-6}	1.0×10^{-1}
Wind-driven missile impact into dry storage	1.0×10^{-5}	2.2×10^{-2}	2.9×10^{-2}	1.2×10^{-2}	5.2×10^{1}	2.2×10^{-7}	2.9×10^{-7}	1.2×10^{-7}	5.2×10^{-4}
Airplane crash into dry storage	1.0×10^{-6} [g]	9.0×10^{0}	3.4×10^{1}	1.2×10^{1}	1.7×10^{4}	9.0×10^{-6}	3.4×10^{-5}	1.2×10^{-5}	1.7×10^{-2}
Airplane crash into dry cell facility	1.0×10^{-6} [g]	7.6×10^{1}	5.8×10^{1}	2.3×10^{1}	1.2×10^{5}	7.6×10^{-5}	5.8×10^{-5}	2.3×10^{-5}	1.2×10^{-1}
Airplane crash into water pool	1.0×10^{-6} [g]	1.4×10^{-1}	5.9×10^{-2}	2.3×10^{-2}	5.6×10^{3}	1.4×10^{-7}	5.9×10^{-8}	2.3×10^{-8}	5.6×10^{-3}

a. Maximum exposed individual (MEI). Dose received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Dose received from inhalation and external pathways.

c. Dose received from inhalation and external pathways.

d. Dose received from inhalation, external, and ingestion pathways.

e. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

f. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

g. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-9. Summary of the Centralization Alternative accident analysis dose and risk estimates for the Oak Ridge Site at 50 percent meteorology.

		50 percent meteorology							
		Dose				Risk			
Accident scenario	Frequency (per year)	MEI[a] (rem)	NPAI[b] (rem)	Worker[c] (rem)	Population[d] (person-rem)	MEI (rem/year)	NPAI (rem/year)	Worker (rem/year)	Population (person-rem/year)
Fuel assembly breach	1.6×10^{-1} [e]	1.2×10^{-3}	6.7×10^{-4}	3.2×10^{-4}	2.5×10^{0}	1.9×10^{-4}	1.1×10^{-4}	5.1×10^{-5}	4.0×10^{-1}
Dropped fuel cask	1.0×10^{-4} [f]	7.5×10^{-1}	2.2×10^{0}	1.0×10^{0}	2.7×10^{3}	7.5×10^{-5}	2.2×10^{-4}	1.0×10^{-4}	2.7×10^{-1}
Severe impact and fire	1.0×10^{-6} [g]	5.5×10^{0}	1.6×10^{0}	7.5×10^{-1}	1.2×10^{4}	5.5×10^{-6}	1.6×10^{-6}	7.5×10^{-7}	1.2×10^{-2}
Wind-driven missile impact into dry storage	1.0×10^{-5}	2.1×10^{-3}	5.5×10^{-3}	2.5×10^{-3}	7.7×10^{0}	2.1×10^{-8}	5.5×10^{-8}	2.5×10^{-8}	7.7×10^{-5}
Airplane crash into dry storage	1.0×10^{-6} [g]	8.9×10^{-1}	6.2×10^{0}	2.7×10^{0}	2.5×10^{3}	8.9×10^{-7}	6.2×10^{-6}	2.7×10^{-6}	2.5×10^{-3}
Airplane crash into dry cell facility	1.0×10^{-6} [g]	7.2×10^{0}	1.1×10^{1}	5.1×10^{0}	1.5×10^{4}	7.2×10^{-6}	1.1×10^{-5}	5.1×10^{-6}	1.5×10^{-2}
Airplane crash into water pool	1.0×10^{-6} [g]	1.3×10^{-2}	1.1×10^{-2}	5.0×10^{-3}	5.2×10^{2}	1.3×10^{-8}	1.1×10^{-8}	5.0×10^{-9}	5.2×10^{-4}

a. Maximum exposed individual (MEI). Dose received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Dose received from inhalation and external pathways.

c. Dose received from inhalation and external pathways.

d. Dose received from inhalation, external, and ingestion pathways.

e. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

f. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

g. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-10. Summary of the Centralization Alternative accident analysis cancer fatality and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
		Cancer fatalities				Cancer fatality risk (cancer fatalities/year)			
Accident scenario	Frequency (per year)	MEI[a]	NPAI[b]	Worker[c]	Population[d]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [e]	6.0×10^{-6}	1.9×10^{-6}	6.0×10^{-7}	2.1×10^{-2}	9.6×10^{-7}	3.0×10^{-7}	9.6×10^{-8}	3.4×10^{-3}
Dropped fuel cask	1.0×10^{-4} [f]	3.9×10^{-3}	6.0×10^{-3}	1.9×10^{-3}	1.9×10^{1}	3.9×10^{-7}	6.0×10^{-7}	1.9×10^{-7}	1.9×10^{-3}
Severe impact and fire	1.0×10^{-6} [g]	5.6×10^{-2}	4.4×10^{-3}	1.4×10^{-3}	1.0×10^{2}	5.6×10^{-8}	4.4×10^{-9}	1.4×10^{-9}	1.0×10^{-4}
Wind-driven missile impact into dry storage	1.0×10^{-5}	1.1×10^{-5}	1.5×10^{-5}	4.9×10^{-6}	5.2×10^{-2}	1.1×10^{-10}	1.5×10^{-10}	4.9×10^{-11}	5.2×10^{-7}
Airplane crash into dry storage	1.0×10^{-6} [g]	4.5×10^{-3}	3.4×10^{-2}	4.8×10^{-3}	1.7×10^{1}	4.5×10^{-9}	3.4×10^{-8}	4.8×10^{-9}	1.7×10^{-5}
Airplane crash into dry cell facility	1.0×10^{-6} [g]	7.6×10^{-2}	5.8×10^{-2}	1.8×10^{-2}	1.2×10^{2}	7.6×10^{-8}	5.8×10^{-8}	1.8×10^{-8}	1.2×10^{-4}
Airplane crash into water pool	1.0×10^{-6} [g]	6.9×10^{-5}	3.0×10^{-5}	9.2×10^{-6}	5.6×10^{0}	6.9×10^{-11}	3.0×10^{-11}	9.2×10^{-12}	5.6×10^{-6}

a. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

f. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

g. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-11. Summary of the Centralization Alternative accident analysis cancer fatality and risk estimates for the Oak Ridge Site at 50 percent meteorology.

		50 percent meteorology							
Accident scenario	Frequency (per year)	Cancer fatalities				Cancer fatality risk (cancer fatalities/year)			
		MEI[a]	NPAI[b]	Worker[c]	Population[d]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [e]	6.0×10^{-7}	3.4×10^{-7}	1.3×10^{-7}	1.3×10^{-3}	9.6×10^{-8}	5.4×10^{-8}	2.1×10^{-8}	2.1×10^{-4}
Dropped fuel cask	1.0×10^{-4} [f]	3.7×10^{-4}	1.1×10^{-3}	4.0×10^{-4}	2.7×10^{0}	3.7×10^{-8}	1.1×10^{-7}	4.0×10^{-8}	2.7×10^{-4}
Severe impact and fire	1.0×10^{-6} [g]	2.8×10^{-3}	8.1×10^{-4}	3.0×10^{-4}	1.2×10^{1}	2.8×10^{-9}	8.1×10^{-10}	3.0×10^{-10}	1.2×10^{-5}
Wind-driven missile impact into dry storage	1.0×10^{-5}	1.0×10^{-6}	2.7×10^{-6}	1.0×10^{-6}	3.8×10^{-3}	1.0×10^{-11}	2.7×10^{-11}	1.0×10^{-11}	3.8×10^{-8}
Airplane crash into dry storage	1.0×10^{-6} [g]	4.4×10^{-4}	3.1×10^{-3}	1.1×10^{-3}	2.5×10^{0}	4.4×10^{-10}	3.1×10^{-9}	1.1×10^{-9}	2.5×10^{-6}
Airplane crash into dry cell facility	1.0×10^{-6} [g]	3.6×10^{-3}	5.5×10^{-3}	2.0×10^{-3}	1.5×10^{1}	3.6×10^{-9}	5.5×10^{-9}	2.0×10^{-9}	1.5×10^{-5}
Airplane crash into water pool	1.0×10^{-6} [g]	6.4×10^{-6}	5.5×10^{-6}	2.0×10^{-6}	5.5×10^{-1}	6.4×10^{-12}	5.5×10^{-12}	2.0×10^{-12}	5.5×10^{-7}

a. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

b. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

c. Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation, external, and ingestion pathways.

e. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

f. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

g. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-12. Summary of the Centralization Alternative accident analysis health effects and risk estimates for the Oak Ridge Site at 95 percent meteorology.

		95 percent meteorology							
Accident Scenario	Frequency (per year)	Total health detriments[a]				Total health detriment risk (detriments/year)			
		MEI[b]	NPAI[c]	Worker[d]	Population[e]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [f]	8.8×10^{-6}	2.8×10^{-6}	8.4×10^{-7}	3.1×10^{-2}	1.4×10^{-6}	4.5×10^{-7}	1.3×10^{-7}	5.0×10^{-3}
Dropped fuel cask	1.0×10^{-4} [g]	5.7×10^{-3}	8.8×10^{-3}	2.6×10^{-3}	2.7×10^{1}	5.7×10^{-7}	8.8×10^{-7}	2.6×10^{-7}	2.7×10^{-3}
Severe impact and fire	1.0×10^{-6} [h]	8.2×10^{-2}	6.4×10^{-3}	1.9×10^{-3}	1.5×10^{2}	8.2×10^{-8}	6.4×10^{-9}	1.9×10^{-9}	1.5×10^{-4}
Wind-driven missile impact into dry storage	1.0×10^{-5}	1.6×10^{-5}	2.1×10^{-5}	6.8×10^{-6}	7.5×10^{-2}	1.6×10^{-10}	2.1×10^{-10}	6.8×10^{-11}	7.5×10^{-7}
Airplane crash into dry storage	1.0×10^{-6} [h]	6.6×10^{-3}	5.0×10^{-2}	6.7×10^{-3}	2.4×10^{1}	6.6×10^{-9}	5.0×10^{-8}	6.7×10^{-9}	2.4×10^{-5}
Airplane crash into dry cell facility	1.0×10^{-6} [h]	1.1×10^{-1}	8.5×10^{-2}	2.6×10^{-2}	1.8×10^{2}	1.1×10^{-7}	8.5×10^{-8}	2.6×10^{-8}	1.8×10^{-4}
Airplane crash into water pool	1.0×10^{-6} [h]	1.0×10^{-4}	4.3×10^{-5}	1.3×10^{-5}	8.2×10^{0}	1.0×10^{-10}	4.3×10^{-11}	1.3×10^{-11}	8.2×10^{-6}

a. The estimated number of cancer fatalities, cancer nonfatalities, and genetic defects resulting from the radiation exposure.

b. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation and external pathways.

e. Radiation exposure received from inhalation, external, and ingestion pathways.

f. The value is $<1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

g. The value is $<1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

h. The value is $<1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

Table 5.15-13. Summary of the Centralization Alternative accident analysis health effects and risk estimates for the Oak Ridge Site at 50 percent meteorology.

		50 percent meteorology							
Accident scenario	Frequency (per year)	Total health detriments[a]				Total health detriment risk (detriments/year)			
		MEI[b]	NPAI[c]	Worker[d]	Population[e]	MEI	NPAI	Worker	Population
Fuel assembly breach	1.6×10^{-1} [f]	8.8×10^{-7}	4.9×10^{-7}	1.8×10^{-7}	1.8×10^{-3}	1.4×10^{-7}	7.8×10^{-8}	2.9×10^{-8}	2.9×10^{-4}
Dropped fuel cask	1.0×10^{-4} [g]	5.5×10^{-4}	1.6×10^{-3}	5.6×10^{-4}	4.0×10^{0}	5.5×10^{-8}	1.6×10^{-7}	5.6×10^{-8}	4.0×10^{-4}
Severe impact and fire	1.0×10^{-6} [h]	4.0×10^{-3}	1.2×10^{-3}	4.2×10^{-4}	1.8×10^{1}	4.0×10^{-9}	1.2×10^{-9}	4.2×10^{-10}	1.8×10^{-5}
Wind-driven missile impact into dry storage	1.0×10^{-5}	1.5×10^{-6}	4.0×10^{-6}	1.4×10^{-6}	5.6×10^{-3}	1.5×10^{-11}	4.0×10^{-11}	1.4×10^{-11}	5.6×10^{-8}
Airplane crash into dry storage	1.0×10^{-6} [h]	6.5×10^{-4}	4.5×10^{-3}	1.5×10^{-3}	3.6×10^{0}	6.5×10^{-10}	4.5×10^{-9}	1.5×10^{-9}	3.6×10^{-6}
Airplane crash into dry cell facility	1.0×10^{-6} [h]	5.2×10^{-3}	8.0×10^{-3}	2.9×10^{-3}	2.2×10^{1}	5.2×10^{-9}	8.0×10^{-9}	2.9×10^{-9}	2.2×10^{-5}
Airplane crash into water pool	1.0×10^{-6} [h]	9.3×10^{-6}	8.0×10^{-6}	2.8×10^{-6}	8.0×10^{-1}	9.3×10^{-12}	8.0×10^{-12}	2.8×10^{-12}	8.0×10^{-7}

a. The estimated number of cancer fatalities, cancer nonfatalities, and genetic defects resulting from the radiation exposure.

b. Maximum exposed individual (MEI). Radiation exposure received from inhalation, external, and ingestion pathways.

c. Nearest public access individual (NPAI). Radiation exposure received from inhalation and external pathways.

d. Radiation exposure received from inhalation and external pathways.

e. Radiation exposure recieved from inhalation, external, and ingestion pathways.

f. The value is $< 1.6 \times 10^{-1}$. For calculational purposes, the value is assumed to be 1.6×10^{-1}.

g. The value is $< 1.0 \times 10^{-4}$. For calculational purposes, the value is assumed to be 1.0×10^{-4}.

h. The value is $< 1.0 \times 10^{-6}$. For calculational purposes, the value is assumed to be 1.0×10^{-6}.

part of an assembly. The fuel cutting accident that has been postulated to occur at Savannah River Site facilities is chosen as representative of the fuel assembly breach accident (E. I. du Pont de Nemours & Co. 1983). During normal operations at the Savannah River Site, the inert, non-uranium-containing extremities of some spent nuclear fuel elements are cutoff in the repackaging basin before the bundling of the elements. The accident occurs when the actual uranium fuel is inadvertently cut, causing a radioactive release. The source term for this accident is shown in Table 5.15-14. The estimated frequency of occurrence for this accident is 1.6×10^{-1} per year based on the Savannah River Site's operating experience with SNF. However, because of anticipated differences in operations and facilities at the ORR, the actual frequency is expected to be much less than 1.6×10^{-1} per year.

5.15.4.1.2 Dropped Fuel Cask—The dropped fuel cask accident that has been postulated to occur at the Hanford Site (reference Volume 1, Appendix A) is chosen as representative of the dropped fuel cask/fuel handling accident for the new Centralization Alternative facility at the ORR. This accident is initiated when a fuel cask is dropped and overturned in the fuel transfer area and broken fuel elements spill out of the cask, within the pool building but away from the pool. It is assumed that the shipping cask ruptures, exposing all of the broken fuel elements in three canisters--42 fuel elements, each containing 22.5 kilograms (50 pounds) of fuel. The source term for this accident is shown in Table 5.15-15. The probability of this accident is estimated to be less than 1×10^{-4} per year.

5.15.4.1.3 Severe Impact and Fire—The severe impact and fire accident that has been postulated to occur at the Hanford Site (reference Volume 1, Appendix A) is chosen as representative of the severe impact and fire/onsite transportation accident for the new Centralization Alternative facility at the ORR. This accident assumes an unspecified initiating event that subjects the fuel assemblies to a severe impact, breach of the transport cask, and a fire. During the accident, the fuel pins rupture on impact or upon heating in the fire, which burns for an hour before being extinguished. Volatiles, particulates, and noble gases are released to the atmosphere. The source term for a release of 540 curies is shown in Table 5.15-16. The estimated probability of occurrence for this accident, reflecting the fact that the facilities at this site would be new, is less than 1×10^{-6} per year.

5.15.4.1.4 Wind-driven Missile Impact into Storage Casks—The wind-driven missile impact into storage casks accident that has been postulated to occur at the Naval Site

Table 5.15-14. Estimated radionuclide releases for a fuel assembly breach accident at ORR.[a]

Radionuclide	Release (Ci)
Iodine-131	7.1×10^{-2}
Iodine-133	1.4×10^{-30}
Krypton-85	1.8×10^{2}
Xenon-133m	1.1×10^{-8}
Xenon-133	1.1×10^{0}

a. Source: E.I. du Pont de Nemours & Co. (1983).

Table 5.15-15. Estimated radionuclide releases for a dropped fuel cask accident at ORR.[a]

	Release (Ci)	
Radionuclide	Onsite (2 hours)	Offsite (8 hours)
Plutonium-236	1.3×10^{-8}	5.4×10^{-8}
Plutonium-238	2.9×10^{-3}	1.2×10^{-2}
Plutonium-239	6.7×10^{-3}	2.7×10^{-2}
Plutonium-240	3.5×10^{-3}	1.4×10^{-2}
Plutonium-241	2.7×10^{-1}	1.1×10^{0}
Plutonium-242	1.3×10^{-6}	5.1×10^{-6}
Americium-241	5.7×10^{-3}	2.3×10^{-2}
Curium-244	2.8×10^{-4}	1.1×10^{-3}
Europium-154	5.4×10^{-3}	2.1×10^{-2}
Cesium-134	7.9×10^{-3}	3.2×10^{-2}
Cesium-137	4.5×10^{-1}	1.8×10^{0}
Cerium-144	1.7×10^{-3}	6.8×10^{-3}
Praseodymium-144	1.7×10^{-3}	6.8×10^{-3}
Praseodymium-144M	2.0×10^{-5}	8.1×10^{-5}
Promethium-147	1.2×10^{-1}	4.9×10^{-1}
Antimony-125	7.3×10^{-3}	2.9×10^{-2}
Tellurium-125M	1.8×10^{-3}	7.3×10^{-3}
Ruthenium-106	3.2×10^{-3}	1.3×10^{-2}
Strontium-90	3.5×10^{-1}	1.4×10^{0}
Yttrium-90	3.5×10^{-1}	1.4×10^{0}

a. Source: Appendix A, Table A-1.

Table 5.15-16. Estimated radionuclide releases for a severe impact and fire accident at ORR.[a]

Radionuclide	Release (Ci)
Hydrogen-3 (Tritium)	4.6×10^{1}
Krypton-85	4.0×10^{2}
Strontium-90	2.7×10^{-2}
Ruthenium-106	1.3×10^{0}
Cesium-134	1.7×10^{1}
Cesium-137	8.0×10^{1}
Plutonium-238	8.9×10^{-4}
Plutonium-239	1.6×10^{-3}
Plutonium-240	1.8×10^{-3}
Plutonium-241	7.3×10^{-2}
Americium-241	1.0×10^{-3}

a. Source: Appendix A, Table A-14.

(reference Volume 1, Appendix D) is chosen as representative of the wind-driven missile accident for the new Centralization Alternative facility at the ORR. This accident is initiated by natural phenomena: a major wind storm or tornado in excess of the facility design basis. In this scenario, a large object is propelled by the wind into a storage container, causing the container seal to be breached. No fuel damage would result from the impact because of the strength of the containers used. The source term is based on the spent nuclear fuel corrosion film. One percent of the original corrosion film on the fuel would be released from the cask into the atmosphere. The source term is shown in Table 5.15-17. The probability of this event is estimated to be less than 1 x 10^{-5} per year based on a design basis tornado probability of 1 x 10^{-3} per year and a missile impact with damage probability of less than 1 x 10^{-2}.

5.15.4.1.5 Airplane Crash Into Dry Storage—The airplane crash into dry storage accident that has been postulated to occur at the Naval Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the dry storage area accident for the new Centralization Alternative facility at the ORR. This accident is externally initiated by an airplane crash into the SNF dry storage facility. The accident is postulated to cause damage to a single storage cask. Due to the severity of the impact, the cask seal is assumed to be breached, resulting in damage to the fuel and the release of corrosion products, located on the SNF exteriors, to the environment. The impact also causes a fire and a release of fission products. It is assumed that 1 percent of all of the fuel units stored inside the cask are damaged either by the impact or by the fire and that those fission products are available for release. Of the available fission products, 100 percent of the noble gases, 3 percent of the halogens, 1.1 percent of the cesium, and 0.1 percent of the remaining solids are released to the environment. Also, 10 percent of the original corrosion products from the fuel units are released from the cask to the atmosphere. The source term for this accident is shown in Table 5.15-18. The probability of this accident, based on analyses of other facilities at the site (Flanagan 1994), is small and assumed to be less than 1 x 10^{-6} per year.

5.15.4.1.6 Airplane Crash into Dry Cell Facility—The airplane crash into the dry cell facility accident that has been postulated to occur at the Naval Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the canning and characterization cell accident for the new Centralization Alternative facility at the ORR. This accident is initiated by an airplane crash into the dry cell facility. The accident was postulated to cause significant damage to the building, resulting in the loss of containment and filtered exhaust

Table 5.15-17. Estimated radionuclide releases for a wind-driven missile impact into a storage cask at ORR.[a]

Radionuclide	Release (Ci)
Cobalt-60	9.6×10^{-2}
Iron-55	1.8×10^{-1}
Cobalt-58	3.5×10^{-2}
Manganese-54	6.0×10^{-3}
Iron-59	5.1×10^{-4}

a. Source: See Section F.1.4.2.2.1, Appendix D to Volume 1.

Table 5.15-18. Estimated radionuclide releases for an airplane crash into dry storage facility at ORR.[a]

Radionuclide	Release (Ci)
Cesium-134	2.6×10^{1}
Cesium-137	3.6×10^{1}
Plutonium-238	5.9×10^{-2}
Barium-137m	3.1×10^{0}
Strontium-90	3.1×10^{0}
Cerium-144	7.2×10^{0}
Niobium-95	4.4×10^{0}
Yttrium-90	3.1×10^{0}
Ruthenium-106	6.1×10^{-1}

a. Source: See Section F.1.4.2.2.2, Appendix D to Volume 1.

systems. The fuel units inside the dry cell could also be damaged due to mechanical impacts and potential fire. The mechanical impact also could result in the release of corrosion products to the environment. For this accident scenario, 1 percent of the fuel units stored inside of the dry cell are assumed to be damaged by either the impact or resultant fire and those fission products would he availahle for release. Of the fission products available for release, 100 percent of the noble gases, 3 percent of the halogens, 1.1 percent of the cesium, and 0.1 percent of the remaining solids could be released to the environment. Ten percent of the available corrosion products could be released to the environment. The source term for this accident is shown in Table 5.15-19. The probability of this accident is estimated to be less than 1 x 10^{-6} per year.

5.15.4.1.7 Airplane Crash into Water Pool—The airplane crash into the SNF water pool accident that has been postulated to occur at the Naval Site (reference Volume 1, Appendix D) is chosen as representative of the airplane crash into the SNF water pool accident for the new Centralization Alternative facility at the ORR. This externally initiated accident occurs when an airplane crashes into an SNF water pool and damages the fuel units stored there. Fission products and corrosion products are released from the fuel units into the water pool hut the pool water is not released to the environment. The presence of the pool water results in a release only of gaseous fission products into the atmosphere. In this accident scenario, 1 percent of all the fuel units stored inside the pool were postulated to be damaged and those fission products are available for release. Of the available fission products, 100 percent of the nohle gases and 25 percent of the halogens are released to the pool water. Due to the presence of pool water, there is a reduction of the halogen release by a factor of 10 prior to release into the atmosphere. The source term for this accident is shown in Table 5.15-20. The prohability of this accident is estimated to be less than 1 x 10^{-6} per year.

5.15.4.1.8 Integration of Existing Facilities— Existing SNF management facilities will be integrated into the Centralization, Regionalization, and Planning Basis Alternative SNF storage functions until the existing ORR operating reactors are shutdown. The accident consequences postulated for the No Action Alternative in subsection 5.15.3 can occur as long as the High Flux Isotope Reactor is operational. After the High Flux Isotope Reactor is no longer operational, the accident consequence will decrease as the spent reactor cores, stored in the pool, age. The reference design basis accident frequency of occurrence and risk will be reduced because refueling operations have ceased and requirements for movement of the dam are reduced. Since the beyond design accident is initiated by natural phenomenon (i.e., tornado), the

Table 5.15-19. Estimated radionuclide releases for an airplane crash into dry cell facility at ORR.[a]

Radionuclide	Release (Ci)
Cesium-134	4.5×10^{1}
Cesium-137	6.2×10^{1}
Plutonium-238	1.0×10^{-1}
Barium-137m	5.4×10^{0}
Strontium-90	5.5×10^{0}
Cerium-144	1.3×10^{1}
Niobium-95	7.7×10^{0}
Yttrium-90	5.5×10^{0}
Ruthenium-106	1.1×10^{0}

a. Source: See Section F.1.4.2.3.3, Appendix D to Volume 1.

Table 5.15-20. Estimated radionuclide releases for an airplane crash into an SNF water pool at ORR.[a]

Radionuclide	Release (Ci)
Iodine-129	7.6×10^{-4}
Iodine-131	1.6×10^{-2}
Hydrogen-3 (Tritium)	4.3×10^{2}

a. Source: See Section F.1.4.2.1.4, Appendix D to Volume 1.

beyond design basis accident frequency of occurrence will remain the same as long as spent High Flux Isotope Reactor cores remain in the spent fuel pool area.

5.15.4.2 Nonradiological Hazards. The two bounding accidents involving nonradiological hazards are a chemical spill and fire and a diesel fuel fire. Both of these accidents are associated with the Expended Core Facility operations and the accident frequencies and impacts are addressed in Volume 1, Appendix D. The analyses of these accidents considered the impacts to workers on the site as well as to the offsite population. The impacts were measured in terms of potential health effects due to exposure to toxic chemicals released during these accidents. Since the Expended Core Facility at this site will be a new design and construction, it will incorporate all applicable standards and regulations and therefore limit the potential exposures to the workers and the public in the event of an accident.

5.15.4.3 Secondary Impacts. In the event of an accidental release of radioactive substances, there is a potential for secondary impacts to cultural resources, endangered species, water resources, public and agricultural land use, the ecology in the vicinity of the accident, national defense, and local economics. Figure 5.15-1 illustrates the radiological impacts to the environment in the event of a severe accident at a new SNF management facility and the release of radioactive material with 50 percent meteorology. The accident chosen for this purpose is an airplane crash into the Centralization Alternative canning and characterization (dry) cell. Figure 5.15-1 shows several isodose lines ranging from 870 millirem per year down to 87 millirem per year. The solid line represents the site boundary, and it can be seen from the figure that some doses exceeding background would exist outside the site boundary.

Table 5.15-21 presents a summary of the postulated severe accident secondary impacts on the environment, economy, and national defense. The evaluation was performed using 50 percent meteorology.

5.15.5 Decentralization Alternative

The Decentralization Alternative is not applicable for the ORR.

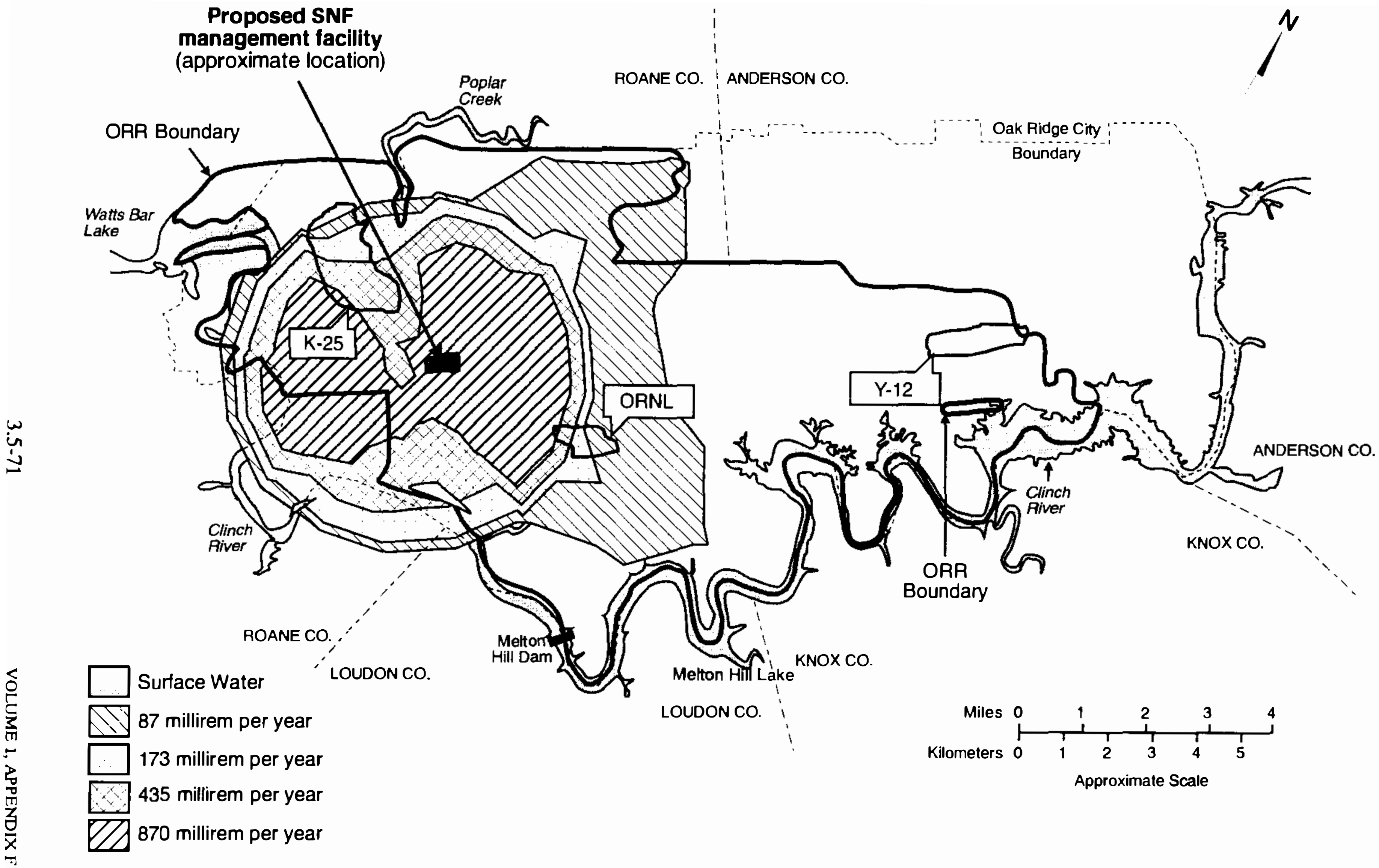


Figure 5.15-1. Isodose lines for an airplane crash into dry cell accident with 50 percent meteorology at Oak Ridge Reservation.

Table 5.15-21. Secondary impacts of Centralization Alternative accidents at the ORR.

Environmental or social factor	Impact
Land use	Yes. Major portions of the ORR, including the ORNL and K-25 areas, will be contaminated. Offsite contamination will occur. Industrial, residential, forest, and agricultural areas will be contaminated.
Cultural resources	Yes. Archaeological sites, cemeteries, and historic sites will be contaminated.
Aesthetic and scenic resources	Possible impact. Scenic public viewing areas are within 2 miles of the ORR border.
Water resources	Yes. The Clinch River will be contaminated. It is used for industrial and public water supplies, navigation, fishing, boating, and swimming.
Ecological resources	Possible impact. Many endangered or threatened plants and animals are potentially on or near the ORR.
Treaty rights	No impact. There are no ORR areas subject to Native American Treaty rights.
National defense	Possible impact. With the 50 percent meteorology, the area of contamination does not envelop U.S. military facilities or the Y-12 area. However, with the 95 percent meteorology, the Y-12 area will be contaminated.
Economic impacts	Yes. Offsite contamination will occur. Industrial, residential, forrest, and agricultural areas will be contaminated. Major portions of the ORR will be contaminated. The accident consequences may require the evacuation and cleanup of onsite facilities, including but not limited to the ORNL and K-25 areas, and adjacent residential, industrial, forest, and agricultural areas. The Clinch River will be contaminated. The associated industrial and residential water supplies will be contaminated. The commercial and recreational fishing industries may be impacted.

5.15.6 1992/1993 Planning Basis Alternative

The facility accident consequences and risks for the ORR No Action Alternative envelop the facility accident consequences and risks for the 1992/1993 Planning Basis Alternative.

5.15.7 Regionalization Alternative

Under the Regionalization Alternative, new facilities will be constructed and operated for SNF. Details for the new facilities needed have not been defined, but it is reasonable to expect that they will be similar to but with less storage requirements than those needed for the Centralization Alternative. Due to smaller throughput and storage requirements, the potential for accidents (i.e., probability of occurrence) will be similar to but less than those described for the Centralization Alternative. The accident consequences will be similar for both alternatives. Consequently, it is reasonable to assume that the accident consequences and risks described for the Centralization Alternative envelop the Regionalization Alternative.

5.15.8 Emergency Preparedness and Plans

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

Officials at each DOE site have specified the emergency preparedness requirements for the DOE facilities under their jurisdiction in a manner consistent with the relevant DOE Orders. All existing facilities have emergency plans and procedures that either implement the DOE and site requirements or are integrated with the site planning.

DOE-Oak Ridge Operations has overall responsibility at the plant and laboratory sites for emergency response. However, primary authority for event response has been delegated to Martin Marietta Energy Systems, Inc., DOE's operating contractor. Although their primary responsibility is onsite, they have agreed to provide offsite assistance if requested under the terms of existing mutual aid agreements or Martin Marietta policies. If a hazardous materials event occurs at a DOE-Oak Ridge Operations facility, the Governor of Tennessee is responsible for the State's response efforts. The Governor's Executive Order No. 4 establishes the Tennessee Emergency Management Agency as the agency given responsibility for coordinating state emergency services. If a hazardous materials accident at DOE-Oak Ridge Operations facilities is beyond the capability of the local government, and assistance is requested. the Tennessee Emergency Management Agency Director may direct that assistance from state agencies be provided to local governments. To accomplish this task and ensure prompt initiation of emergency response actions, the Director may cause the State Emergency Operations Center and Field Coordination Center as well as any local Emergency Operations Center to be activated.

5.16 Cumulative Impacts and Impacts From Connected or Similar Actions

The ORR already contains several major DOE and non-DOE facilities, unrelated to SNF, that would continue to operate throughout the operating life of the proposed SNF management facilities. A number of offsite industrial and research facilities in surrounding areas would also continue to operate throughout this period. The activities associated with these existing facilities produce environmental consequences that have been included in the baseline environmental conditions (Chapter 4) against which Sections 5.1 through 5.15 have assessed the environmental consequences of the Centralization and Regionalization alternatives. This section uses the environmental baseline conditions presented in Chapter 4 to assess potential cumulative impacts from the proposed SNF management facilities, if constructed at the ORR, plus other reasonably foreseeable activities planned by government agencies or private concerns for areas on or near the ORR.

In addition to the proposed SNF management facilities, reasonably foreseeable activities considered in this cumulative impact assessment include the proposed Expended Core Facility, proposed hazardous waste remediation activities on the ORR, and activities proposed in the present Five-Year Plan for the ORR. Major programmatic initiatives planned for the ORR in the Five-Year Plan (MMES 1994a) consist of constructing the following: the proposed Advanced Neutron Source Facility; the proposed Uranium-Atomic Vapor Laser Isotope Separation Facility; facilities proposed for construction as a part of Complex-21; proposed low-level waste disposal facilities; the proposed Mixed Waste Treatment Facility; the proposed Environmental, Life, and Social Sciences Complex; the proposed Materials, Science, and Engineering Complex; and the proposed Solid Waste Storage Area-7. Several minor construction projects such as the refurbishment or expansion of existing facilities, widening of roadways, and installation of utilities are also included in the Five-Year Plan.

The ORR is part of the City of Oak Ridge, which also includes an urban area to the north of the ORR and several industrial areas in various locations around the perimeter of the ORR. Additional construction and expanded operational activities is anticipated in these industrial areas. For example, the Scientific Ecology Group, a private business in the Bear Creek Industrial Park on Bear Creek Road west of the ORR, is considering expanding its operations and is presently constructing a second radioactive waste incinerator. The City of Oak Ridge Comprehensive Plan encourages further development of several presently undeveloped lots in several industrial parks (City of Oak Ridge 1989). The Comprehensive Plan also anticipates additional residential and commercial development in the City. The City of Oak Ridge is presently proposing construction of a golf course and residential development on approximately 700 acres (2.8 square kilometers) east of the ORR.

The following cumulative impacts analysis considers in detail the potential incremental effects from the proposed SNF management facilities; the proposed Expended Core Facility; and the proposed Advanced Neutron Source facility. Adequate information is not available to consider in detail the other proposed Five-Year Plan activities or the proposed activities for areas in the City of Oak Ridge outside of the ORR. The potential incremental impacts from these activities are therefore assessed in a more qualitative manner.

5.16.1 Centralization Alternative

Separate analyses of potential cumulative impacts from the Centralization Alternative to each of the environmental resources addressed in Chapter 5 are provided below.

5.16.1.1 Land Use. Construction of the proposed SNF management facilities would require the dedication of 90 acres (0.36 square kilometer) of undeveloped land on Bear Creek Road in the western part of the ORR. Construction of the proposed Expended Core Facility would require the dedication of an additional 30 acres (0.12 square kilometer) of undeveloped land on the ORR. Construction of the proposed Advanced Neutron Source facilities would require the dedication of an additional 75 to 115 acres (0.30 to 0.46 square kilometer) of land on the ORR (MMES 1992c). The cumulative land area dedicated to these three projects would total as much as 235 acres (0.95 square kilometer), which represents only about 1 percent of the roughly 20,600 acres (83 square kilometers) of undeveloped land remaining on the 34,667-acre (140 square kilometer) ORR. Additional unspecified areas of undeveloped land, generally parcels of under 100 acres (0.40 square kilometer), would have to be dedicated to some of the activities proposed in the Five-Year Plan. Many of these proposed activities do not require the dedication of undeveloped land. Additional undeveloped land on the ORR might have to be dedicated to the other planned activities, but their land requirements have not yet been quantified.

Although large areas of undeveloped land remain both on the ORR and in the City of Oak Ridge, much of this land is steep or otherwise has constraints that limit its future development potential. The City of Oak Ridge indicates in its Comprehensive Plan that it seeks to have additional ORR land declared excess by the DOE and made available for urban expansion by the City (City of Oak Ridge 1989). Demand for buildable land on the ORR by the City of Oak Ridge represents another cumulative demand for ORR land. The site of the proposed residential development and golf course east of the ORR is land recently sold by the DOE to the City of Oak Ridge since adoption of the Comprehensive Plan.

5.16.1.2 Occupational and Public Health. The annual collective effective dose equivalent from the existing ORR facilities to the population within 50 miles (80 kilometers) of the ORR is 52 person-rem (MMES 1994a). Added to this baseline, operation of the proposed SNF management facilities might contribute an additional 5 person-rem, and operation of the proposed Advanced Neutron Source facilities might contribute an additional 4.3 person-rem (MMES 1992c), resulting in a cumulative effective dose of 61 person-rem to the population within 50 miles of the ORR.

The annual collective effective dose equivalent from the existing ORR facilities to a potential maximally exposed individual at the site boundary is 3.3 millirem per year. Operation of the proposed SNF management facilities might contribute an additional 6.2 millirem per year, resulting in a cumulative annual dose of 9.5 millirem per year to this maximally exposed individual.

The total annual baseline worker dose seen from normal ORR operations is about 48 person-rem. The total annual SNF management facility worker dose is expected to be roughly 32 person-rem. Hence, the cumulative annual dose might be 80 person-rem.

Over the planned 40-year operational lifetime of the SNF management facility, a total population dose of roughly 2,500 person-rem will be observed from continuous operation of the existing ORR facilities and the SNF management facility. This equates to a total health detriment (the summated risk of fatal cancer, nonfatal cancer, and genetic effects) of 1.8 over the 40-year span. For the maximally exposed individual, a total dose of 380 millirem will be observed over the 40-year period, which equates to a total detriment of 2.8×10^{-4}. For the SNF management worker, a total dose of 3,200 person-rem will be observed over the 40-year span; this corresponds to a total health detriment of 1.8.

Additional radiological impacts are not expected from operation of the proposed Expended Core Facility. Analysis has shown that the dose to all individuals considered (workers and offsite individuals) from Oak Ridge Expended Core Facility operations might be much less than 1 millirem per year.

5.16.1.3 Noise. Cumulative increases in noise levels from the proposed SNF management facilities, the proposed Expended Core Facility, and the proposed Advanced Neutron Source facilities would be limited to temporary, minor construction noise and small increases in traffic noise occurring along various access routes to the ORR due to increases in employment. This increase is not expected to result in any increased annoyance to the public. Noise levels from other planned activities have not yet been determined. Each would, at a minimum, involve temporary periods of construction noise, but information on operational noise is not available.

5.16.1.4 Groundwater and Surface Water Resources. Operation of the proposed SNF management facilities would require the withdrawal of an estimated 4 million gallons per year (15 million liters per year) of groundwater. Operation of the proposed Expended Core Facility would require the withdrawal of an estimated additional 2 million gallons per year (8 million liters per year). Although the specific water demands of the proposed Advanced Neutron Source facility and other proposed activities are not known, the combined water demands would likely represent a small percentage of the total average discharge of the Clinch River, as measured at Melton Hill Dam, of 5,300 cubic feet per second (150 cubic meters per second).

Discharges of wastewater from the SNF management facilities would increase the flow of Grassy Creek by an estimated average of less than 1 percent. Discharge points would be selected in accordance with permit requirements to minimize impacts to surface water resources. The sanitary wastewater and cooling water from the Advanced Neutron Source facility would be discharged to separate streams and therefore would not contribute to cumulative impacts to Grassy Creek. Discharges from other planned facilities have not yet been designed. There are no expected cumulative impacts to groundwater quality and quantity.

5.16.1.5 Biotic Resources. Construction of the proposed SNF management facilities would require the disturbance of approximately 90 acres (0.36 square kilometer) of mostly forested terrestrial habitat, construction of the proposed Expended Core Facility would require the disturbance of an additional 30 acres (0.12 square kilometer), and construction of the proposed Advanced Neutron Source facilities would require the disturbance of an additional 75 to 115 acres (0.30 to 0.46 square kilometer). This would result in a combined conversion of as much as 235 acres (0.94 square kilometer) of forested habitat to developed uses. Additional areas of forested habitat on the ORR would be lost during construction of activities proposed in the Five-Year Plan. Additionally, losses of similar forested habitat off of the ORR are anticipated due to future construction in the City of Oak Ridge. For example, construction of the proposed golf course and residential development east of the ORR by the City of Oak Ridge would result in the conversion of several hundred acres of forested habitat to structures and lawns.

The total losses would represent only a small percentage of the total forested area on the ORR and in the surrounding vicinity. However, the several scattered areas of habitat disturbance planned for the ORR, including that associated with the SNF management facilities, would increase fragmentation of the relatively contiguous forest cover over much of the ORR. This fragmentation could affect the suitability of the forested habitat on the ORR for several species.

5.16.1.6 Air Resources. The potential cumulative air emissions from the proposed SNF management facility, Expended Core Facility, and Advanced Neutron Source facilities would not result in an exceedance of the National Ambient Air Quality Standards or Tennessee state criteria. Also, there would be no exceedance of Federal National Emissions Standards for Hazardous Air Pollutants or DOE radiological standards. Air emission data for the other planned activities (Five-Year Plan or offsite) are not available.

5.16.1.7 Socioeconomics. Operation of the proposed SNF management facilities might generate up to 800 new jobs during the year 2005. Operation of the proposed Expended Core Facility might generate up to 562 additional jobs during that year, resulting in a combined increase of up to 1,362 new jobs. The 16,980 jobs presently forecasted for the ORR in the year 2005 would be increased by 8 percent, to as much as 18,342 jobs. The 360,000 jobs presently forecasted for the surrounding area in the year 2005 might be increased by less than 1 percent, to as much as 361,352 jobs. Additional employment increases could also result from the proposed Advanced Neutron Source facility project, activities proposed in the Five-Year Plan, and new offsite activities, but specific estimates are not available.

The proposed SNF management facilities could cause cumulative growth-inducing effects when coupled with the proposed Advanced Neutron Source facilities or with other planned activities on the ORR. Previous actions at the ORR have had a modest effect on long-term growth and productivity in Knox County and Loudon County, but they did not have a greater effect on long-term growth and productivity in Anderson County and Roane County.

5.16.1.8 Transportation. For transportation, minor levels of service changes might occur due to employment increases associated with the proposed SNF management facilities, the proposed Expended Core Facility, the proposed Advanced Neutron Source facility, some of the proposed onsite activities in the Five-Year Plan, and some of the proposed offsite activities. Maps included in the Five-Year Plan show several road improvements on the ORR to accommodate presently projected regional traffic increases.

5.16.1.9 Waste Management. Operation of the proposed SNF management facilities would generate an estimated 203 cubic meters per year of low-level waste and an estimated 16 cubic meters per year of transuranic waste. Operation of the proposed Expended Core Facility would generate an additional 425 cubic meters of low-level waste (for a combined total by both facilities of 628 cubic meters) but would not generate any additional transuranic waste. No other radioactive waste, including high-level waste or mixed waste, would be generated by either facility. Although it is known that the proposed Advanced Neutron Source facility would generate low-level waste, comparable quantitative data are not available for it or for offsite activities, or for activities proposed in the Five-Year Plan. All wastes generated by the proposed SNF management facilities and other planned activities on the ORR would be treated and disposed of in accordance with all applicable Federal and state regulations.

5.16.1.10 Other Resources. The absence of impacts, or the potential for very minimal impacts, from the proposed SNF management facilities to cultural resources, aesthetic and scenic resources, utilities, and geologic resources ensures that their potential contribution to cumulative impacts affecting these resources would be negligible. No further analysis is necessary.

5.16.2 Regionalization Alternative

The Regionalization Alternative would have similar or fewer cumulative impacts than the Centralization Alternative. Generally, the alternative requires less construction and smaller scale operations, and the potential for cumulative impacts is therefore less.

5.17. Adverse Environmental Effects That Cannot Be Avoided

5.17.1 Overview

This section discusses potentially unavoidable adverse impacts to the environment resulting from construction and operation of the proposed spent nuclear fuel (SNF) management facilities at the Oak Ridge Reservation (ORR) under the Centralization and Regionalization Alternatives. Unavoidable adverse impacts are impacts that cannot be mitigated by changes in project design, operation, construction, or by other measures.

5.17.2 Centralization Alternative

Operation of the proposed SNF facilities at the ORR under the Centralization Alternative would increase the radiation dose rate to the maximally exposed individual by 6.2 millirem per year, resulting in a 34 percent increase in cancer risk to this individual from ORR operations. These cancer risks still would be minimal. The number of fatal cancers resulting from 1 year of operations on the ORR from all sources (including baseline and the SNF facilities) would be

3.0×10^{-2}, the number of nonfatal cancers per year would be 5.9×10^{-3}, and the number of genetic effects per year would be 7.7×10^{-3}.

Construction of the proposed SNF management facilities would require the disturbance of approximately 90 acres (0.36 square kilometer) of mostly forested undeveloped land and the long-term dedication of approximately 85 acres (0.34 square kilometer) of land. Although this represents less than 1 percent of the undeveloped land on ORR, it would eliminate potential foraging and nesting habitat and would destroy plant species in the area. It would also require the dedication of a reasonably level land parcel that could have otherwise accommodated other construction projects.

The potential impacts from the Centralization Alternative to the other environmental resources discussed in Chapter 5 are not unavoidable adverse impacts.

5.17.3 Regionalization Alternative

Potential unavoidable adverse impacts associated with the Regionalization Alternative would resemble those discussed above for the Centralization Alternative. The extent of the impacts could be less due to the reduced land requirements, reduced extent of construction disturbance, and reduced scale of operations.

5.18 Relationship Between Short-Term Use of the Environment and the Maintenance of Long-Term Productivity

Implementation of any of the SNF management alternatives would cause some adverse impacts to the environment and permanently commit certain resources. These resources include use of the environment and those associated with construction and operation of the SNF management facilities.

The proposed alternatives for SNF management would require the short-term use of resources including energy, construction materials, and labor in order to achieve the objective of safety managing SNF to minimize the risk to workers, the public, and the environment.

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 ORR regional communities. The ORR High Flux Isotope Reactor is an important source of radiopharmaceuticals. The reactors are unique research and training facilities for researchers and students in many fields of research and development: materials science, environmental science, physics, biology, and electronics.

Development of new SNF interim management facilities would commit lands to those uses from the time of construction through the cessation of operations, at which time the 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 could be restored following decommissioning.

5.19. Irreversible and Irretrievable Commitments of Resources

5.19.1 Overview

This section discusses the irreversible and irretrievable commitments of resources resulting from the use of materials that cannot be recovered or recycled, or that must be consumed or reduced to irrecoverable forms.

5.19.2 Centralization Alternative

Construction and operation of spent nuclear fuel (SNF) management facilities under the Centralization Alternative would require commitments of electrical energy, fuel, concrete, steel, sand, gravel, and miscellaneous chemicals. Most of the water that would be withdrawn from the Clinch River to operate the SNF management facilities would be returned to surface water in the Clinch River watershed, although some evaporative losses would be unavoidable. The land dedicated to the SNF management facilities could become available for other urban uses following closure and decommissioning. However, the soils on the site would have to be amended to support land uses such as agriculture, forestry, or wildlife management.

5.19.3 Regionalization Alternative

Irreversible and irretrievable commitments of resources associated with the Regionalization Alternative would resemble those discussed above for the Centralization Alternative. However, the extent of these resource commitments could be less due to the reduced land requirements and reduced scale of operations.

5.20 Potential and Mitigation Measures

5.20.1 Pollution Prevention

The DOE Oak Ridge Field Office established a Waste Minimization and Pollution Prevention Awareness Plan to reduce the quantity and toxicity of hazardous, mixed, and radioactive wastes generated at Oak Ridge. The plan is designed to reduce the possible pollutant releases to the environment and thus increase the protection of employees and the public. All contractors and users that exceed the EPA criteria for small-quantity generators are establishing their own waste minimization and pollution prevention awareness programs. Contractor programs ensure that waste minimization activities are in accordance with Federal, state, and local environmental laws and regulations, and DOE Orders.

Additional goals include the promotion and use of nonhazardous materials, establishment of a baseline of waste generation data, calculations of annual reductions of waste generated, and implementation of recycling programs. Goals also include incorporation of waste minimization concepts and technologies in planning and design of new processes and facilities, and in upgrades of existing facilities. A waste minimization task force composed of representatives from each contractor has been established to coordinate waste minimization and pollution awareness activities.

5.20.2 Potential Mitigation Measures

Potential impact avoidance and mitigation measures are addressed in Chapter 5, Sections 1 through 15 as appropriate.

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7.0 ABBREVIATIONS AND ACRONYMS

°C	degrees Celsius
CFR	Code of Federal Regulations
Ci	curie(s)
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
EIS	environmental impact statement
ECF	Expended Core Facility
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
FEMA	Federal Emergency Management Agency
g	gram
gal	gallon(s)
hr	hour
INEL	Idaho National Engineering Laboratory
kg	kilogram
km	kilometer
kv	kilovolt
ℓ	liter
m	meter
m^3	cubic meter
mi	mile
mi^2	square mile
min	minute
mph	miles per hour
mR	milliroentgen
mrem	millirem
MTHM	metric tons of heavy metal
MW	Megawatt
nCi	nanocurie
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission

NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl
pCi	picocurie(s)
PEIS	Programmatic Environmental Impact Statement
PM^{10}	particulate matter less than 10 microns in diameter
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
SNF	spent nuclear fuel
SRS	Savannah River Site
TVA	Tennessee Valley Authority
μg	micrograms
USGS	U.S. Geological Survey
yr	year

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TABLES

1. INTRODUCTION

The U.S. Department of Energy (DOE) is performing a DOE-wide programmatic evaluation of spent nuclear fuel (SNF) management alternatives in order to determine the appropriate means of managing existing and projected quantities of SNF from now until the year 2035. At the same time, the DOE is performing a site-specific assessment of the Idaho National Engineering Laboratory (INEL) in order to determine how to manage environmental restoration, waste management, and SNF at the INEL. Sites currently involved with the management of major fractions of DOE SNF (i.e., the Hanford Site, Savannah River Site, and INEL), alternative sites being analyzed for management of SNF (Oak Ridge Reservation and Nevada Test Site), and sites involved with management of SNF from Naval Reactors are addressed in separate appendixes to this volume of the environmental impact statement (EIS).

This appendix addresses other DOE sites and locations which currently generate and manage small quantities of SNF. These facilities are presently storing and/or generating, in most cases, relatively small quantities of SNF which the DOE has taken title to, has possession of, or will take possession of at sometime in the future. These facilities, referred to in this document as "originating sites," include the following:

- DOE, University, and Other Research and Test Reactors

The following DOE facilities are addressed in this appendix:

<u>Brookhaven National Laboratories</u>

- High Flux Beam Reactor
- Brookhaven Medical Research Reactor

<u>Los Alamos National Laboratory</u>

- Omega West Reactor
- Chemistry-Metallurgy Research Facility

Sandia National Laboratories

- Manzano Storage Structures
- Annular Core Research Reactor
- Sandia Pulse Reactor II and III and Critical Assembly
- Hot Cell Facility
- Special Nuclear Materials Storage Facility

Argonne National Laboratory - East

- Alpha-Gamma Hot Cell
- Chicago Pile 5

In addition, the DOE has title to SNF from university and other domestic research reactors. These facilities are identified and data provided on both the quantity of spent fuel in storage and estimates of the future generation rate of SNF at these facilities. However, rather than address each of these university and other research reactor facilities individually, representative facilities will be used when addressing specific topics related to facilities, the SNF, or projected environmental impacts associated with the various fuel management alternatives.

- Commercial Power Reactor Fuels

The DOE has possession of 125 spent nuclear fuel assemblies and 20 complete or sectioned spent nuclear fuel rods from various nuclear power plants that were to be used to support DOE-sponsored research and development programs. This SNF is currently in storage at either the West Valley Demonstration Project in West Valley, New York, or the B&W Lynchburg Technology Center in Campbell County, Virginia.

In addition, according to the terms of a three-party agreement between the Public Services Company of Colorado, General Atomics, and the Atomic Energy Commission, the DOE has a commitment to provide dry storage at the INEL for eight segments of Fort St. Vrain spent fuel (approximately 1,920 spent fuel elements). Three segments of this SNF have been shipped to the INEL; the other five are currently being stored at the Fort St. Vrain site.

The DOE also has possession of other commercial SNF, including that from the Arkansas, Calvert Cliffs, Connecticut Yankee, Consolidated Edison, Cooper, Dresden, H. B. Robinson, Monticello, Oconee, Peach Bottom, Point Beach, Quad Cities, Saxton, Shippingport, Surry, and Three Mile Island reactors. These represent very small quantities of SNF and are currently stored at the Hanford Site, INEL, SRS, Naval Reactor Facility at the INEL, or the ORR. This commercial SNF is addressed in the corresponding appendix for each of these sites and is not discussed in detail in this appendix.

Spent nuclear fuel from commercial power reactors which is currently at commercial reactor sites will fall under the purview of the DOE's Office of Civilian Radioactive Waste Management and is outside the scope of this EIS.

Although these facilities represent small sources of SNF, an evaluation has been conducted in order to consider the impacts at these originating sites along with the cumulative impacts of management of all DOE SNF.

Of the five SNF management alternatives being evaluated (Volume 1, Chapter 3), only the two alternatives that preclude the shipment of SNF (Alternative 1 - No Action and Alternative 2 - Decentralization) have a definable impact on the sites and facilities discussed in this appendix. Several facilities generating SNF have limited storage capacities, and/or the facility license from the U.S. Nuclear Regulatory Commission (NRC) may limit the quantity of fuel permitted to be stored onsite. Implementation of the No Action Alternative could mean that some of the facilities with limited SNF storage capacity would have to shut down. The impact on some facilities would be the need to construct additional onsite SNF storage capacity in order to continue safe operation. Expansion of SNF storage capacity is only viable provided adequate space and adequate funding are available and expansion is approved through the NRC licensing process.

In the case of the West Valley Demonstration Project, the SNF is currently being stored in accordance with the applicable DOE Orders. Extended storage of SNF at this site would require construction of a concrete pad for a dry storage facility. However, the DOE has entered into an agreement with the New York State Energy Research and Development Authority (NYSERDA and DOE 1986) to remove all SNF from the West Valley Demonstration Project. An extension to the schedule for removal of SNF has been requested by DOE and the agreement with the state is being renegotiated.

The other alternatives, which involve the shipment of the SNF from the site at which it is generated to one or more DOE SNF interim storage facilities, reflect the current mode of SNF management at the generating facilities. Even though the selection of a site where SNF may he transported and stored may be different than the current planning basis, shipment to a different location does not impact the facility or site at which the SNF is generated.

Section 2 of this appendix presents a description of SNF management at the originating sites, including an overview of the types and inventories for SNF in three major categories: DOE test and experimental reactors; domestic research reactors; and nuclear power reactor spent fuel. Section 3 presents summary descriptions of the potentially affected environments for the three categories, and Section 4 describes the environmental consequences of SNF management alternatives at these sites. Cumulative impacts are presented in Section 5, adverse impacts that cannot be avoided in Section 6, and irreversible and irretrievable commitments in Section 7.

2. SNF MANAGEMENT AT ORIGINATING SITES

2.1 Overview of SNF Types, Inventories, and Generation Rates

This appendix addresses the management of SNF at originating sites, defined as DOE test and experimental reactors, domestic research reactors, and certain nuclear power plant spent fuels now in storage. Specific discussions of the various sites are provided in following sections.

- DOE experimental reactors and small-quantity storage: These reactors and SNF storage facilities are located on DOE-owned sites, such as Brookhaven National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories. These sites host a variety of research and development or production activities, which may include test or experimental reactors and storage of small quantities of SNF, in different areas of the site.

- Domestic research reactors: The greatest variations in site characteristics are those associated with research reactors. Most sites are at colleges or universities. However, a few of them are sited at government and industrial facilities.

- Nuclear power plant spent fuel: The SNF in this category is not located at currently operating nuclear reactor facilities. The facilities housing the subject SNF are located at the following sites: 1) the former West Valley fuel reprocessing site, 2) the shutdown Fort St. Vrain nuclear power plant site (currently undergoing decommissioning), and 3) a commercial research laboratory (B&W Lynchburg Technology Center) located on a large rural site. The DOE also has possession of other commercial SNF, including that from the Arkansas, Calvert Cliffs, Connecticut Yankee, Consolidated Edison, Cooper, Dresden H. B. Robinson, Monticello, Oconee, Peach Bottom, Point Beach, Quad Cities, Saxton, Shippingport, Surry, and Three Mile Island reactors. These represent very small quantities of SNF and are currently stored at the Hanford Site, INEL, SRS, Naval Reactors Facility at the INEL, or the ORR. This commercial SNF is addressed in the corresponding appendix for each of these sites and is not discussed further in this appendix.

The SNFs addressed in this appendix are of varying sizes and design configurations. In general, nuclear fuel consists of an assembly of structural components, such as plates or hollow rods, containing fissionable material. The fuel may be in the form of metal or a compound (e.g., oxide, carbide, nitride) and may vary in the degree of enrichment of the uranium-235 isotope. The structural materials may be aluminum, stainless steel, zirconium alloy, or other material such as ceramics. They form a barrier isolating the fuel (and fission products) from the reactor coolant or storage facility environment as well as providing structural support for maintaining the geometry of the fuel. The components are arranged into a specific geometric configuration determined by the type of reactor and desired performance. This assembly of fuel-bearing components is referred to as a "fuel element" (also referred to in the nuclear industry as a fuel assembly).

For each of the major facility categories, the following subsections provide details on the quantities of SNF currently in storage and the quantities of additional SNF expected to be produced by the end of the year 2035.

2.1.1 DOE Experimental Reactors and Small-Quantity Storage

The Brookhaven National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories use test and experimental reactors for research and for small-scale production of medical and other specific isotopes. In addition, small quantities of SNF are currently in storage at these sites as well as at Argonne National Laboratory - East. The amount of SNF generated by these facilities, the amount expected to be generated through the year 2035, and accommodations being undertaken at the present time to store the SNF located at these facilities are discussed in the following sections.

2.1.1.1 Brookhaven National Laboratory.

2.1.1.2.1 High Flux Beam Reactor—By mid-1995 there are projected to be 937 High Flux Beam Reactor elements (0.241 MTHM) in the reactor or in onsite wet storage. A total of 5,600 additional SNF elements (1.498 MTHM) are predicted to be produced if the reactor continues operation through the year 2035 (Wichmann 1995a).

2.1.1.1.2 Brookhaven Medical Research Reactor—The Brookhaven Medical Research Reactor is operating at the present time and has 36 elements (0.0034 MTHM) in the reactor or in onsite wet storage. Thirty-two additional SNF elements (0.0028 MTHM) are expected to be produced by the year 2035 (Wichmann 1995a).

2.1.1.2 Los Alamos National Laboratory.

2.1.1.2.1 Omega West Reactor—The Omega West Reactor has been permanently shut down. This reactor is being decommissioned. There are no elements in the reactor, and all of the 86 elements (0.014 MTHM) are in temporary dry storage at the Chemistry and Metallurgy Research Complex (Wichmann 1995a).

Additional reactor sites and critical facilities that are part of the Los Alamos National Laboratory are listed below. Each contains some radioactive and fissionable materials but does not routinely produce SNF (ANS 1988):

- Big Ten Critical Assembly
- Fast Burst Reactor - GODIVA
- Fast Burst Reactor - SKUA
- Flattop Critical Assembly
- General Purpose Critical Assembly - COMET
- General Purpose Critical Assembly - HONEYCOMB
- General Purpose Critical Assembly - PLANET
- General Purpose Critical Assembly - VENUS
- General Purpose Critical Assembly Machine
- Solution High Energy Burst Assembly

2.1.1.3 Sandia National Laboratories. The Sandia National Laboratory reactors operate as needed on a low duty cycle, so the fission product inventories remain low and the fuel loading lasts for the life of the reactor, eliminating routine generation of spent fuel. Hence, except for a few broken plates that are in storage, the SNF at Sandia National Laboratories is still in use in the reactors (DOE 1993d).

The Sandia National Laboratories contain five SNF storage facilities: the Manzano Storage Structures, the Annular Core Research Reactor Facility, the Sandia Pulse Reactor Facility, the Hot Cell Facility, and the Special Nuclear Materials storage facility (DOE 1993b).

2.1.1.3.1 Manzano Storage Structures—The Manzano Storage Structures are reinforced concrete bunkers located in the southeast portion of Kirtland Air Force Base. Until recently, when Sandia National Laboratories took responsibility for the site, the Manzano facilities were operated and maintained by the Department of Defense. The Sandia National Laboratories currently use four structures for dry storage of reactor-irradiated nuclear material (DOE 1993b). There is a total of 0.025 metric tons of heavy metal (MTHM) of SNF in storage at this facility (Wichmann 1995a).

2.1.1.3.2 Annular Core Research Reactor—The Annular Core Research Reactor is a pool-type research reactor capable of steady-state, pulse, and tailored transient operation. The Annular Core Research Reactor facility includes the reactor pool, one safe, and eight dry floor storage vaults, all located in the high-bay of Building 6588. The eight storage vaults on the high-bay floor are used to securely store irradiated experiments containing a variety of nuclear materials, but principally U-235. Materials from only three experiments containing reactor irradiated nuclear materials are stored at the Annular Core Research Reactor (DOE 1993b). There are a total of 438 elements plus uranium from three experiments (for a total of 0.04 MTHM) in use or storage at these facilities (Wichmann 1995a).

In addition, DOE is considering using the Annular Core Research Reactor for production of molybdenum-99. If the molybdenum-99 production mission is assigned to the Annular Core Research Reactor, the current reactor fuel would likely be removed and would need to be stored at the start of, or within a few years of starting, operation (SNL 1994).

2.1.1.3.3 Sandia Pulse Reactor II and III, and Critical Assembly—Three reactors are in operation at the Sandia Pulse Reactor facility: Sandia Pulse Reactor II and Sandia Pulse Reactor III are unmoderated, fast-burst reactors capable of pulsed and steady-state operation. The Critical Assembly is a small, water-moderated reactor used to perform measurements of key reactor parameters to benchmark the computer calculations and thereby refine the designs for a planned space propulsion reactor. The yard storage holes are 19 stainless-steel types located in a corner of the Sandia Pulse Reactor compound. These tubes are surrounded by a high-density concrete monolith. The yard holes are used to securely store irradiated experiments containing a variety of nuclear materials, but principally U-235. All of the materials remain in their own containers, some of which consist of double containment. At the Special Nuclear Material dry storage facility, Sandia National Laboratories stores previously failed fuel elements from Sandia Pulse Reactor II and elements from experiments that have been exposed to short irradiation periods (DOE 1993b). There are a total of 43 elements (with a total of 0.37 MTHM) of SNF in use or storage at these facilities (Wichmann 1995a).

Future plans include bringing on-line an additional pulse reactor named Sandia Pulse Reactor IIIM. With this new reactor, a total of three pulse reactors would be located at Sandia National Laboratories' Technical Area V.

2.1.1.3.4 Hot Cell Facility—The Hot Cell Facility at Sandia National Laboratories is a nonreactor nuclear facility housed in Building 6580 in Technical Area V. Research programs at Sandia National Laboratories--material studies, fuel studies, and safety studies--require that experiments containing radioactive materials be assembled and/or disassembled, samples prepared, and microscopic and chemical analyses performed. The principal storage facility for the Hot Cell Facility is Room 108, which is a heavily shielded room used previously as a preparation room next to the irradiation room of the Sandia Engineering Reactor, which has been defueled. There are a series of 13 storage holes under the Hot Cell Facility Monorail that are available to store irradiated material coming into or out of the Hot Cell Facility. Only one of the boles is currently in use. The other areas of the Hot Cell Facility are used for storing minor amounts of material (DOE 1993b) There is a total of 0.009 MTHM of SNF in storage at this facility (Wichmann 1995a).

2.1.1.4 Argonne National Laboratory - East. The Alpha-Gamma Hot Cell Facility, operated by the Materials Science Division, consists of a concrete-shielded, low-flow inert-atmosphere complex that was designed for the examination of irradiated plutonium fuel assemblies and related hardware (DOE 1993d). There are a total of four units of Experimental

Breeder Reactor fuel, one canister containing remnants of commercial SNF, and 16 SNF elements from Oak Ridge (for a total of 0.081 MTHM) in storage (Wichmann 1995a).

The Chicago Pile 5 Building houses a heavy-water, moderated reactor whose fuel has been removed and shipped offsite. Currently, the Chicago Pile 5 is in the process of being decontaminated and decommissioned and contains only two highly enriched uranium target (i.e., converter) elements (DOE 1993d).

2.1.2 Domestic Licensed Research Reactors

Table 2.1-1 identifies 57 non-DOE facilities representing domestic, licensed, small generators of SNF (NRC 1993a; ANS 1988). They include training, research, and test reactors at universities, commercial establishments, and several government installations; all but one (McClellan Air Force Base) have been licensed by the NRC. Although they are not DOE facilities, DOE has title to the SNF and has the responsibility for interim storage and ultimate disposition.

In order to assess their SNF management capabilities, these 57 facilities have been identified as belonging to one of three categories. These categories identify the key characteristics of a facility relevant to the assessment of DOE-postulated SNF alternatives. The three categories are:

- Category 1 - Facilities that have limited onsite storage capacity compared to the amount of SNF projected to be generated at their facility by the year 2035

- Category 2 - Facilities that do not routinely generate additional SNF

- Category 3 - Facilities that no longer possess SNF onsite.

The category for each facility is identified in Table 2.1-1.

Table 2.1-1. Domestic non-DOE research reactors.

Licensee location	Reactor type	NRC Docket no.	Category
Aerotest San Ramon, CA	TRIGA (Indus)	50-228	2
Arkansas Tech Univ. Russellville, AR	TRIGA	50-606	2
Armed Forces Radiobiology Research Institute (AFRRI) Bethesda, MD	TRIGA	50-170	2
Brigham Young Univ. Provo, UT	L-77	50-262	3
Catholic University Washington, DC	AGN-201	50-77	3
Cintichem, Inc. Tuxedo, NY	Pool	50-54	3
Cornell University Ithaca, NY	TRIGA	50-157	2
Cornell University Ithaca, NY	ZPR	50-97	2
Dow Chemical Company Midland, MI	TRIGA	50-264	2
General Atomics San Diego, CA	TRIGA Mark I	50-89	2
General Atomics San Diego, CA	TRIGA Mark F	50-163	2
General Electric Co. Pleasanton, CA	NTR	50-73	1
Georgia Institute of Technology Atlanta, GA	Research HW	50-160	2
Idaho State University Pocatello, ID	AGN-201	50-284	2
Iowa State University Ames, IA	MTR-10 Pool	50-116	2
Kansas State University Manhattan, KS	TRIGA	50-188	1

Table 2.1-1. (continued).

Licensee location	Reactor type	NRC Docket no.	Category
McClellan Air Force Base McClellan, CA	SNRS	None	2
Manhattan College Riverdale, NY	Tank-ZPR	50-199	2
Massachusetts Institute of Technology Cambridge, MA	Research HW	50-20	1
N.S. Savannah Mount Pleasant, SC	PWR	50-238	3
NASA Plum Brook Sandusky, OH	NASA Tr. Tank	50-185	3
National Institute of Standards and Technology (NIST) Gaithersburg, MD	Test	50-184	1
North Carolina State U. Raleigh, NC	Pulstar	50-297	2
Ohio State University Columbus, OH	Pool	50-150	2
Oregon State University Corvallis, OR	TRIGA	50-243	2
Penn State University University Park, PA	TRIGA	50-5	2
Purdue University West Lafayette, IN	Lockheed	50-182	2
Reed College Portland, OR	TRIGA	50-288	2
Rensselaer Polytechnic Institute Troy, NY	Critical Assembly	50-225	2
Rhode Island Atomic Energy Commission Narragansett, RI	Pool	50-193	1
State Univ. of New York Buffalo Buffalo, NY	Pulstar	50-57	1
Texas A&M University College Station, TX	AGN-201	50-59	2

Table 2.1-1. (continued).

Licensee location	Reactor type	NRC Docket no.	Category
Texas A&M University College Station, TX	TRIGA	50-128	1
U.S. Geological Survey Denver, CO	TRIGA	50-274	1
University of Arizona Tucson, AZ	TRIGA	50-113	2
University of California at Berkeley Berkeley, CA	TRIGA	50-224	3
University of California at Irvine Irvine, CA	TRIGA	50-326	2
University of California at Los Angeles Los Angeles, CA	Educator	50-142	3
University of Florida Gainesville, FL	Argonaut	50-83	2
University of Illinois Urbana, IL	LOPRA	50-356	1
University of Kansas Lawrence, KS	Lockheed	50-148	3
University of Maryland College Park, MD	TRIGA	50-166	2
University of Mass. at Lowell Lowell, MA	GE Pool	50-223	2
University of Michigan Ann Arbor, MI	Pool	50-2	1
University of Missouri Columbia Columbia, MO	Tank	50-186	1
University of Missouri Rolla Rolla, MO	Pool	50-123	2
University of New Mexico Albuquerque, NM	AGN-201	50-252	2
University of Texas Austin, TX	TRIGA-Mark II	50-602	2

Table 2.1-1. (continued).

Licensee location	Reactor type	NRC Docket no.	Category
University of Utah Salt Lake City, UT	TRIGA	50-407	2
University of Virginia Charlottesville, VA	Pool	50-62	1
University of Washington Seattle, WA	Argonaut	50-139	3
University of Wisconsin Madison, WI	TRIGA	50-156	2
Veterans Admin. Medical Center Omaha, NE	TRIGA	50-131	2
Washington State U. Pullman, WA	TRIGA	50-27	2
Watertown Army Materials Research Reactor Watertown, MA	Pool	50-47	3
Westinghouse Zion Training Reactor Pittsburgh, PA	W Tank	50-22	3
Worcester Polytechnic Institute Worcester, MA	Pool	50-134	2

2.1.2.1 Reactors with Limited Storage Capacity. The sites in Category 1 have limited storage capacity when compared to the amount of SNF that is projected to be generated by 2035. Table 2.1-2 lists the projected inventory as of June 1, 1995 with the corresponding MTHM at each of the Category 1 sites. Assuming continuing operation of each reactor, the projected amount of additional SNF that would be generated through 2035 is also provided in Table 2.1-2.

To reduce the risk of theft or diversion of highly enriched uranium fuel and the consequences to public health, safety, and the environment from such theft or diversion, the NRC has imposed limitations on the use of highly enriched uranium fuel in domestic nonpower reactors. Unless the NRC has determined that the nonpower reactor has a unique purpose requiring the use of high enriched uranium fuel, each licensee will replace all highly enriched uranium fuel in its possession with available low enriched uranium fuel acceptable to the Commission. If federal government funding for conversion is not available, the conversion from high enriched uranium fuel to low enriched uranium fuel may be deferred on an annual basis. A number of domestic research reactors are in the process of converting from highly enriched uranium fuel to low enriched uranium fuel.

2.1.2.2 Reactors with Sufficient Storage Capacity. Licensed domestic research reactor sites with sufficient SNF storage capacity are listed in Table 2.1-3. These Category 2 sites include operating facilities with low fuel burnup rates, where the amount of SNF generated is not expected to exceed the current onsite storage capacity. Some Category 2 sites are also converting from highly enriched uranium fuel to low enriched uranium fuel but have sufficient capacity to store this additional SNF onsite.

The projected inventory at each reactor site as of June 1, 1995 and the corresponding MTHM are presented in Table 2.1-3. The amount of SNF that is projected to be generated through the year 2035 is also listed in Table 2.1-3.

2.1.2.3 Reactors without SNF Onsite. The licensed domestic research reactors that are no longer operating and have shipped all SNF offsite are identified as Category 3 in Table 2.1-1. These sites either have been decommissioned or are in the process of decommissioning. Some of the facilities have been decontaminated, although they may not have been completely dismantled.

Table 2.1-2. Category 1 projected SNF inventories.[a]

Licensee location	Inventory as of June 1, 1995		Future increases through 2035	
	Elements	MTHM	Elements	MTHM
Kansas State University Manhattan, KS	107	0.020	140	0.027
Massachusetts Institute of Technology Cambridge, MA	66	0.021	480	0.150
National Institute of Standards and Technology Gaithersburg, MD	186	0.04	1,160	0.300
Rhode Island Atomic Energy Commission Narragansett, RI	57	0.030	160	0.222
State University of New York - Buffalo Buffalo, NY	25	0.493	5	0.100
Texas A&M (TRIGA) College Station, TX	186	0.030	378	0.060
U.S. Geological Survey Denver, CO	161	0.032	39	0.010
University of Illinois Urbana, IL	198	0.037	313	0.59
University of Michigan Ann Arbor, MI	103	0.072	480	0.400
University of Missouri Columbia, MO	82	0.055	1,040	0.700
University of Virginia Charlottesville, VA	65	0.066	60	0.210

a. Source: Wichmann 1995a.

Note: Projected inventory as of June 1, 1995 is 0.896 MTHM.
Projected additional SNF generated through 2035 is 2.769 MTHM.

Table 2.1-3. Category 2 projected SNF inventories.[a]

Licensee location	Inventory as of June 1, 1995		Future increase through 2035	
	Elements	MTHM	Elements	MTHM
Aerotest San Ramon, CA	91	0.015	0	0
Arkansas Tech. Univ. Russellville, AR	0	0	0	0
Armed Forces Radiobiology Research Institute Bethesda, MD	95	0.018	0	0
Cornell University (TRIGA) Ithaca, NY	123	0.023	770	0.143
Cornell University (ZPR) Ithaca, NY	814[d]	1.7[d]	0	0
Dow Chemical Company Midland, MI	78	0.014	0	0
General Atomics[c] San Diego, CA	263	0.058	20	0.016
GE Nuclear Test Reactor Plesanton, CA	8	0.008	0	0
Georgia Institute of Technology Atlanta, GA	50	0.030	120	0.107
Idaho State University Pocatello, ID	9[d]	0.011[d]	0	0
Iowa State University Ames, IA	27	0.024	0	0
McClellan Air Force Base McClellan, CA	90	0.015	0	0
Manhattan College Riverdale, NY	17[d]	0.019[d]	0	0
North Carolina State U. Raleigh, NC	34	0.428	25	0.315
Ohio State University Columbus, OH	24 and 638[b]	0.021	0	0
Oregon State University Corvallis, OR	96	0.017	96	0.060
Pennsylvania State Univ. University Park, PA	175	0.041	40	0.0[illegible]9
Purdue University West Lafayette, IN	13	0.002	13	0.063
Reed College Portland, OR	67	0.013	0	0
Rensselaer Polytechnic Institute[b] Troy, NY	597[d]	0.388[d]	0	0

Table 2.1-3. (continued).

Licensee location	Inventory as of June 1, 1995		Future increase through 2035	
	Elements	MTHM	Elements	MTHM
Texas A&M - AGN-201 College Station, TX	9	0.011	0	0
University of Arizona Tucson, AZ	97	0.081	8	0.0015
University of California Irvine Irvine, CA	113	0.021	0	0
University of Florida Gainesville, FL	23	0.04	22	0.172
University of Maryland College Park, MD	93	0.016	93	0.016
University of Mass. Lowell Lowell, MA	26	0.004	26	0.100
University of Missouri Rolla, MO	56	0.269	0	0
University of New Mexico Albuquerque, NM	9[d]	0.004[d]	0	0
University of Texas Austin, TX	154	0.029	0	0
University of Utah Salt Lake City, UT	139	0.026	0	0
University of Wisconsin Madison, WI	228	0.039	0	0
Veterans Admin. Medical Center Omaha, NE	56	0.001	0	0
Washington State Univ. Pullman, WA	215	0.037	112	0.051
Worcester Polytechnic Institute Worcester, MA	27	0.022	0	0

a. Source: Wichmann 1995a and Wichmann 1995b.

b. Fuel pins, not reactor assemblies.

c. Reactor scheduled to shut down in 1998.

d. Contact-handled fuel/targets (i.e., with radiation levels low enough to permit handling without shielding or remote operations), even though slightly irradiated, are not included as SNF.

Note: The projected inventory as of June 1, 1995 is expected to be 1.323 MTHM and the approximate total for the additional SNF projected to be generated through 2035 is 1.054 MTHM. Numbers may not sum due to rounding.

The SNF that originated at these sites has either been reprocessed or is stored and accounted for at DOE storage facilities.

2.1.3 Nuclear Power Plant Spent Nuclear Fuel

This subsection addresses spent nuclear power plant fuel that DOE has possession of or will take possession of sometime in the future. Currently this fuel is in storage at one of three sites: the West Valley Demonstration Project, the Fort St. Vrain nuclear power plant site, and the B&W Lynchburg Technology Center in Lynchburg, Virginia. In all cases, no new additional SNF is being or will be added to existing SNF inventories.

2.1.3.1 West Valley Demonstration Project. The West Valley Demonstration Project is located on the site of the first U.S. commercial nuclear fuel reprocessing plant, which was operated by Nuclear Fuel Services, Inc., until 1972 (WVNS 1994).

Nuclear Fuel Services, Inc., shut down the reprocessing facility in 1972 in order to implement modifications for the purpose of increasing the facility's capacity. From 1973 to 1975 Nuclear Fuel Services, Inc., continued to accept a total of 750 SNF elements. However, in 1976, it withdrew from the reprocessing business (WVNS 1994).

In 1980 Congress enacted Public Law 96-368, the West Valley Demonstration Project Act. The act directed the DOE to develop and demonstrate the technology for solidifying high-level waste in storage at the West Valley Demonstration Project so that this waste would be suitable for transportation to and long-term disposal in a federal repository (WVNS 1994).

The owners of the 750 SNF elements still in storage at the West Valley facility fuel storage pool were informed in 1981 that they would have to take back their SNF. By 1986, 625 of the elements had been returned to their respective owners; then, however, DOE took possession of the remaining 125 SNF elements (26.65 MTHM) under an agreement with Nuclear Fuel Services, Inc. The DOE was to use these 125 elements to demonstrate the safe transportation and long-term storage of SNF in a dual-purpose cask. These 125 SNF elements are included in this EIS (Wichmann 1995a).

2.1.3.2 Fort St. Vrain. Fort St. Vrain, a 330 MWe (Megawatt electric) high-temperature, gas-cooled reactor power plant, went into operation in January 1979 and terminated commercial operation in August 1989. It is currently undergoing decommissioning (FSV 1990a; NRC 1991a).

Prior to August 1989 a three-party agreement was reached between the Public Services Company of Colorado (the owner of Fort St. Vrain), General Atomics (the reactor developer), and the DOE that called for the DOE to take possession of eight segments of approximately 240 SNF elements each of SNF from the Fort St. Vrain for dry storage at the INEL. SNF from the Fort St. Vrain had been shipped to the INEL when a court action was initiated by the state of Idaho to stop any additional shipment of SNF to INEL.

In an effort to facilitate the continued decommissioning of the Fort St. Vrain station, the Public Services Company of Colorado has decided to store the Fort St. Vrain's SNF in a modular vault dry storage system, which is a reinforced concrete and sheathed steel frame building located on the Fort St. Vrain site immediately adjacent to but outside the fence around the Fort St. Vrain site. The modular vault dry storage system, designed to house 1,482 high-temperature, gas-cooled reactor SNF elements, 6 neutron source elements, and 37 keyed top reflector elements, became operational in late 1991 (FSV 1990a). There are 1,464 elements (16 MTHM) currently in storage in the modular vault dry storage system (Wichmann 1995a).

2.1.3.3 B&W Lynchburg. The B&W facility in Lynchburg, Virginia, is engaged in research and development on uranium fuels and the overall fuel cycle, and in the examination and testing of irradiated fuels (NRC 1987).

B&W Lynchburg currently has in storage at its facility 0.044 MTHM of SNF stored in 15 cannisters (Wichmann 1995a) consisting of 3 full-length fuel rods, 17 sectioned fuel rods, and a small quantity of fuel debris from Three Mile Island 2. All of this SNF material is in the possession of the DOE and was provided to B&W under a DOE contract for Fuel Performance Improvements Programs. None of the activities ongoing at B&W Lynchburg could result in the generation of additional SNF for which the DOE has responsibility, since the facility's three reactors have been decommissioned (Wright 1993; ANS 1988).

2.2 Spent Nuclear Fuel Management Program Plans and Alternatives

The plans for management of SNF at originating sites, including generating and storage sites, or facilities generating small annual quantities of SNF, were determined by conducting a survey of the NRC licensees and others operating these sites. These plans, as they are projected to be affected by the alternatives being assessed in this EIS, are presented in this section.

Availability of onsite SNF storage capacity is the primary consequence of DOE SNF management decisions for all originating sites. Of the five DOE SNF management alternatives, only Alternative 1 (No Action - no SNF transportation) may not have been addressed under the NRC licensing process for an individual SNF originating site. DOE management plans for the alternatives which involve SNF transportation would not affect the originating sites. The management plans at the DOE facilities to which the SNF may be shipped are addressed in the sections of this EIS dealing with those DOE facilities. The alternate plans with regard to transportation are analyzed in Appendix I to Volume 1. Accordingly, the next few subsections will focus primarily on the No Action Alternative and describe general information on SNF produced at the originating sites, including non-DOE facilities storing SNF.

2.2.1 No Action

The No Action Alternative is intended to evaluate the impact of storage of SNF at the current storage and originating sites. This means that all facilities which are generating or storing SNF and intend to ship SNF to a DOE facility would maintain their SNF onsite. If the SNF-originating site has adequate storage capacity, operations at the site would continue without change of plans. If SNF storage capacity is inadequate, new plans, including expansion of storage capacity or decreasing the rate of fuel burn-up, would have to be considered. Possible SNF management plans are discussed more specifically in the following subsections.

Of the total of approximately 2,700 MTHM of SNF estimated as the total DOE inventory by 2035, approximately 51 MTHM of SNF is associated with the facilities addressed in this appendix (Wichmann 1995a).

2.2.1.1 DOE Experimental Reactors and Small Quantity Storage. There is insufficient onsite storage capacity at the High Flux Beam Reactor at Brookhaven National Laboratory to store all of the SNF projected to be generated through the year 2035. If SNF shipments are not made to another DOE storage facility, at the current rate of generation the remaining onsite storage space would be depleted in January 1996. There is a plan to install a storage rack in the existing wet storage facility that would add space for 162 elements. Even with this rack, storage space would be depleted in 1998. If SNF could not be shipped by that time, the arrangement of existing racks could be modified to provide additional space. There are no plans to shut down the reactor in the near future (Carelli 1993).

2.2.1.2 Domestic Research Reactors. Based on current projections, the onsite storage capacity of 11 of the 45 domestic research reactors would be exhausted before the year 2035 if the No Action Alternative were to be implemented. All 11 of these facilities have been identified as Category 1.

Several of the facilities in Category 1 have indicated that they would consider various options of increasing storage capacity if the No Action Alternative were to be implemented. Five would consider reracking, one would consider expanding dry storage within the reactor building, three would consider expanding wet storage within the reactor building, and one would consider adding 200 square feet (18.6 square meters) of wet storage area outside the reactor building.

Any previously planned expansion of onsite SNF storage capacity at individual originating facilities is addressed in site-specific NRC environmental assessments and thus is not considered to be a consequence of the proposed actions under this EIS. The facilities that are already planning to expand their SNF storage capacity include the Massachusetts Institute of Technology and the National Institute of Standards and Technology.

At one of these facilities the expanded storage capacity is projected to be adequate through the year 2005. However, without SNF transportation through the year 2035, none of the facilities would have adequate storage capacity. One of the facilities in Category 1 has offloaded its highly enriched uranium fuel and would consider reracking but might elect to shut down in 2001 because of a lack of wet storage capacity (Jentz 1993).

All 34 facilities identified as Category 2 have sufficient SNF storage capacity onsite to accommodate any of the DOE SNF alternatives. Two facilities may elect to shut down before the year 2005: one because it may not renew its license; the other because, without transferring SNF offsite, it might not meet licensing limits on possession of uranium-235 after conversion from highly enriched uranium fuel to low enriched uranium fuel. One facility, which expects to convert from highly enriched uranium fuel to low enriched uranium fuel, might elect to shut down in the year 2005 if no offsite transportation were available, unless it can expand its SNF wet storage capacity. A few facilities have indicated that they will appeal the NRC-required conversion of highly enriched uranium fuel to low enriched uranium fuel if no offsite transportation is allowed. Although several Category 2 facilities can operate practically indefinitely without refueling, it is questionable how many of them would operate as planned if there were no SNF transportation through the year 2035. Many research reactors operate with variable core loadings, storing, and reusing partially depleted fuel elements as well as adding new fuel to the reactor (Jentz 1993).

2.2.1.3 Nuclear Power Plant Spent Nuclear Fuel. The No Action Alternative necessitating extended interim onsite storage of SNF would require a revision of the SNF management program at the West Valley Demonstration Project. The need to revise this program is a result of the following (DOE 1993b):

- The West Valley fuel pool is almost 30 years old and does not meet current DOE design criteria.

- The pool is single-walled, unlined, and lacks the capability for leak detection, thus presenting the potential for an undetected release to the environment.

- Continued storage of fuel onsite would interfere with and for some areas prevent the ongoing decontamination and decommissioning activities at the West Valley Demonstration Project facility from proceeding as planned.

The management of SNF at the West Valley Demonstration Project is to continue the use of the existing spent fuel pool with no modifications.

Loss of access to the INEL for storage of its SNF has already resulted in the construction of new onsite SNF storage at Fort St. Vrain. However, under this alternative Public Service Company of Colorado would not achieve its goal of becoming free of radioactive materials by 1998 under this option.

Adequate storage capacity exists and the storage facilities are in adequate condition at the B&W Lynchburg Technology Center (DOE 1993b).

2.2.2 Decentralization

Alternative 2, Decentralization, is similar to the No Action Alternative except that limited offsite shipments are permitted as required to allow continued operation of the given facility. Decentralization is not expected to impose additional requirements for storing SNF at the facilities included in this appendix above those already identified under the No Action Alternative. Planning at the sites receiving SNF shipments that would be allowed under this alternative is addressed in Appendixes A, B, and C. Intersite transportation impacts are analyzed in Appendix I to Volume 1.

2.2.2.1 DOE Experimental Reactors and Small Quantity Storage. Compared to the restrictions imposed under the No Action Alternative, Decentralization does not change the management plans at these DOE experimental reactors and small-quantity storage facilities.

2.2.2.2 Domestic Research Reactors. The Decentralization Alternative is similar to the No Action Alternative, except that limited offsite shipments are permitted as required to allow continued operation of the given facility. Under this alternative, the domestic research reactors are allowed to return to DOE any SNF in excess of their current onsite storage capacity. Additional storage capacity would be not be required at these originating facilities. Therefore, decentralization does not affect existing SNF management plans at university research reactors or other facilities in the domestic research reactor group, except for possible rerouting of SNF shipments to INEL or Savannah River Site.

2.2.2.3 Nuclear Power Plant Spent Nuclear Fuel. The Decentralization Alternative is similar to the No Action Alternative, except that limited offsite shipments are permitted as required to allow continued operation of the given facility. The three facilities being addressed in this subsection are only storing SNF and do not generate additional SNF. Because SNF would not be shipped offsite, SNF remaining at the site could interfere with the planned decontamination and decommissioning operations at West Valley Demonstration Project. Under this option, Public Service Company of Colorado would not achieve its goal of becoming free of radioactive material by 1998.

2.2.3 1992/1993 Planning Basis

Alternative 3, 1992/1993 Planning Basis, would not be expected to change any existing SNF management plans at the sites included in this appendix. Alternative 3 would permit the timely shipment of SNF from the originating sites to DOE interim storage facilities at INEL or Savannah River Site. Planning at these SNF-receiving sites is addressed in Appendixes A, B, and C. Interstate transportation impacts are analyzed in Appendix I to Volume 1.

2.2.3.1 DOE Experimental Reactors and Small Quantity Storage. Implementation of this alternative could require a transition period of several years. Therefore, limited onsite construction of temporary SNF storage facilities or acquisition of SNF transportation containers, suitable for use as temporary dry storage containers, may be necessary until shipment to a DOE interim storage site(s) is accomplished.

2.2.3.2 Domestic Research Reactors. Alternative 3 does not affect the existing SNF management plans at domestic research reactor facilities. Management of SNF at these reactors would continue to follow the same plans as in the past.

2.2.3.3 Nuclear Power Plant Spent Nuclear Fuel. Under Alternative 3, DOE plans to ship the SNF currently in storage at the West Valley Demonstration Project to INEL Test Area North for storage. Implementation of this alternative would therefore preclude the need for any additional action at the West Valley Demonstration Project related to providing a new onsite SNF storage facility.

If Public Service Company of Colorado shipped the remaining fuel segments, the Fort St. Vrain Site would be free of radioactive materials by 1998.

This alternative would have no impact on the management of the SNF material in storage at the B&W Lynchburg Technology Center.

2.2.4 Regionalization

Alternative 4, Regionalization, would not be expected to change any existing SNF management plans at the sites included in this appendix. Alternative 4 would permit the shipment of SNF from the originating sites to regional DOE interim storage facilities. Planning at the SNF-receiving sites is addressed in Appendixes A, B, C, and F. Intersite transportation impacts are analyzed in Appendix I to Volume 1.

2.2.4.1 DOE Experimental Reactors and Small Quantity Storage. Implementation of this alternative could require a transition period of several years. Therefore, limited onsite construction of temporary SNF storage facilities or acquisition of SNF transportation containers, suitable for use as temporary dry storage containers, may be necessary until shipment to a DOE interim storage site(s) is accomplished.

2.2.4.2 Domestic Research Reactors. Regionalization does not affect the existing SNF management plans at domestic research reactor facilities, except for possible rerouting of SNF shipments.

2.2.4.3 Nuclear Power Plant Spent Nuclear Fuel. The Regionalization Alternative for SNF addressed in this appendix is the same as the 1992/1993 Planning Basis Alternative except that the SNF would be sent to other locations. With the exception of INEL, facilities are not presently available for SNF storage at receiving sites considered under regionalization for SNF from West Valley Demonstration Project and Fort St. Vrain. The SNF would remain in storage at West Valley Demonstration Project and Fort St. Vrain until facilities are available for receipt at the selected regional SNF management sites.

2.2.5 Centralization

Alternative 5, Centralization, would not be expected to change any existing SNF management plans at the sites included in this appendix. Alternative 5 would permit the shipment of SNF from the originating sites to centralized DOE interim storage facilities. Planning at the SNF-receiving sites is addressed in Appendixes A, B, C, and F. Intersite transportation plans are analyzed in Appendix I to Volume 1.

2.2.5.1 DOE Experimental Reactors and Small Quantity Storage. Implementation of this alternative could require a transition period of several years. Therefore, limited onsite construction of temporary SNF storage facilities or acquisition of SNF transportation containers, suitable for use as temporary dry storage containers, may be necessary until shipment to a DOE interim storage site(s) is accomplished.

2.2.5.2 Domestic Research Reactors. Centralization does not affect the existing SNF management plans of domestic research reactor facilities except for rerouting of SNF shipments.

2.2.5.3 Nuclear Power Plant Spent Nuclear Fuel. The Centralization Alternative for SNF being addressed in this appendix is described as being the same as the 1992/1993 Planning Basis Alternative except that the SNF would be sent to other locations. With the exception of INEL, facilities are not presently available for SNF storage at receiving sites considered under centralization for SNF from West Valley Demonstration Project and Fort St. Vrain. The SNF would remain in storage at West Valley Demonstration Project and Fort St. Vrain until facilities are available for receipt of the SNF at the selected central SNF management site.

3. AFFECTED ENVIRONMENTS

Descriptions of those facilities generating and/or storing small quantities of spent nuclear fuel for which DOE has accepted responsibility are presented in this section. The following subsections present environmental information for each of the three categories of originating sites: DOE Test and Experimental Reactors, Domestic Research Reactors, and Nuclear Power Plant Spent Nuclear Fuel Storage Sites.

The wide variety of facilities and installations included in this category precludes the definition of their affected environments in a consistent and uniform manner. The information available in existing facility documents used as the bases for this analysis varies widely with the nature of the installation and the requirements of the overseeing or regulatory agencies.

3.1 DOE Experimental Reactors and Small-Quantity Storage

The DOE experimental reactors and small-quantity SNF storage facilities included in this category are located at the Brookhaven National Laboratory, Los Alamos National Laboratory, Sandia National Laboratory, and Argonne National Laboratory - East. The facilities, sites, and their environments are described in this section. Only those DOE sites at which spent nuclear fuel is currently generated and/or stored are discussed. Information on environmental factors that are not uniformly available in existing National Environmental Policy Act documentation for all four sites (including aesthetic and scenic resources, noise, traffic and transportation, and utilities and energy) is not provided in this document.

3.1.1 Brookhaven National Laboratory

There are two reactors at the Brookhaven National Laboratory which generate SNF potentially affected by actions analyzed in this EIS: the 60 MW High Flux Beam Reactor and the 5 MW Brookhaven Medical Research Reactor (ANS 1988).

3.1.1.1 High Flux Beam Reactor. The 60 MW High Flux Beam Reactor is a heavy water moderated and cooled research reactor which replaces an earlier 40 MW reactor. The High Flux

Beam Reactor began operation in 1965. The High Flux Beam Reactor facility is composed of five buildings located on the 5,265-acre (2,131-hectare) site of the Brookhaven National Laboratory. The distance from the reactor to the nearest site boundary is to the south at 3700 feet (1288 meters). The spent nuclear fuel is stored in an 8-foot-wide, 43-foot-long, 20-foot-deep canal (2.4 meters wide, 13.2 meters long, 6.1 meters deep). Within the canal, the fuel is located in storage racks, either in a 30-cell rack or in a long-term storage rack (Carelli 1993).

3.1.1.2 Brookhaven Medical Research Reactor. The Brookhaven Medical Research Reactor is a 5 MW heterogeneous, thermal, tank type reactor which is light water moderated and cooled. The reactor, used for research, became fully operational in 1959. The Brookhaven Medical Research Reactor is located in one building at the Brookhaven National Laboratory approximately 0.25 mile (0.4 kilometer) south of the High Flux Beam Reactor site. Fuel storage at the Brookhaven Medical Research Reactor consists of a shelf, lined with boral sheets, in the upper part of the reactor vessel above the active core region. The shelf is located under 8 feet (2.5 meters) of water and is considered critically safe when fully loaded. Like the High Flux Beam Reactor, there is no facility for dry storage at the Brookhaven Medical Research Reactor (Carelli 1993).

3.1.1.3 Affected Environment at Brookhaven National Laboratory.

3.1.1.3.1 Land Use—The Brookhaven National Laboratory is located approximately 60.1 miles (97 kilometers) east of New York City on Long Island, New York. The site is located in a primarily suburban area. Land on the 5,265-acre (2,131-hectare) site is divided between undeveloped natural areas and the developed areas that support the laboratory's scientific research (BNL 1992c).

Regional land use includes a variety of residential, commercial, industrial, agricultural, institutional, recreational, and public uses. Although agricultural and undeveloped forest land have been the dominant land uses in the region, development pressures for residential and commercial land uses have increased steadily in recent years (BNL 1992c).

3.1.1.3.2 Socioeconomics—The Brookhaven National Laboratory is located in central Suffolk County just at the fringe of developed areas, in an area of rapidly growing population. About 1.32 million persons reside in Suffolk County and about 410,000 persons reside in Brookhaven Township, within which the Laboratory is situated. Between 1995 and 2040, population in Suffolk County is expected to increase 14.6 percent (DOC 1991a). Approximately 8,000 persons reside within a half mile (0.8 kilometer) of the laboratory boundary (BNL 1992b).

The population of Suffolk County is approximately 96 percent urban and has a substantially higher median family income than the rest of the state (DOC 1991c). Between 1970 and 1990, total employment in Suffolk County increased 103.8 percent (DOC 1992).

Dominant industries in the area include government, manufacturing, retail and services, with approximately 20 percent of earnings in Suffolk County coming from government spending (DOC 1992).

The Brookhaven National Laboratory is composed of a total staff of 3449 regular employees (BNL 1993a).

As reported in 1988, there were a total of 69 personnel working at the reactors (ANS 1988). This number included operators, experimenting scientists, and support personnel. While not their main occupation, part of the duties of the operators and some support personnel include tasks associated with refueling, storing, inventorying, packaging, and shipping SNF.

3.1.1.3.3 Cultural Resources—The Brookhaven National Laboratory has no properties designated as National Historic Landmarks.

The Old Reactor Building (Building 701) and the Old Cyclotron Enclosure (Building 902) are eligible for inclusion on the National Register of Historic Places (NRHP). Camp Upton training trenches from World War I are also eligible for inclusion on the NRHP.

3.1.1.3.4 Geology—The Brookhaven National Laboratory site is in the upper part of the Peconic River Valley, which is bordered by two lines of low hills. These extend east and west beyond the limits of the valley nearly the full length of Long Island and form its most prominent topographic features (ERDA 1977).

A maximum horizontal ground surface acceleration of 0.19 g at Brookhaven National Laboratory is estimated to result from an earthquake that could occur once every 2000 years (DOE 1994a). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities should be evaluated on a facility specific basis consistent with DOE orders and standards and site specific procedures.

No earthquake has yet been recorded in the Brookhaven National Laboratory area with a Modified Mercalli intensity in excess of III. Long Island lies in the Uniform Building Code Zone 2A (moderate) seismic hazard area. No active earthquake producing faults are known in the Long Island area (ERDA 1977).

3.1.1.3.5 Air Resources—In terms of meteorology, the laboratory can be characterized, like most Eastern Seaboard areas, as a well-ventilated site. The prevailing ground-level winds are from the southwest during the summer, from the northwest during the winter, and about equally from these two directions during the spring and fall (BNL 1992b).

The mean annual temperature for the site during 1991 was 52.8°F (11.6°C), with temperatures ranging from 21.2°F (-6°C) to 83.8°F (28.8°C). The annual precipitation during 1991 was 45.3 inches (115 centimeters), which is about 3.6 inches (9.0 centimeters) below the 40-year annual precipitation average of 48.4 inches (123 centimeters) (BNL 1992b).

The State of New York has adopted ambient air quality standards that specify maximum permissible short- and long-term concentrations for various contaminants. These standards are generally the same as the national standards for criteria pollutants (NYSDEC 1977). 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, particluates, sulfur dioxide, nitrogen dioxide, and lead (NYSDEC 1993).

3.1.1.3.6 Water Resources—The Brookhaven National Laboratory site lies on the western rim of the shallow Peconic River watershed. The marshy areas in the north and eastern sections of the site are a portion of the Peconic River headwaters. The Peconic River both recharges and receives water from the groundwater aquifer, depending on the hydrogeological potential. In times of drought the river water typically recharges to groundwater, while in times of normal to above normal precipitation, the river receives water from the aquifer (BNL 1992b).

Groundwater flow in the vicinity of Brookhaven National Laboratory is controlled by many factors. The main groundwater divide lies 1.25 to 5 miles (2 to 8 kilometers) south of Long Island Sound parallel to the Sound. This divide is known to shift 0.6 to 1.25 miles (1 to 2 kilometers), north to south. East of Brookhaven National Laboratory is a secondary groundwater divide that defines the southern boundary of the area contributing groundwater to the Peconic River. The exact location of the triple-point intersection of these two divides is not known and may be under Brookhaven National Laboratory. South of these divides, the groundwater moves southward to Great South Bay and to Moriches streams. In general, the groundwater from the area between the two branches of the divide moves out eastward to the Peconic River. North of the divide, groundwater moves northward to Long Island Sound. Pressure of a higher water table to the west of the Brookhaven National Laboratory area generally inhibits movement toward the west. Variability in the direction of flow in the Brookhaven National Laboratory site is a function of the hydraulic potential and is further complicated by the presence of clay deposits that accumulate perched water at several places plus the pumping/recharge of groundwater that are part of Brookhaven National Laboratory daily operations. In general, groundwater in the northeast and northwest sections of the site flows toward the Peconic River. On the western portion of the site, groundwater flow tends to be toward the south, while along the southern and southeastern sections of the site it tends to be toward the south to southeast (BNL 1992b).

In all areas of the site, horizontal groundwater velocity is estimated to range from 12 to 18 inches (30 to 45 centimeters) a day. The site occupied by Brookhaven National Laboratory has been identified by the Long Island Regional Planning Board and Suffolk County as being over a deep recharge zone for Long Island. This implies the precipitation and surface water which recharges within this zone has the potential to replenish the lower aquifer systems (Magothy and/or Lloyd) which exist below the Upper Glacial Aquifer. The extent to which the Brookhaven National laboratory site contributes to deep flow recharge is currently under evaluation. However, it is estimated that up to two-fifths of the recharge from rainfall moves into the deeper aquifers. These lower aquifers discharge to the Atlantic Ocean (BNL 1992b).

The three aquifers (Upper Glacial, Magothy and Lloyd) underlying the Brookhaven National Laboratory comprise the Nassau/Suffolk Aquifer System, which has been designated as a sole source aquifer by the U.S. Environmental Protection Agency. More detailed aquifer characterization information can be found in the Brookhaven National Laboratory Site Baseline Report (SAIC 1992).

3.1.1.3.7 Ecological Resources—Approximately 75 percent of Brookhaven National Laboratory is primarily woodland. Terrestrial habitats include pine plantations, moderately mature pitch pine/oak forest, predominantly deciduous forest, early successional shrub/sapling community, pine barrens shrub/sapling wetlands, and lawn areas (BNL 1993a).

The isolation of the Brookhaven National Laboratory site and its variety of wildlife habitats have made it a refuge for a surprisingly diverse animal population. Thirty species of mammals have been recorded on site or within a 10-mile (16-kilometer) radius. All of these are year-round residents except for five summer-resident and two migrant species of bats. (BNL 1992c)

About 400 non-extinct species of birds have been recorded on all of Long Island since records have been kept, and at least 180 of these have been recorded on site. Thirty-three species are found throughout the year and all except six of these breed on site. Forty-nine other species are summer residents. All except nine nest on site, four others probably do, and the rest nest elsewhere on Long Island, most nearby (BNL 1993).

In September 1990, the U.S. Fish and Wildlife Service confirmed that no Federal or State endangered species occur in the vicinity of Brookhaven National Laboratory. However, the State endangered tiger salamander breeds in a pond in the southeast corner of the site (BNL 1992c).

3.1.1.3.8 Public Health and Safety—The calculated effective dose equivalent associated with effluent releases from the most recent reports for a 5-year period are presented below (BNL 1993b, 1992a, 1992b, 1990, 1989). The annual doses for each year are only a fraction of the DOE Public Dose Limit of 100 millirem per year. The data are from all laboratory operations, including storage of SNF.

Year	Airborne effluents (maximum site boundary)	Liquid effluents (maximum individual)
1988	0.113 millirem	0.15 millirem
1989	0.120 millirem	0.96 millirem
1990	0.067 millirem	0.85 millirem
1991	0.170 millirem	0.74 millirem
1992	0.097 millirem	0.91 millirem

The collective (population) dose equivalent (total population dose) beyond the site boundary, within a radius of 50 miles (80 kilometers), attributed to laboratory operations from reports for a 5-year period is presented below (BNL 1993b, 1992a, 1992b, 1990, 1989). The data are from all laboratory operations, including storage of SNF.

1988	2.5 person-rem
1989	3.2 person-rem
1990	1.8 person-rem
1991	3.6 person-rem
1992	3.2 person-rem

3.1.1.3.9 Waste Management — Brookhaven National Laboratory generates low-level, low-level mixed and hazardous wastes, in conjunction with its activities as a scientific research center. In 1992, the site generated approximately 508 tons (461 metric tons) of solid waste and 19.6 cubic yards (15 cubic meters) of liquid waste (DOE 1994b).

Brookhaven National Laboratory currently stores about 110 cubic yards (84 cubic meters) of low-level mixed waste and has no current or planned onsite treatment facilities. All waste streams are currently shipped to Hanford. These waste streams include organic liquids, acid and alkaline solutions, uranium hydride, cleaning/degreasing solvents, chromic acid cleaning solutions, and lead- and mercury-contaminated equipment (DOE 1993g).

In 1989, EPA listed BNL on the National Priorities Lists and in 1992 an Interagency Agreement was signed among DOE, EPA Region II, and the New York State Department of Environmental Conservation. Seven operable units have been identified for remedial investigation/feasibility studies and evaluated for suitable remedial action. The operable units consist of various groupings (generally by area) of buildings and sumps, underground pipes and tanks, the sewage runoff and discharge areas, trichloroethylene and reactor spill areas and groundwater. Some contamination at the site was the result of U.S. Army practices from 1917 to 1947 (DOE 1993g).

3.1.2 Los Alamos National Laboratory

The Omega West Reactor, operated by the Los Alamos National Laboratory, is a thermal, heterogeneous, closed-tank research reactor normally functioning at a power level of 8 MW. The Omega West Reactor was operational from 1956 until December 1992, when it was shut down. This reactor is permanently shut down and is being decommissioned. All spent nuclear fuel, consisting of 86 fuel elements, is in temporary storage at the Chemistry and Metallurgy Research Complex in Wing 9. They are being stored in old "Rover Project" casks which were once certified for transport of spent nuclear fuel. LANL has no permit for long-term storage of spent fuel.

3.1.2.1 Land Use. Los Alamos National Laboratory is located approximately 60 miles (96 kilometers) north-northeast of Albuquerque, New Mexico. Los Alamos occupies an area of about 28,000 acres (11,000 hectares) located primarily in Los Alamos County in northern New Mexico, about 24 miles (39 kilometers) northwest of Santa Fe. The County of Los Alamos has zoned the entire area of the lab Federal Land. Los Alamos National Laboratory has developed nine land use classifications for its operations. There are no prime farmlands on the Los Alamos National Laboratory, although portions are designated as a National Environmental Research Park (DOE 1993a).

3.1.2.2 Socioeconomics. The civilian labor force in the region of interest grew 144 percent, increasing from 34,467 in 1970 to 84,107 in 1990. Total employment increased from 31,155 to 79,846 between 1970 and 1990, an annual growth rate of 5 percent. The unemployment rates for 1970 and 1990 were 9.6 percent and 5.1 percent, respectively. For the same years, personal income increased from approximately $324.7 million to $2.3 billion (an annual average of 10 percent), and per capita income increased from $3,396 to $15,348 (DOE 1993a).

Between 1975 and 1990, employment at Los Alamos National Laboratory increased from 5,094 to 7,622, representing 10 percent of the region of interest employment in 1990. As of September 1992, employment at Los Alamos National Laboratory had increased to 7,450. The prepared Fiscal Year 1994 budget projects a reduction in expenditures at the site resulting in reduced employment (DOE 1993a).

In 1991, more than half of the Los Alamos National Laboratory workforce resided in the unincorporated communities of Los Alamos and White Rock in Los Alamos County. Between 1970 and 1990, the population in the region of interest increased 61 percent to 151,408. During the same period, the New Mexico population increased 49 percent. The population in the three-county region of interest is projected to increase from an estimated 169,000 in 2000 to 191,000 by 2020, an annual rate of less than 1 percent (DOE 1993a).

Employment associated with SNF management such as routine operations of the facility including care and periodic inventories of the SNF amounts to about 1.3 person-years per year (Cruz 1995).

3.1.2.3 Cultural Resources. The prehistoric chronology for the Los Alamos National Laboratory area consists of six broad time periods: Paleoindian (10,000-4000 B.C.), Archaic (5500 B.C.-A.D. 600), Early Developmental (A.D. 600-900), Late Developmental (A.D. 900-1100) Coalition (A.D. 1110-1325), and Classic (A.D. 1325-1600). Prehistoric site types identified in the vicinity of Los Alamos National Laboratory include large multiroom pueblos, pithouse villages, field houses, talus houses, cave kivas, shrines, towers, rockshelters, animal traps, hunting blinds, water control features, agricultural fields and terraces, quarries, rock art, trails, campsites, windbreaks, rock rings, and limited activity sites. Approximately 75 percent of Los Alamos National Laboratory has been inventoried for cultural resources. Coverage for some inventories has been less than 100 percent; however, about 60 percent of Los Alamos National Laboratory has received 100 percent coverage. Over 975 prehistoric sites have been recorded; about 95 percent of these sites are considered eligible or potentially eligible for the National Register of Historic Places (DOE 1993a).

Native Americans in this area include those living in the San Ildefonso, San Juan, Santa Clara, Nambe, Tesuque, Pojoaque pueblos east of Los Alamos, and the Jemez and Cochiti pueblos. Native American resources on Los Alamos National Laboratory may consist of prehistoric sites with ceremonial features such as kivas, village shrines, petroglyphs, or burials; all of these site types or features would be of concern to local groups (DOE 1993a).

3.1.2.4 Geology. Los Alamos National Laboratory is located on the Pajarito Plateau. The surface of the plateau is dissected by deep, southeast-trending canyons separated by long, narrow mesas (DOE 1993a).

Los Alamos National Laboratory lies in the Uniform Building Code Zone 2B seismic hazard area. The strongest earthquake in the last 100 years within a 50-mile (80-kilometer) radius was estimated to have a magnitude of 5.5 to 6 and a Modified Mercalli Intensity of VII. Studies suggest that several faults have produced seismic events with a magnitude of 6.5 to 7.8 in the last

500,000 years. Los Alamos National Laboratory operates a seismic hazards program which monitors seismicity through a seismic network and conducts studies in paleoseismology. These studies have determined the presence of three faults in the area that are considered active as defined by 10 CFR 100, Appendix A. These form the Pajarito fault system, which includes the Pajarito, Water Canyon, and Guaje Mountain faults. The Guaje Mountain fault had movement on it between 4,000 and 6,000 years ago. There is no evidence of movement along the Pajarito fault system during historical times. The 100-year earthquake at Los Alamos is regarded as having a magnitude of 5, with an event of magnitude 7 being the maximum reasonably foreseeable earthquake. These values are currently used in design considerations at Los Alamos (DOE 1993a).

Maximum horizontal ground surface accelerations ranging from 0.17 to 0.25g at Los Alamos National Laboratory are estimated to result from an earthquake that could occur once every 2000 years (DOE 1994a). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities should be evaluated on a facility specific basis consistent with DOE orders and standards and site specific procedures.

Geological concerns associated with the Los Alamos National Laboratory area include potential downslope movements in association with regional seismic activity. Although isolated rockfalls commonly occur from the canyon rims, landslides are an unlikely hazard (DOE 1993a).

3.1.2.5 Air Resources. The climate at Los Alamos National Laboratory and in the surrounding region is characterized as a semiarid tropical and subtropical steppe. Mountain barriers deplete a large portion of the moisture from the maritime air masses from the Pacific Ocean, a condition that contributes to the semiaridness. The annual average temperature in the area is 56.2°F (13.4°C); average daily temperatures range from 22.3°F (-5.4°C) in January to 92.8°F (33.8°C) in July. The average annual precipitation in the area is 8.1 inches (20.6 centimeters). The average monthly precipitation ranges from 0.38 inch (0.97 centimeter) in November to 1.51 inches (3.84 centimeters) in August (DOE 1993a).

3.1.2.6 Water Resources. The major surface water body in the immediate vicinity of Los Alamos National Laboratory is the Rio Grande east of the site. The primary surface water features near Los Alamos National Laboratory are intermittent streams. Sixteen drainage areas pass through or start in the Los Alamos National Laboratory site. Most Los Alamos National Laboratory facilities are located well above the streambeds. Only those Technical Areas located within canyons would be within the 500-year floodplain (DOE 1993a).

No surface water is withdrawn at Los Alamos National Laboratory for either drinking water or facility operations. The water supply system for Los Alamos is based on a series of groundwater supply wells and springs (DOE 1993a).

Los Alamos, Sandia, and Mortandad canyons currently receive treated industrial or sanitary effluent. Acid-Pueblo Canyon does not receive Los Alamos National Laboratory effluents. Surface waters in these canyons are not a source of municipal, industrial, or agricultural water supply. Only during periods of heavy precipitation or snow melt would waters from Acid-Pueblo, Los Alamos, or Sandia Canyons extend beyond Los Alamos National Laboratory boundaries and reach the Rio Grande. In Mortandad Canyon, there has been no surface runoff to the laboratory's boundary since studies were initiated in 1960 (DOE 1993a).

The main aquifer consists mainly of sediments of the Santa Fe Group. Nearly all groundwater at Los Alamos National Laboratory is obtained from deep wells that produce water from this aquifer. The Bandelier Tuff, a volcanic unit that lies above the Santa Fe Group, contains fractures that yield small amounts of water to springs. A minor amount of groundwater at Los Alamos National Laboratory is obtained from springs. The aquifers that lie beneath Los Alamos National Laboratory are considered Class II aquifers, having current sources of drinking water and water with other beneficial uses (DOE 1993a).

The water in the main aquifer moves slowly from the major recharge area in the west to discharge springs in White Rock Canyon along the Rio Grande. The depth to the aquifer ranges from about 1,200 feet (365 meters) on the west to about 600 feet (183 meters) on the east. The total saturated thickness penetrated by production wells ranges up to at least 1,700 feet (518 meters) (DOE 1993a).

3.1.2.7 Ecological Resources. Terrestrial habitats within undeveloped areas of Los Alamos National Laboratory support six major vegetative communities: juniper-grassland, pinyon pine-juniper, ponderosa pine, mixed conifer, spruce-fir, and subalpine grassland. Undeveloped areas within Los Alamos National Laboratory provide habitat for a diversity of terrestrial wildlife. Los Alamos National Laboratory was designated a National Environmental Research Park in 1976 (DOE 1993a).

National Wetland Inventory maps indicate that wetlands within Los Alamos National Laboratory are restricted to several canyons containing the Rio Grande or its tributaries. Most of the wetlands shown on the National Wetland Inventory maps have been designated as temporary or seasonal (DOE 1993a).

Aquatic habitats on Los Alamos National Laboratory are limited to the Rio Grande and several springs and intermittent streams in the canyons. These habitats currently receive National Pollutant Discharge Elimination System-permitted wastewater discharges. Fourteen species of fish are known to inhabit the roughly 6-mile (10-kilometer) reach of the Rio Grande between Los Alamos National Laboratory and Chochiti Lake. The springs and streams on the site support limited, if any, aquatic life (DOE 1993a).

Seventeen federally listed or New Mexico-listed threatened, endangered, or candidate species potentially occur in the vicinity of Los Alamos National Laboratory. Four of these species have been observed on Los Alamos National Laboratory, including the bald eagle (*Haliaeetus leucocephalus*)(a federally listed endangered species that roosts along the Rio Grande); the peregrine falcon (*Falco peregrinus*)(a federally listed endangered species that historically nests in the northeast corner of Los Alamos National Laboratory); the northern goshawk (*Accipiter gentilis*) (A Federal candidate Category 2 species that forages in the northwest corner of Los Alamos National Laboratory); and the giant helleborine orchid (*Epipactic gigantea*) (a state-listed endangered species that occurs near springs in White Rock Canyon). Five other species occur in close proximity to Los Alamos National Laboratory and are likely to exist on the site (DOE 1993a).

3.1.2.8 Public Health and Safety. The total maximum individual dose to a member of the public associated with both gaseous and liquid effluents from the most recent reports for a 5-year period is presented below (LANL 1993, 1992, 1990, 1989, 1988). The annual doses for each year are only a fraction of the DOE Public Dose Limit of 100 millirem per year. The data are from all laboratory operations, including storage of SNF.

1987	6.1 millirem
1988	6.2 millirem
1989	3.9 millirem
1990	3.1 millirem
1991	4.4 millirem

The population collective effective dose equivalent attributable to laboratory operations to persons living within 50 miles (80 kilometers) of the laboratory for a 5-year period is presented below (LANL 1993, 1992, 1990, 1989, 1988). The data are from all laboratory operations, including storage of SNF.

1987	3.5 person-rem
1988	2.2 person-rem
1989	3.1 person-rem
1990	3.1 person-rem
1991	1.1 person-rem

3.1.2.9 Waste Management. Current low-level radioactive waste management activities at Los Alamos National Laboratory may require expansion of the existing landfill at Los Alamos National Laboratory. A portion of the proposed expansion area for the existing landfill has been contaminated by a chemical plume from the hazardous chemical disposal site, which restricts further development. DOE is considering the expansion to ensure continued operation of laboratory activities that generate low level radioactive waste and to provide safe isolation of the wastes (DOE 1993a).

Waste minimization has been implemented by Los Alamos National Laboratory's Environmental Management Division using programmatic controls such as source reduction, inventory control, product substitution, and waste exchange programs. A Waste Minimization and Pollution Prevention Awareness Plan was completed in 1991. Major waste generating operations have been prioritized by severity of hazard and volume in order to determine which generating systems to address. Also, halogenated solvent substitution has been evaluated for a number of research processes (DOE 1993a).

3.1.3 Sandia National Laboratories

Sandia National Laboratories, headquartered in Albuquerque, New Mexico, maintain facilities in three locations: Albuquerque, New Mexico; Livermore, California; and Tonopah, Nevada. The facilities discussed in this document refer only to the Albuquerque location, located adjacent to the city of Albuquerque, New Mexico. The site is approximately 6.5 miles (10 kilometers) southeast of downtown Albuquerque. Sandia National Laboratories consist of 8,300 acres (3,360 hectares) on Kirtland Air Force Base allocated to DOE.

Sandia National Laboratories use facilities at five Technical Areas and a Test Field (DOE 1993a).

- Technical Area I--Administration, site support, technical support, component development, research, energy programs, microelectronics, defense programs, and exploratory systems.

- Technical Area II--Testing of explosive components.

- Technical Area III--Testing and simulation of a variety of natural and induced environments, including two rocket sled tracks, two centrifuges, and a radiant heat facility.

- Technical Area IV--A remote site for pulsed power sciences such as X-ray, gamma-ray, and particle beam fusion accelerators.

- Technical Area V--A remote area for experimental and engineering reactors and particle accelerators.

- Coyote Test Field--Land parcels scattered throughout the Coyote Test Field used for testing.

The Sandia National Laboratories contain five SNF storage facilities: the Manzano Storage Structures, the Annular Core Research Reactor Facility, the Sandia Pulse Reactor Facility, the Hot Cell Facility, and the Special Nuclear Materials storage facility (DOE 1993b).

3.1.3.1 Manzano Storage Structures. The Manzano Storage Structures are reinforced concrete bunkers located in the southeast portion of Kirtland Air Force Base. Until recently, when the Sandia National Laboratories took responsibility for the site, the Manzano facilities were operated and maintained by the Department of Defense. The Sandia National Laboratories currently use four structures for dry storage of reactor irradiated nuclear material. The two types of bunkers which Sandia National Laboratories utilize are reinforced concrete bunkers with an earth covering, and reinforced concrete bunkers bored into the mountain. The average storage space available is 1800 square feet (167 square meters). A ring road encircles the mountain and provides access to all of the bunkers. The ventilation is natural air circulation (DOE 1993b).

3.1.3.2 Annular Core Research Reactor. The Annular Core Research Reactor is a pool-type research reactor capable of steady-state, pulse, and tailored transient operation. The reactor has a large central irradiation cavity (primary experiment location) that extends through the core, two interchangeable, fuel-ringed external cavities, an unfueled external cavity and two neutron radiography facilities. The Annular Core Research Reactor facility includes the reactor pool, one safe, and eight dry floor storage vaults, all located in the high-bay of Building 6588. The Annular Core Research Reactor is used primarily for testing electronics and for reactor safety research. The eight storage vaults on the high-bay floor are used to securely store irradiated experiments containing a variety of nuclear materials, but principally uranium-235. Materials from only three experiments containing reactor irradiated nuclear materials are stored at the Annular Core Research Reactor (DOE 1993b).

3.1.3.3 Sandia Pulse Reactor II and III, and Critical Assembly. Three reactors are operated at the Sandia Pulse Reactor facility; Sandia Pulse Reactor II and Sandia Pulse Reactor III are unmoderated, fast-burst reactors capable of pulsed and steady-state operation. They are designed to produce a neutron energy spectrum similar to that produced from fission. The primary experiment location for each reactor is a central cavity that extends through the core. The principal use of the reactors is to irradiate electronic devices requiring high neutron fluence and/or high dose rates. The Critical Assembly is a small, water-moderated reactor used to perform measurements of key reactor parameters to benchmark the computer calculations and thereby refine the designs for a planned space propulsion reactor. The yard storage holes are 19 stainless-steel types located in a corner of the Sandia Pulse Reactor compound. These tubes are surrounded by a high-density concrete monolith. The yard holes are used to securely store irradiated experiments containing a variety of nuclear materials, but principally uranium-235. All of the materials reside in their own containers, some of which have double containment (DOE 1993b).

3.1.3.4 Hot Cell Facility. The Hot Cell Facility at Sandia National Laboratories is a nonreactor nuclear facility that is housed in Building 6580 in Technical Area V. The Hot Cell Facility includes the Hot Cell, the Glove Box Laboratory, Radiochemistry Laboratory, and support facilities in rooms 101, 104, 105, 106, 107, 108, 110, 111, 112, 113, 113A, 203, and 212A. This facility is designed to permit safe handling and experimentation with Special Nuclear Materials, both irradiated and unirradiated. Research programs at Sandia National Laboratories (material studies, fuel studies, and safety studies) require that experiments containing radioactive materials be assembled and/or disassembled, samples prepared, and microscopic and chemical analyses performed. The principal storage facility for the Hot Cell Facility is Room 108, which is a heavily shielded room used previously as a preparation room next to the irradiation room of the Sandia Engineering Reactor which has been defueled. There are a series of 13 storage holes under the Hot Cell Facility Monorail that are available to store irradiated material coming into or out of the Hot Cell Facility. Only one of the holes is currently in use. The other areas of the Hot Cell Facility are used for storing minor amounts of material (DOE 1993b).

3.1.3.5 Special Nuclear Material Storage Facility. At this dry storage facility, Sandia National Laboratories stores previously failed fuel elements from Sandia Pulse Reactor II and elements from experiments that have been exposed to short irradiation periods. The complex also provides for a loading area, a maintenance area, and an administrative office area. The ventilation consists of a forced air filtered system (DOE 1993b).

3.1.3.6 Affected Environment at Sandia National Laboratories.

3.1.3.6.1 Land Use—Sandia National Laboratories are located approximately 6.5 miles (10.5 kilometers) southeast of downtown Albuquerque, New Mexico. There are no prime farmlands on Sandia National Laboratories (DOE 1993a).

3.1.3.6.2 Socioeconomics—The civilian labor force in the region of interest grew 132 percent, increasing from 133,798 in 1970 to 310,252 in 1990. Total employment increased from 124,605 to 293,905 between 1970 and 1990, an annual growth rate of 4 percent. The unemployment rates for 1970 and 1990 were 6.9 percent and 5.3 percent, respectively. For the same years, personal income increased from approximately $1.3 billion to $9.4 billion (an annual average of 10 percent), and per capita income increased from $3,438 to $15,992 (DOE 1993a).

Between 1970 and 1990, employment levels at Sandia National Laboratories increased from 6.440 to 7,536, representing 3 percent of the region of interest employment in 1990. Changes in mission requirements have historically led to fluctuations in employment levels over the period. For example, employment decreased to 5,542 in 1975 and increased to 7,051 by 1985. As of September 30, 1992, employment levels at Sandia National Laboratories had increased to 8,473. The prepared Fiscal Year 1994 budget projects a reduction in expenditures at the site, resulting in reduced employment. The reduction in work force associated with the budget reductions is only estimated at this time (DOE 1993a).

Between 1970 and 1990, the population in the region of interest increased 58 percent to 589,131. During the same period, the population of New Mexico increased 49 percent. The population in the three-county region of interest is projected to increase from an estimated 682,000 in 2000 to 771,000 by 2020, an annual rate of less than 1 percent (DOE 1993a).

As reported in 1988, there were a total of 21 personnel working at the reactors (ANS 1988). This number included operators, experimenting scientists, and support personnel. While not their main occupation, part of the duties of the operators and some support personnel include tasks associated with refueling, storing, inventorying, packaging, and shipping SNF.

3.1.3.6.3 Cultural Resources—The prehistoric chronology for the Sandia National Laboratories area consists of three broad time periods: Paleoindian (10,000-5500 B.C.), Archaic (5500 B.C.-A.D. 1), and Anasazi (A.D. 1600). Prehistoric site types include pueblos, pithouse villages, rockshelters, hunting blinds, agricultural terraces, quarries, lithic and ceramic scatters, lithic scatters, and hearths. About 22 percent of Sandia National Laboratories/DOE-controlled land has been intensively inventoried for cultural resources; another 28 percent has received less intensive surveys. Because techniques and procedures varied greatly between projects in these areas, most surveys are not considered adequate. All five DOE Technical Areas have been intensively surveyed; no prehistoric sites were recorded. Sixty-four prehistoric sites have been recorded in DOE-owned or controlled lands beyond the five Technical Areas. About 88 percent of these sites are considered eligible for the National Register of Historic Places (DOE 1993a).

Native Americans in this area include those living on the Sandia Pueblo, north of Albuquerque, and the Isleta Pueblo, south of Kirtland Air Force Base. Native American resources on Sandia National Laboratories/DOE-controlled lands may consist of prehistoric sites with ceremonial features such as kivas, village shrines, petroglyphs, or burials; all of these types or features would be of concern to local groups (DOE 1993a).

3.1.3.6.4 Geology—Sandia National Laboratories lie on a sequence of sedimentary, igneous, and Precambrian basement rocks. The northern and western sections of Sandia National Laboratories rest on Miocene to Quaternary gravels, sands, silts, and clays deposited in the basin formed by uplift of the mountains to the east. The eastern portion of Sandia National Laboratories is underlain primarily by Precambrian rocks (DOE 1993a).

The eastern portion of Sandia National Laboratories is cut by the Tijeras, Hubble Springs, Sandia, and Manzano faults. Both the Tijeras and Sandia faults, which intersect on the site, are considered capable faults (DOE 1993a).

Sandia National Laboratories lies in the Uniform Building Code 2B seismic hazard area. The facility is situated in a region of high seismic activity but low magnitude and intensity. Available records indicate that more than 1,100 earthquakes have occurred during the past 127 years. However, during the past century, only three have caused damage at Albuquerque. Intensities have been as high as a Modified Mercalli Intensity of VII. which can cause damage (DOE 1993a).

Possible geological concerns include potential ground shaking and rupturing associated with regional seismic activity and the two capable faults intersecting on the site. Statistical studies indicate that a nondamaging earthquake (Modified Mercalli Intensity less than III) may be expected every 2 years, with a damaging event every 100 years (DOE 1993a).

A maximum horizontal ground surface acceleration of 0.28g at Sandia National Laboratory is estimated to result from an earthquake that could occur once every 2000 years (DOE 1994a). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities should be evaluated on a facility specific basis consistent with DOE orders and standards and site specific procedures.

3.1.3.6.5 Air Resources—The climate at Sandia National Laboratories and in the surrounding region is characteristic of a semiarid steppe. The annual average temperature in the area is 56.2°F (13.4°C); temperatures vary from an average daily minimum of 22.3°F (-5.4°C) in January to an average daily maximum of 92.8°F (33.8°C) in July. The average annual precipitation is 8.1 inches (20.6 centimeters) (DOE 1993a).

3.1.3.6.6 Water Resources—Sandia National Laboratories are located within the Kirtland Air Force Base on the Albuquerque East Mesa. The mesa slopes gently southwest to the Rio Grande, the primary drainage channel for the area. The average flow of the Rio Grande is 1,008 cubic feet (28.5 cubic meters) per second. No perennial streams flow through the Sandia National Laboratories area. The two primary surface channels at Sandia National Laboratories are Tijeras Arroyo and the smaller Arroyo del Coyote. The Arroyo del Coyote joins the Tijeras Arroyo to discharge into the Rio Grande approximately 5 miles (8 kilometers) from the western edge of Kirtland Air Force Base. Both arroyos flow intermittently during spring snow melt or following thunderstorms. Springs in the eastern mountains provide a perennial flow in the upper reaches of Tijeras Arroyo. Most of this flow evaporates or percolates into the soil before reaching Kirtland Air Force Base (DOE 1993a).

High peak flows of short duration characterize floods in the area. High-intensity summer thunderstorms produce the greatest flows, but the probability of flooding is not considered high at Kirtland Air Force Base. The southeast corner of Technical Area IV and the east side of Technical Area II lie within the 500-year floodplain of Tijeras Arroyo (DOE 1993a).

Sandia National Laboratories lie within the north-south trending Albuquerque basin. The principal aquifer of the Albuquerque basin is the Valley Fill aquifer. The Valley Fill consists of unconsolidated and semiconsolidated sands, gravels, silts, and clays that vary in thickness from a few feet (meters) adjacent to the mountain ranges to over 21,000 feet (6,400 meters) at a point 5 miles (8 kilometers) southwest of Kirtland Air Force Base airfield. The Valley Fill aquifer is considered a Class IIa aquifer, having a current source of drinking water and waters with other beneficial uses. (DOE 1993a)

The regional water table is separated by a fault complex that divides the area into a deep region on the west side of the complex and a shallower region on the east side. The depth to groundwater ranges from 50 to 100 feet (15 to 30 meters) on the east side of the fault complex and from 380 to 500 feet (115 to 1150 meters) on the west side. Based on available data, the apparent direction of groundwater flow west of the fault complex is generally to the north and northwest. The direction of groundwater flow east of the fault complex typically is west toward the fault system (DOE 1993a).

3.1.3.6.7 Ecological Resources—Most undeveloped lands within Technical Areas I and III of Sandia National Laboratories support grassland vegetation. Terrestrial wildlife using grassland habitats on Sandia National Laboratories are typical of similar habitats in central New Mexico. The size and diversity of wildlife populations are thought to be limited by the poor availability of water. An inventory of wildlife species on Kirtland Air Force Base (including Sandia National Laboratories) has been recently updated (DOE 1993a).

No wetland inventories have been performed for Sandia National Laboratories, and no National Wetland Inventory maps have been published. Several springs exist on Kirtland Air Force base, including Sol se Mete Spring, Coyote Springs, and G Spring. These are associated with canyons and arroyos. No springs exist in Technical Areas I through V, and none are located within permitted land to which Sandia National Laboratories has access (DOE 1993a).

Potential aquatic habitat within Kirtland Air Force Base is limited to arroyos and canyons and the few springs associated with them. The nearest major perennial aquatic habitat is the Rio Grande, approximately 5 miles (8 kilometers) to the west (DOE 1993a).

No federally listed threatened or endangered species are known to occur on Sandia National Laboratories. The peregrine falcon (*Falco peregrinus*), a federally and state-listed endangered species, could potentially occur in the mountainous areas of Kirtland Air Force Base surrounding Sandia National Laboratories, but the likelihood is low because of the poor quality habitat for this species. The grama grass cactus (*Pediocactus papyracanthus*), a Federal Candidate Category 2 and state-listed endangered species, is known to occur in grasslands on Kirtland Air Force Base similar to those occurring on Sandia National Laboratories. The spotted bat (*Euderma maculatum*), also a Federal Category 2 and state-endangered species, has a low probability of occurrence on Sandia National Laboratories. Sandia National Laboratories lie within the breeding range of several Federal Candidate bird species (DOE 1993a).

3.1.3.6.8 Public Health and Safety—The annual dose to a maximally exposed individual due to release of gaseous radionuclides from laboratory operations from reports for a 5-year period is presented below (SNL 1993, 1992, 1991, 1990, 1989). The data are from all laboratory operations, including storage of SNF.

1988	0.00034 millirem
1989	0.00088 millirem
1990	0.0020 millirem
1991	0.0014 millirem
1992	0.0034 millirem

The estimated population dose to persons living within a 50-miles (80-kilometer) radius surrounding the laboratory due to release of gaseous radionuclides from laboratory operations from reports for a 5-year period is presented below (SNL 1993, 1992, 1991, 1990, 1989). The data are from all laboratory operations, including storage of SNF.

1988	0.039 person-rem
1989	0.097 person-rem
1990	0.82 person-rem
1991	0.052 person-rem
1992	0.020 person-rem

3.1.3.6.9 Waste Management— Low-level radioactive waste at Sandia National Laboratories is generated in both technical and remote test areas as a result of research and development activities. Most of the low-level radioactive waste consists of contaminated equipment and combustible decontamination materials and cleanup debris. All generated low-level radioactive waste is temporarily stored at generator sites or above ground in transportation containers at the Technical Area III disposal site. All low-level radioactive waste packages are currently onsite pending approval of transport by commercial carriers offsite for burial (DOE 1993a).

Mixed wastes include radioactively contaminated oils and solvents and radioactively contaminated or activated lead or other heavy metals. Other mixed wastes may be generated as a result of weapons tests (DOE 1993a).

3.1.4 Argonne National Laboratory - East

The Argonne National Laboratory - East stores reactor irradiated nuclear materials in the Alpha-Gamma Hot Cell (Building 212, Wing F), the Chicago Pile 5 Building, and analytical laboratories within Building 205. The principal mission (past and present) of the Alpha-Gamma Hot Cell is research on the behavior of materials, fuel, and structures used in nuclear reactors. Chicago Pile 5 houses a shut-down, heavy-water, moderated reactor whose fuel has been removed and shipped offsite. Currently Chicago Pile 5 is in the process of being decontaminated and decommissioned and contains only two highly enriched uranium target (i.e., converter) elements. Building 205 contains analytical laboratories that perform analyses on gram quantities of SNF samples coming from the Alpha-Gamma Hot Cell (DOE 1993b).

3.1.4.1 Land Use. The laboratory and support facilities occupy about a 200-acre (81-hectare) tract; 1,700 acres (688 hectares) within the site perimeter are devoted to forest and landscaped areas. The Dupage County Forest Preserve District operates 2,040-acre (826-hectare) green belt forest preserve, known as the Waterfall Glen Forest Preserve, which surrounds the site. Much of this forest preserve was formerly Argonne National Laboratory property but was deeded to the Forest Preserve District in 1973 for use as a public recreation area, nature preserve, and demonstration forest. In the past few years, a number of industrial parks have been constructed to the north and northwest of the laboratory. Also, many commercial establishments and a large number of dwelling units have been constructed within a few miles (kilometers) of Argonne National Laboratory. Before being occupied by Argonne National Laboratory, most of the site was wooded and the remaining land was used for farming (ANL-E 1993a).

3.1.4.2 Socioeconomics. Argonne National Laboratory is located within the Chicago Standard Metropolitan Statistical Area, which comprises six Illinois and two Indiana counties around the southwest corner of Lake Michigan. The population between 1970 and 1990 in the region increased 1.2 percent from 6,491,300 to 6,568,800 people. During this time total Illinois population increased 2.9 percent. Data sources for this information include U.S. Bureau of the Census, Bureau of Economic Analysis, and Department of Energy documents (DOC 1992).

The nearby areas of Will and Cook Counties have generally developed at a considerably lower rate than has the DuPage County area, except along the Illinois Waterway where industrial development has taken place. Included within a 50-mile (80-kilometer) radius are portions of Lake and Porter Counties in Indiana, and all of DuPage, Will, Cook, Kendall, and Kane Counties in Illinois (DOC 1992).

Beyond the forest preserve at Argonne National Laboratory's perimeter, the population density is low, except for a high-density residential area--over 15 units per acre (37 units per hectare) and about 4,500 residents--beginning some 650 yards (600 meters) east of the perimeter. DuPage County's growth rate has been the highest of any metropolitan Illinois county. In 1990, the total number of housing units within region equaled 2,548,736. Cook County contained the largest percentage of the region's housing units (DOC 1991b).

With its workforce of about 4,700 persons, Argonne National Laboratory is one of the three largest employers in DuPage County. Employees commute to Argonne National Laboratory from distances as far as 30 miles (50 kilometers); thus the payroll is spread over a wide area. However, nearby villages, notably Lemont and Downers Grove, do house high numbers of Argonne National Laboratory employees. About 50 percent of Argonne National Laboratory employees reside within 10 miles (16 kilometers) of the site. The laboratory also purchases much of its utilities, outside services, equipment, and supplies locally (DOC 1992).

Employment associated with SNF management such as routine operations of the facility including care and periodic inventories of the SNF amounts to about 0.5 person-years per year (Neimark 1995).

3.1.4.3 Cultural Resources. The ANL-E site has no properties designated as National Historic Landmarks or listed on the National Register of Historic Places.

In 1992, 26 archaeological properties had been recorded at ANL-E. One site has been evaluated as being potentially eligible for the National Register, 19 sites are not considered eligible, and 6 sites have not been evaluated (ANL-E 1993a).

The Illinois State Historic Preservation Agency has not evaluated the ANL-E site's potential to contain additional unidentified archaeological or architectural resources. The potential of the ANL-E site to contain traditional cultural resources of interest to Native American groups has not been evaluated (ANL-E 1993a).

3.1.4.4 Geology. The topography at ANL-E is generally gently rolling; the average elevation is 725 feet (221 meters) above sea level. Slopes of consequence are found only adjacent to streams and near the southern edge of the site, where the fall into the Des Plaines

River Valley begins (ANL-E 1993b). The geology of the Argonne National Laboratory area consists of about a 100-foot-thick (30-meter-thick) deposit of glacial till on top of dolomite bedrock. The bedrock at Argonne National Laboratory is the Niagaran and Alexandrian dolomite of Silurian age (about 400 million years old). These formations are underlain by Maquoketa shale of Ordovician age, and older dolomites and sandstones of Ordovician and Cambrian age. The beds are nearly horizontal (ANL-E 1993b).

The Niagaran and Alexandrian dolomite are about 200 feet (60 meters) thick in the Argonne National Laboratory area, and are widely used in DuPage County as a source of groundwater. The Maquoketa shale separates the upper dolomite aquifer from the underlying sandstone and dolomite aquifers. This shale retards hydraulic connection between the upper and lower aquifers; the lower aquifer has a much lower piezometric level and does not appear to be affected by pumpage from the overlying Silurian bedrock (ANL-E 1993a).

A capable fault is one that has had movement at, or near, the ground surface at least once within the past 35,000 years or recurring movement within the past 500,000 years (10 CFR 100, Appendix A). A few minor earthquakes have occurred in northern Illinois, believed to have been caused by isostatic adjustments of the Earth's crust in response to glacial unloading. Several areas of seismic activity are present at moderate distances from ANL-E, including the New Madrid Fault zone in the St. Louis area of southwestern Missouri, the Wabash Valley Fault zone along the southern Illinois-Indiana border, and the Anna region of western Ohio. Ground motions induced by near and distance seismic sources are expected to be minimal at the Laboratory (ANL-E 1993a).

A maximum horizontal ground surface acceleration of 0.15g at Argonne National Laboratory - East is estimated to result from an earthquake that could occur once every 2000 years (DOE 1994a). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities should be evaluated on a facility specific basis consistent with DOE orders and standards and site specific procedures.

No active volcanoes are considered to be in the ANL-E region (Keller 1979). Therefore, the potential for damage from volcanic activity is minimal.

The major soil type present at ANL-E is Morley silt loam. This soil covers approximately 70 percent of the site. Stream valley soils, including the Askum, Peotone, and Sawmill silty clay loams, cover approximately 15 percent of the site, urban land soils approximately 10 percent, and other minor soils the remaining 5 percent (Mapes 1979).

3.1.4.5 Air Resources. The regional climate around Argonne National Laboratory is characterized as being continental, with relatively cold winters and hot summers. The area is subject to frequently changing weather as storm systems move from the Great Plains toward the east. The weather is slightly modified by Lake Michigan, which is about 22 miles (35 kilometers) east-northeast of the Laboratory (ANL-E 1993a).

Meteorological data presented here were compiled from the National Weather Service Station at the O'Hare International Airport in Chicago and from the meteorological tower operated at ANL-E. The prevailing winds for the airport are from the south and southwest with a northeast component. The frequency of calm winds, defined as those less than 2 miles per hour (1 meter per second), was approximately 4 percent. The 1992 average wind rose for the ANL-E site is very similar to this pattern, with prevailing winds from the west to south, but with a more significant northeast component. In 1992, the percentage of calm winds at ANL-E was approximately 3 percent (ANL-E 1993a).

The amount of rainfall recorded in 1992, 31.5 inches (80.01 centimeters), was nearly identical to the site's historical average of 31.48 inches (79.95 centimeter). The temperatures recorded during 1992 were also similar to the site's long-term averages. The coldest months during 1992 were January and December, with monthly averages of 27.9°F (-2.3°C) and 28.0°F (-2.2°C), respectively. The warmest months were July and August, with monthly averages of 68.5°F (20.3°C) and 66.9°F (19.4°C), respectively (ANL-E 1993a).

The area experiences about 40 thunderstorms annually. Occasionally, these storms are accompanied by hail, damaging winds, or tornadoes. From 1957 to 1969 there were 371 tornadoes in the state, with more than 65 percent occurring in the spring months. The theoretical probability of a tornado strike at Argonne is 8.54 x 10^{-4} each year, or a recurrence interval of 1 tornado every 1,200 years. The Argonne National Laboratory site was struck by tornadoes in 1976 and 1978, with minor damage to power lines, roofs, and trees.

The State of Illinois has adopted ambient air quality standards that specify maximum permissible short- and long-term concentrations of various contaminants (State of Illinois Rules and Regulations 1992). These standards are the same as the National Ambient Air Quality Standards for criteria pollutants (NAAQS; 40 CFR 50). In addition to standards for criteria pollutants, the Illinois Environmental Protection Agency has made applicable all regulations promulgated by the EPA relating to National Emission Standards for Hazardous Air Pollutants (NESHAP), under Section 112 of the Clean Air Act (40 USC 7412, 7601a).

The ANL-E site and the surrounding counties are classified by the EPA as severe nonattainment areas for the criteria pollutant ozone (O_3). All other surrounding counties and areas are in attainment of the remaining National Ambient Air Quality Standards criteria pollutants: nitrogen dioxide (NO_2), sodium dioxide (SO_2), lead (Pb), particulate matter less than 10 microns in diameter (PM_{10}) and carbon monoxide (CO) (with the exception of the Lyons Township in southeast Chicago, which is listed as a moderate nonattainment area for PM_{10}) (ANL-E 1993b).

3.1.4.6 Water Resources.

Surface Water - The ANL-E is in the Des Plaines River drainage basin 24 miles (39 kilometers) west of Lake Michigan and is on the northern margin of the Des Plaines River valley. The largest onsite stream is Sawmill Creek, which originates north of the site and enters the Des Plaines River about 1.25 miles (2.01 kilometers) southeast from the center of the site. Two small streams originate onsite and combine to form Freund Brook, which discharges into a Sawmill Creek. Most of ANL-E is drained by Freund Brook. The Des Plaines River flows southwest about 30 miles (48 kilometers) until it joins with the Kankakee River to form the Illinois River (ANL-E 1993a). As noted in *National Wild and Scenic Rivers System, December 1992* (USGS, 1992) the ANL-E region has no federally designated wild and scenic rivers.

Flow in Sawmill Creek, upstream from the ANL-E wastewater outfall, averaged 6.3 cubic feet (0.18 cubic meters) per second in 1992. Flow in the Des Plaines River near the site is approximately 900 feet^3 (25.5 meters) per second (ANL-E, 1991). In addition, ANL-E facilities are not in the 500-year floodplain. The floodplain areas are largely confined to areas within 200 feet (61 meters) of the surface streams (ANL-E 1993a).

The potable and site water supplies are obtained from groundwater (ANL-E 1993b). The first downstream location where surface water is used for drinking is at Alton, on the Mississippi River, about 370 miles (595 kilometers) from ANL-E. The first downstream location where surface water is used for drinking is at Alton, on the Mississippi River, about 370 miles (595 kilometers) from ANL-E (ANL-E 1993b).

The ANL-E has nine National Pollutant Discharge Elimination System permitted outfalls, most of which discharge directly or indirectly to Sawmill Creek (ANL-E 1991).

In addition to this outfall monitoring, surface water bodies in the region are routinely monitored for radioactive and nonradioactive parameters. In 1990, measurable levels of americium-241, californium-249, californium-252, cesium-137, curium-242, curium-244, neptunium-237, plutonium-238, plutonium-239, strontium-90, and tritium were detected in Sawmill Creek downstream from the only small fraction of the DOE-derived concentration guides for water (DOE Order 5400.5). Dilution in the Des Plaines River reduced the concentration of the measured radionuclides to levels below their respective detection limits. Streams sediments in the ANL-E region are routinely sampled for radionuclides at 3 onsite and 10 offsite locations. These samples are not routinely analyzed for chemical constituents (ANL-E 1991).

Groundwater - The ANL-E vicinity uses two principal aquifers for its water supply. The upper aquifer is the Niagara and Alexandria dolomite, which is about 200 feet (61 meters) thick in the region and has a potentiometric surface between 500 and 100 feet (152 and 30 meters) below ground (ANL-E 1993b). Water flows through this unit in a southern direction (ANL-E 1991). No aquifers in the region are considered sole source aquifers under the Safe Drinking Water Act regulations (EPA 1994).

The ANL-E receives its potable water supply from four wells in the Niagara dolomite aquifer. These wells are approximately 300 feet (91 meters) deep and provide hard water that requires treatment before use (ANL-E 1993b). Treated sanitary and laboratory wastewater from ANL-E are combined and discharged into Sawmill Creek. This effluent averaged 0.83 million gallons (3.1 million liters) per day (ANL-E 1993a).

Groundwater is monitored for radioactive and nonradioactive parameters at 32 ANL-E locations. Groundwater in the four onsite drinking water wells is also monitored for radioactive and nonradioactive parameters, as required by the Safe Drinking Water Act. In 1990, all results were less than the limits established by the Safe Drinking Water Act except for elevated levels of total dissolved solids and turbidity. The average concentration of tritium was approximately 1 percent of the EPA Primary Drinking Water Standard of 20,000 picocuries per liter. One well was removed from service in 1990 (ANL-E 1991).

3.1.4.7 Ecological Resources. The Argonne National Laboratory site lies within the Prairie Peninsula Section of the Oak-Hickory Forest Region. The Prairie Peninsula is a mosaic of oak forest, oak openings, and tall-grass prairie occurring on glaciated parts of Illinois, northwest Indiana, southern Wisconsin, and parts of other states. Forests in the Argone National Laboratory-East region are predominantly oak hickory. Other forested areas consist of sugar maple, red oak, and basswood (ANL-E 1993a).

The mixture of vegetational communities (open fields, deciduous forests, pine plantations, wetlands, and mowed rights-of-way), coupled with a large degree of protection from human intrusion, makes the Argonne National Laboratory site an effective refuge for many species of animals. These animals are characteristically found in open fields, forests, and forest-edge communities in the Midwest. Also other bird species use the Argonne National Laboratory site as a stopover during spring and fall migrations. By far, the most numerous animals on the site are the small invertebrates (ANL-E 1993b).

The site is inhabited by fallow deer, (*Dama dama*), eastern cottontail rabbit, opossum, raccoon and squirrels. Although fallow deer have several color varieties, only the white variety occurs at Argonne. Invertebrate fauna consist primarily of dipteran larvae, crayfish, caddisfly larvae, and midge larvae. Few fish are present due to the low summer flows and high temperatures. Wetlands include a cattail marsh and wooded swamp habitat (ANL-E 1993b).

An opinion rendered by the U.S. Fish and Wildlife Service indicated that the only federally listed endangered or threatened vertebrate species likely to be present in the vicinity of the Argonne National Laboratory site is the Indiana bat (*Miotis sodalis*). An unconfirmed capture of an Indiana bat in nearby waterfall Glen Forest Preserves indicates that the bat may occur on the ANL-E site. In addition, a September 1980 updated of the "Red Book" for the North-Central Region lists the federally endangered bald eagle (*Haliaeetus leucocephalus*) as wintering in nearby Will County. Both American and Arctic subspecies of the peregrine falcon (*Falco peregrinus anatum* and *F. p. tundrius*) and Kirtland's warbler (*Dendroica kirtlandii*) migrate through northeastern Illinois and thus might occasionally be found on or near the Argonne National Laboratory site. All three of these bird taxa are on the Federal endangered species list (ANL-E 1993b).

At least two plant species proposed for Federal endangered/threatened designation are known to occur in counties near the Argonne National Laboratory site and therefore might be present here. These are *Thismia americana*, found on wet prairies in Cook County; and *Plantago cordata*, a plant of wet woodlands recorded in Will County (ANL-E 1993b).

3.1.4.8 Public Health and Safety. The highest annual dose received by an offsite resident from a combination of the separate airborne and direct exposure pathways from the most recent reports for a 5-year period is presented below (ANL-E 1993a, 1992, 1991, 1990, 1989). The annual doses are only a fraction of the DOE Public Dose Limit of 100 millirem per year. The data are from all laboratory operations, including storage of SNF.

1988	0.66 millirem
1989	0.49 millirem
1990	0.41 millirem
1991	0.29 millirem
1992	0.34 millirem

The total annual population dose to the entire area within a 50-mile (80-kilometer) radius of the laboratory for a 5-year period is presented below (ANL-E 1993a, 1992, 1991, 1990, 1989). The data are from all laboratory operations, including storage of SNF.

1988	25 person-rem
1989	17 person-rem
1990	15 person-rem
1991	15 person-rem
1992	17 person-rem

3.1.4.9 Waste Management. Activities conducted at ANL-E generate a variety of radioactive and hazardous waste streams (DOE 1994b).

The ANL-E reports 10 mixed waste streams in the inventory of operations waste. Of these, eight are low-level mixed waste streams and two are mixed transuranic waste streams. The ANL-E currently stores about 2.5 cubic yards (1.9 cubic meters) of mixed transuranic waste and projects that 2.1 yards^3 (1.6 meters^3) of additional transuranic wastes will be generated through the end of 1997. This waste will be processed as necessary (characterized, repackaged, immobilized) to meet the waste acceptance criteria of the Waste Isolation Pilot Plant (DOE 1993e).

The ANL-E has no facilities for treating low-level mixed waste and transuranic waste. ANL-E currently stores about 125 cubic yards (96 meters^3) of low-level transuranic waste, which includes low-level waste and transuranic waste reclassified as low-level transuranic waste. Roughly 30 meters^3 (39 cubic yards) of low-level transuranic waste are projected to be generated through the end of 1997 (DOE 1993e).

Two major, unused facilities at ANL-E are undergoing environmental restoration. The Laboratory expects to complete removal of the Experimental Boiling Water Reactor vessel by the end of Fiscal Year 1995 and to complete the conversion of the CP-5 reactor building to an interim safe storage condition during Fiscal Year 1994 (DOE 1993f).

3.2 Domestic Research Reactors

The environments of domestic research reactors that may be affected by SNF activities are described in this section. Representative environments of sites generating and storing SNF are described as a basis for assessing the 57 reactor sites identified in Subsection 2.1.2. This approach was selected to permit enveloping the characteristics of the large number of sites covered. Additionally, it is recognized that the programmatic SNF analyses in this EIS are not intended to be site specific. Site-specific environmental information has already been presented to the NRC and analyzed as part of the facility licensing process.

Domestic research reactors are located in a wide variety of environmental settings, ranging from relatively densely populated urban areas to rural/semirural university campuses and industrial parks. To provide reasonably representative descriptions of potentially affected environments for these diverse installations, environmental information has been provided for 5 of the 11 Category 1 reactor sites. These five reactor sites encompass the diverse range of reactor types and power level as well as diverse environmental setting.

As reported in 1988, there were a total of 268 personnel working at the 11 Category 1 reactors (ANS 1988). This number included operators, experimenting scientists, and support personnel. While not their main occupation, part of the duties of the operators and some support personnel include tasks associated with refueling, storing, inventorying, packaging, and shipping SNF.

Environmental information is provided for those facilities whose ability to store SNF is limited when compared to their fuel burnup rate. For those operating facilities possessing adequate storage for their SNF, projected to be generated through 2035, there would be no incremental impacts on the surrounding environment. Accordingly, no environmental analyses have been performed and no information is provided in this section.

The environmental information for each of these reactors has been presented as part of their license applications to the NRC and has been assessed by that agency as part of the licensing process for each facility. The environmental impacts of expanded storage of SNF at these facilities are expected to be minimal (although other effects on the institutions themselves may be extensive). Information on environmental factors that are not affected by the activities of storing SNF at these sites (including cultural resources, aesthetic and scenic resources, ecological resources, noise, traffic and transportation, utilities and energy, materials and waste management) is not provided in this document.

Data on the calculated doses to the general public resulting from effluents from NRC licensed research reactors is not available, since their license and reporting requirements were not the same as those for DOE facilities. At the time of the reports (1987-1993), the effluent release limits in 10 CFR 20 (specified as maximum permissible concentrations) were based on a dose limit of 500 millirem per year to a hypothetical member of the public. The conservative assumptions made in calculating the 10 CFR 20 concentration limits were that the person only drank the water and breathed the air released from the licensed facility. The licensed research reactors proved to the NRC that the dose limit of 500 millirem per year for the general public was being met by maintaining the release concentrations at the site boundary below the maximum permissible concentration limits specified in 10 CFR 20. In reality, the actual dose received by any member of the public was well below the prescribed limit of 500 millirem per year because 1) no individual drinks the water discharged in the sewer systems from these facilities, 2) no individual stands at the closest downwind location for 24 hours a day, 365 days a year, and 3) the radioactivity concentrations at the site boundary are well below the concentration limits.

As of 1993, licensed research reactors are required to meet the dose limits specified by the EPA in 40 CFR 61 of 10 millirem per year to the maximum exposed individual from airborne effluents. In addition, as of 1994, the licensed research reactors are required to comply with the new 10 CFR 20, in which exposure to any member of the public from all pathways is limited to 100 millirem per year.

3.2.1 National Institute of Standards and Technology Research Reactor

The National Institute of Standards and Technology research reactor, formerly known as the National Bureau of Standards Reactor, is a highly enriched, heavy-water-cooled and moderated vessel-type reactor. The National Institute of Standards and Technology reactor received an Atomic Energy Commission provisional license in 1967 to operate at 10 MW. On May 16, 1984, the NRC upgraded the National Institute of Standards and Technology research reactor license to operate for 20 years at up to 20 MW (NRC 1983).

The spent fuel storage pool, located in the basement of the confinement building, is used to store spent fuel under filtered, demineralized water until the fuel is shipped offsite. A spent-fuel storage pool cooling system is installed to dissipate the decay heat from elements stored in the pool. Storage racks are provided to store both full fuel elements and cut fuel pieces in a defined geometry. Boral or stainless steel spacers are placed between elements as required to control criticality. The storage rack arrangement ensures that the fuel in the pool remains subcritical (NRC 1983).

The National Institute of Standards and Technology site is a 576-acre tract of land in upper Montgomery County, Maryland, approximately 1 mile (1.6 kilometers) southwest of the City of Gaithersburg, Maryland. According to the 1990 census, the population of Gaithersburg was 39,542 (Rand 1992). The general area is a combination of residential and rural. The nearest population centers are Gaithersburg, adjacent to the site, and Rockville, 5 miles (8 kilometers) southeast of the site. The National Institute of Standards and Technology site is located approximately 20 miles (32 kilometers) northwest of the center of the District of Columbia. The National Institute of Standards and Technology campus is bounded on the east by a major interstate highway (I-270), on the north and west by Maryland Route 124, and on the southeast by Muddy Branch Road. The area adjacent to the reactor building is occupied by a parking lot, the reactor cooling tower, and roads. Thus, the area within a 500-foot (152-meter) radius of the reactor building stack is not readily available for the construction of new buildings, and planning for future development of the National Institute of Standards and Technology site does not include any new buildings within 500 feet (152 meters) of the reactor stack. The site boundary nearest to the National Institute of Standards and Technology reactor is approximately 0.25 mile (0.4 kilometer) southwest of the reactor. The nearest offsite residential or commercial housing is about 1,500 feet (457 meters) to the southeast of the reactor (NRC 1983).

During the period 1955-1967, 28 tornadoes were reported in a 2 degree latitude-longitude square containing the site. The computed recurrence interval for a tornado at the National Institute of Standards and Technology site is about 2000 years. Numerous tropical storms, tornadoes and hurricanes have affected the area. In the period from 1871 to 1978, about 20 tornadoes or hurricanes have passed within 100 miles (160 kilometers) of the site (NRC 1983).

There is no known major fault in the site vicinity (Seismic Zone 1). There is no known relationship between mapped faults and the moderate seismicity in the region. The maximum potential earthquake for the area was estimated to result in a maximum ground acceleration of 0.07 g at the reactor site. The effects of stresses developed by 0.1 g earthquake loadings have been evaluated, and it was demonstrated that the confinement building and reactor equipment would remain intact and maintain their capability (NRC 1983).

A summary of the radioactive material released in airborne and liquid effluents from the National Institute of Standards and Technology from the most recent reports for a 5-year period is presented below (NIST 1993, 1992, 1991, 1990, 1989).

Year	Airborne effluents		Liquid effluents into sanitary sewer	
	Argon-41	Tritium	Tritium	Other beta-gamma emitters
1988	900 Ci	393 Ci	5.1 Ci	0.0026 Ci
1989	328 Ci	461 Ci	2.9 Ci	0.0039 Ci
1990	687 Ci	309 Ci	2.2 Ci	0.0011 Ci
1991	971 Ci	251 Ci	1.8 Ci	0.0016 Ci
1992	665 Ci	351 Ci	1.5 Ci	0.0004 Ci

3.2.2 Massachusetts Institute of Technology Research Reactor

The Massachusetts Institute of Technology Reactor is a tank-type, light-water cooled and moderated, heavy-water reflected, plate fuel, research and training reactor. The Massachusetts Institute of Technology Reactor received its 5 MW operating license June 9, 1958 and originally was designed to have a heavy-water moderated and cooled core utilizing curved plate-type fuel elements, highly enriched in uranium-235. The major revision of the core design occurred in 1970 (MIT 1981, 1970).

The reactor building is a steel, gas-tight, 70-foot (21.3-meter) internal diameter, 50-foot (15.2-meter) high, domed right cylinder with 2-foot (0.6-meter) thick concrete shielding walls on the inside. The reactor building basement contains an 8-foot (2.4-meter) diameter, 20-foot-deep (6-meter-deep) spent fuel storage tank of demineralized water. The containment building has an air conditioning and multiple filter ventilation system which exhausts to a 150-foot (46-meter) stack.

Irradiated fuel elements can be stored in any of the following locations:

a) In the reactor core

b) In the cadmium-lined fuel storage ring (holds 27 SNF elements) attached to the flow shroud, or briefly in a three-element rack in the core tank used during transfers of spent fuel out of the core tank

c) In 22 steel-lined dry storage holes, 5 inches (13 centimeters) in diameter, on the reactor top biological shield

d) In the spent fuel storage tank in the basement of the reactor building

e) In the fuel element transfer flask or other proper shield within the controlled area.

The Massachusetts Institute of Technology Reactor is located a few blocks northwest of the main Massachusetts Institute of Technology campus in Cambridge, Massachusetts and less than 2,000 feet (610 meters) from the Charles River, which separates Cambridge from Boston. According to the 1990 census, Cambridge had a population of 95,802 (Rand 1992). The MIT Reactor is located in the midst of a heavily industrialized section of Cambridge. The site measures approximately 280 feet in length by 150 feet in width (85 meters by 46 meters). Boston and Albany Railroad tracks, used exclusively for freight traffic, run parallel to the back of the reactor exclusion area. Although the site boundary comes nearest to the reactor on the side facing the railroad tracks, the closest point of normal public occupancy near the site boundary is on the Albany Street side at approximately 120 feet (37 meters). (MIT 1970)

The Massachusetts Institute of Technology Meteorology Department has stated that conditions for the reactor site should vary only slightly from those at Logan Airport in east Boston. The area atmospheric conditions vary from highly stable situations with light winds to unstable periods with strong winds in excess of 47 miles (75.6 kilometers) per hour. Water drainage from the reactor site is into the Charles River and on into Boston Harbor and Massachusetts Bay. The drainage in this section of Cambridge is such that after a record-breaking 20 inches (0.5 meter) of rain fell in 48 hours, the Charles River did not overflow its banks, nor was the area inundated (MIT 1970).

The Cambridge area lies in the Boston Basin which has been relatively free of earthquakes in the past 150 years but had several earthquakes in the preceding centuries. The region is located in Seismic Zone 2. The most severe shock with a probable epicenter near Cambridge occurred in 1755 with a Rossi-Forel intensity of 9 (equivalent to Modified Mercalli Intensity IX or X). Partial or total destruction of some buildings occurred. Since 1817, no earthquake with a Rossi-Forel intensity of more than 5 (equivalent to Modified Mercalli Intensity VI) has been reported near Boston (MIT 1970).

A summary of the radioactive material released in airborne and liquid effluents from the Massachusetts Institute of Technology Research Reactor from the most recent reports for a 5-year period is presented below (MIT 1992, 1991, 1990, 1989, 1988). Liquid radioactive wastes generated at the Massachusetts Institute of Technology Research Reactor facility are discharged only to the sanitary sewer serving the facility. All releases were in accordance with Technical Specifications 3.8-1 and 10 CFR 20. All activities were substantially below the limits specified in 10 CFR 20.303. Gaseous radioactivity is discharged to the atmosphere from the containment building exhaust stack. All gaseous releases were in accordance with the Technical Specifications and all nuclides were below the limits of 10 CFR 20. The information is reported by fiscal year, from July 1 of the previous year to June 30 of the current year.

Year	Airborne effluents	Liquid effluents into sanitary sewer	
	Argon-41	Tritium	Other beta-gamma emitters
1988	2627 Ci	0.071 Ci	0.0011 Ci
1989	1529 Ci	0.107 Ci	0.0034 Ci
1990	543 Ci	0.059 Ci	0.0220 Ci
1991	684 Ci	0.115 Ci	0.0071 Ci
1992	728 Ci	0.023 Ci	0.0137 Ci

3.2.3 University of Missouri/Columbia Research Reactor

The University of Missouri/Columbia Research Reactor is a 10 MW tank in pool light water moderated and cooled research reactor. The reactor uses plate-type fuel containing 93 percent enriched uranium-235. The core forms an annular fuel region which is pressurized and cooled by forced convection. The University of Missouri/Columbia Research Reactor received its operating license October 11, 1966 and initially operated at 5 MW. The reactor power was increased to 10 MW in 1974 (UMC 1965; NRC 1991b).

The reactor is housed in a five-level, poured-concrete, gas-tight containment building which is in the center of the Research Reactor Facility, a one-level building of poured-concrete, block and brick construction. The reactor vessel is located eccentrically within an open pool 10 feet (3 meters) in diameter and 30 feet (9 meters) deep. Permanent SNF storage is provided within the biological shield, in a pool separated from the reactor by a massive submerged concrete weir (UMC 1965).

The University of Missouri/Columbia Research Reactor currently has 44 fuel elements in the core, 20 SNF elements in wet storage and none in dry storage. Without offsite shipment of SNF, the University of Missouri/Columbia Research Reactor's storage capacity of 120 elements would be filled by June 1996. Before this could occur, NRC approval would be required to raise the reactor's uranium-235 possession limit above 165 pounds (75 kilograms). Increased SNF storage capacity could be achieved by reracking and building a new wet-storage area within the reactor building. However, there are no plans to expand the current SNF storage capacity (Jentz 1993).

The University of Missouri/Columbia Research Reactor Facility is located within the 85-acre (0.344-square-kilometer) Research Park about 1 mile (1.6 kilometers) southwest of the main campus of the University of Missouri, south of the main business district of the city of Columbia, Boone County, Missouri. According to the 1990 census, the population of Columbia was 69,101 (Rand 1992). The nearest permanent residence is approximately 1,000 feet (305 meters) from the reactor. There are a number of small industrial activities in the area, but for the county, agriculture is the leading activity.

Wind speeds up to 50 miles (80 kilometers) per hour are not uncommon at Columbia. Ninety-four-mile-per-hour (151-kilometer-per-hour) winds have an average recurrence interval of 100 years; winds of 105 miles (169 kilometers) per hour have an average recurrence interval of 200 years. The frequency of tornadoes is so low that it is difficult to estimate the probability of the event. In most of the Midwest, there are an average 2.5 tornadoes per year in a 10,000 square-mile (25,900-square-kilometer) area. Surface drainage from the site moves south to enter Hinkson Creek, which drains to Perche Creek and then to the Missouri River (UMC 1961).

Columbia's position within the stable area of Missouri (Seismic Zone 1) and the seismic history of the area indicate that the probability of seismic damage to the area is extremely low.

A summary of the radioactive material released in airborne and liquid effluents from the University of Missouri/Columbia Research Reactor from the most recent reports for a 5-year period is presented below (UMC 1992, 1991, 1990, 1989, 1988). The information is reported by fiscal year, from July 1 of the previous year to June 30 of the current year.

Year	Airborne effluents		Liquid effluents into sanitary sewer	
	Argon-41	Tritium	Tritium	Other beta-gamma emitters
1988	813 Ci	14.5 Ci	0.077 Ci	0.0080 Ci
1989	920 Ci	2.8 Ci	0.0352 Ci	0.0085 Ci
1990	590 Ci	2.3 Ci	0.555 Ci	0.0385 Ci
1991	520 Ci	15.0 Ci	0.1600 Ci	0.0250 Ci
1992	440 Ci	0.73 Ci	0.2094 Ci	0.0488 Ci

3.2.4 University of Michigan Ford Nuclear Reactor

The University of Michigan's Ford Nuclear Reactor is a pool-type heterogeneous 2-megawatt-thermal reactor that is light-water cooled and moderated. The Ford Nuclear Reactor has been operated since 1957 and received a 20-year license renewal from the NRC on July 29, 1985 (NRC 1985c). Its principal function is for teaching, research, activation, and experiments (NRC 1985d).

The reactor is located in a windowless, four-story reinforced concrete building that is approximately a 70-foot (21.3-meter) cube. The reactor room, designed to restrict leakage, is equipped with its own ventilation system and exhaust stack (NRC 1985d).

The Ford Nuclear Reactor site situated on the North Campus, which is about 1.75 miles (2.8 kilometers) northeast of the old University of Michigan campus. The North Campus is a tract of nearly 900 acres (3.64 square kilometers), approximately 1.5 miles (2.4 kilometers) northeast of the center of Ann Arbor. According to the 1990 census, the population of the city of Ann Arbor was 109,592 (Rand 1992). The University of Michigan controls all the land within 1500 feet (457 meters) of the reactor site, with the exception of a small portion of the highway right-of-way along Glacier Way to the southeast and the Arborcrest Cemetery, located 800 feet

(244 meters) to the east of the site. The reactor exclusion area consists of all the land 500 feet (152 meters) to the east, 1000 feet (305 meters) to the west and north, and 1200 feet (366 meters) to the south (NRC 1985d).

The reactor building and the contiguous Phoenix Memorial Laboratory are located near the center of the North Campus area. The following guidelines were used by the university in developing the North Campus area: (1) only laboratory and research buildings will be constructed within 50 feet (15 meters) of the reactor and (2) no housing or other buildings containing housing facilities will be erected within 1500 feet (457 meters) of the reactor. Therefore, all buildings, except the reactor and laboratory buildings, are generally occupied during normal school hours only. The closest permanent residences are about 1500 feet (457 meters) from the Ford Nuclear Reactor facility (NRC 1985d).

The heaviest rainfall intensity occurs in connection with thundershower activity, and the heaviest recorded 24-hour period of rainfall was approximately 5 inches (13 centimeters). Hourly intensities as high as 1.2 inches (3 centimeters). occur with a frequency of once every 2 years. Average annual snowfall is 30.2 inches (76.7 centimeters.). Annual totals have ranged from 13 to 54 inches (33 to 137 centimeters). The heaviest recorded snowfall for a single day was 6.2 inches (15.7 centimeters). The highest wind velocity recorded in the Ann Arbor area was 60 miles per hour (27 meters per second). Michigan lies at the northeastern edge of the nation's maximum frequency belt for tornadoes. For the past decade, Michigan has averaged nine tornadoes per year, 90 percent of which have been in the southern half of the lower peninsula (NRC 1985d).

The University of Michigan Ann Arbor site, within the Central Stable Region, is characterized by a relatively low level of seismic activity (Seismic Zone 1). Recent interpretations of geophysical investigations suggest that different areas of the Central Stable Region exhibit different levels of seismic activity. For instance, Barstow et al. developed an earthquake frequency map for the eastern United States that places Ann Arbor in a zone where 8-15 earthquakes per 4500 square miles (11,660 square kilometers), with Modified Mercalli Intensities of III or greater, have occurred during the time period 1800-1977. The Anna, Ohio, location experienced a frequency of 32-63 earthquakes per 4500 square miles (11,660 square kilometers) with Modified Mercalli Intensity III or greater for the same time period. The

Michigan Basin area, in general, is considered to have had no more than 0-3 earthquakes per 4,500 square miles (11,660 square kilometers) of Modified Mercalli Intensity III or greater. A seismicity map developed by the Geological Survey of the State of Michigan shows that for the time period from 1872-1967, only 34 earthquakes were felt (reported) in the entire State of Michigan. A U.S. Geological Survey seismicity map of the State of Michigan shows a total of 83 earthquakes in the state since 1872. The nearest of these to Ann Arbor (March 13, 1978; Modified Mercalli Intensity IV) was about 30 miles (48 kilometers) away. Only six earthquakes have been reported within 60 miles (96 kilometers) of Ann Arbor. The risk of damage from earthquakes to well-designed structures is relatively low for the Ann Arbor area. In addition, the earthquake intensity/magnitude potential is relatively low for the Michigan region, and there are no known structures in the Ann Arbor area capable of causing earthquakes (NRC 1985d).

A summary of the radioactive material released in airborne and liquid effluents from the Ford Nuclear Reactor from the most recent reports for a 5-year period is presented below (UMI 1994, 1993, 1992, 1991, 1990).

Year	Airborne effluents	Liquid effluents into sanitary sewer	
	Argon-41	Tritium	Other beta-gamma emitters
1989	31 Ci	0.051 Ci	0.18 Ci
1990	35 Ci	0.069 Ci	0.48 Ci
1991	41 Ci	0.079 Ci	0.11 Ci
1992	39 Ci	No discharges	
1993	39 Ci	No discharges	

3.2.5 University of Texas TRIGA

The University of Texas General Atomic TRIGA Mk-II Reactor replaces an earlier TRIGA Mk-I reactor which had been in operation on the main campus in Austin, Texas since 1963. The TRIGA Mk-II is a 1.1 MW heterogeneous, pool-type reactor incorporating solid uranium-zirconium hydride fuel-moderator elements with an enrichment of 19.7 percent uranium-235.

The University of Texas TRIGA core is similar to most other TRIGA reactors operated throughout the world as well as the United States. It received its NRC operating license on January 17, 1992 (NRC 1985a, 1992).

The University of Texas TRIGA Mk-II Reactor facility is housed in the Nuclear Engineering Teaching Laboratory on the east tract of the Balcones Research Center about 7 miles (11.3 kilometers) north of the University of Texas main campus, in the City of Austin, Travis County. According to the 1990 census, the City of Austin had a population of 465,622 (Rand 1992). Residential areas are located from 0.8 to 1.3 miles (1.3 to 2.1 kilometers) from the reactor facility. Most areas adjacent to the research center are developed for mixed commercial and industrial activities. Major activities in the area are from the University of Texas main campus at Austin and the State of Texas government and the business district of the City of Austin (NRC 1985a).

Destructive wind and damaging hailstorms are infrequent. On rare occasions, dissipating tropical storms affect the city with strong winds and heavy rains. Tornado activity at the site is roughly one event per year per 1000 square miles (2,600 square kilometers), or 4×10^{-6} per year for an area of 333 square feet (30.8 square meters), which is roughly equal to the general site area. Water drainage at the immediate site is primarily related to the potential but temporary occurrence of extreme rainfall rates. Surface water runoff from the Balcones Research Center site is drained into the Shoal Creek Watershed except for the extreme northeast region of the site, which drains into the Walnut Creek watershed. The facility is located in the northeast site region with drainage into the Walnut Creek watershed. It is situated at an elevation well above the local area flood plain, and is located nearly equidistant 0.5 mile (0.8 kilometer) from the drainage easements of both watersheds. Thus no significant general site area flooding is anticipated (NRC 1985a).

The University of Texas TRIGA reactor site is located in a zone where no damage from earthquakes is expected (Seismic Zone 1). This does not mean, however, that the area is aseismic. The Austin region has experienced three (recorded) earthquakes within a 50-mile (92.6-kilometer) radius since the late nineteenth century:

- May 1, 1873--Manor earthquake with epicentral Modified Mercalli Intensity III-IV
- January 5, 1887--Paige earthquake with epicentral Modified Mercalli Intensity V
- October 9, 1902--Creedmore earthquake with epicentral Modified Mercalli Intensity IV-V.

Other regions in central and east Texas have experienced earthquakes of epicentral Modified Mercalli Intensity V and possibly VI. Damage from an Modified Mercalli Intensity VI earthquake is limited to cracked plaster and damage to chimneys. Structures of good design do not begin to experience damage from intensities below Modified Mercalli Intensity VII. Therefore, when state-of-the-art engineering practices for general structures of common design are adhered to, seismic excitations from earthquakes of Modified Mercalli Intensities V or VI are not expected to affect the integrity of the reactor (NRC 1985a).

The University of Texas TRIGA reactor recently became operational, with its first criticality occurring in March 1992. There is no history of releases and exposures for this reactor.

3.3 Nuclear Power Plant Spent Nuclear Fuel

In this section, the environments of three facilities housing power reactor SNF to be managed by DOE are described. These facilities are the West Valley Demonstration Project in New York State; the Fort St. Vrain SNF Storage Facility in Colorado; and the B&W Research Technology Center in Virginia. General environmental concerns related to these facilities and their operation have been addressed either during their initial licensing/permitting activities or during a subsequent amendment process. Information on environmental factors that are not uniformly available in existing NEPA documentation for all three sites (noise, traffic, utilities and energy, and waste management) are not provided in this document.

3.3.1 West Valley Demonstration Project

The West Valley Demonstration Project consists of numerous structures and facilities. The Fuel Receiving & Storage facility, located adjacent to the original fuel reprocessing plant, is where SNF management activities at the West Valley Demonstration Project are currently performed. The Fuel Receiving & Storage facility consists of the following buildings and systems (WVNS 1993).

- Fuel Receiving & Storage Building - This building contains the spent fuel pool, cask unloading pool, cask decontamination area, cask and fuel handling equipment, and the spent fuel pool water treatment system.

- The water treatment system maintains a water quality that ensures visual clarity for underwater operations and that degradation of the SNF is minimized.

- The spent fuel pool provides shielding from irradiated fuel and ensures that stored assemblies are maintained in a critically safe geometry. The pool is about 30 years old and was not designed with a liner or a leak detection system, nor were the fuel racks designed to withstand a design-basis earthquake.

- Radwaste Process Building - This building houses the equipment for the Radwaste Treatment System, including the high integrity containers used to store spent resins and filter media, as well as shields for those containers.

- Recirculation Ventilation Building - This building houses the ventilation equipment for the Fuel Receiving & Storage building including fans, filters, heaters, chiller, and controls.

The Western New York Nuclear Service Center is located in the town of Ashford, Cattaraugus County, in rural western New York State, approximately 31 miles (50 kilometers) south of Buffalo and 24.5 miles (40 kilometers) inland (east) of Lake Erie. The West Valley

Demonstration Project site consists of a 220-acre (88-hectare) tract which is located in the center of the 3,345-acre (1,341-hectare) Western New York Nuclear Service Center, (WVNS 1992a).

3.3.1.1 Land Use. Regional land use is predominantly agricultural, with some scattered residential areas. The communities of West Valley, Riceville, Ashford, Hollow, and the village of Springville are located within 5 miles (8 kilometers) of the West Valley Demonstration Project. The proximity of the city of Buffalo, Lake Erie, and Lake Ontario influence land use patterns in the region (WVNS 1992a).

3.3.1.2 Socioeconomics. The West Valley Demonstration Project comprises Cattaraugus and Erie Counties in the State of New York. These counties collectively account for 96 percent of the site's employee residential distribution. Most West Valley Demonstration Project employees live in Erie County. Total employment in the region increased 14.4 percent between 1970 and 1990. During the same period, total population in the region decreased 12.2 percent. Personal income in 1990 for Cattaraugus and Erie County residents was $13,698 and $18,305, respectively (DOC 1992). The total number of housing units within the region is 438,970.

The number of regular employees working at West Valley Demonstration Project is 1050 personnel. Employment associated with SNF management at West Valley amounts to 9 person-years per year (Connors 1995).

3.3.1.3 Cultural Resources. The cultural resources of 360 acres (145 hectares) that may be affected by future West Valley Demonstration Project Plans and/or West Valley Demonstration Project completion and Western New York Nuclear Service Center closure have been investigated. No recorded extant historic structures are located within or adjacent to the study area, but seven recorded prehistoric sites are within a 1.5-mile (2.4-kilometer) radius of the study area described below. There are no structures or prehistoric sites within the study area nor within the town of Ashford that are listed on the New York State Register of Historic Places or the National Register of Historic Places (WVNS 1994).

3.3.1.4 Aesthetic and Scenic Resources. The natural landscape in the area consists of rolling wooded hillsides, a mix of actively used agricultural fields, inactive farm fields reverting to brush, and rural homesites. Large portions of the Western New York Nuclear Service Center are relatively undisturbed and consist of a mixture of abandoned agricultural areas in various stages of ecological succession, forested tracts, and wetlands joined by transitional ecotones. The terrain in the area of the Western New York Nuclear Service Center is not unique in terms of landforms, vegetation, expanses of water, or land use (WVNS 1993).

3.3.1.5 Geology. 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 (WVNS 1993).

No fold or fault of any consequence is recognized within the site. The Clarendon-Linden Structure is the closest active "capable" earthquake (fault)-producing feature known to exist in the region. It is approximately 23 miles (37 kilometers) from the site (WVNS 1993). 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 Claredon-Linden Structure would produce an earthquake of Modified Mercalli Intensity of VI to VII and a maximum horizontal acceleration of approximately 0.12g at the site. The Claredon-Linden Fault Zone is located approximately 18 miles (29 kilometers) east of the West Valley Demonstration Project (WVNS 1993).

The West Valley Demonstration Project region has no active volcanoes (Keller 1979). The major soil types at the West Valley Demonstration Project include the well-drained Chenango gravelly loam, the poorly drained Erie silt loam, and the poorly drained Mahoning silt loam.

3.3.1.6 Air Resources. A 200 feet (60-meter) onsite meteorological tower is operated by DOE at the West Valley Demonstration Project. A review of the West Valley Demonstration Project tower's 1992 data indicates that the prevailing wind was from the south-southeast with a mean wind speed of 5.4 miles per hour (2.4 meters per second). The precipitation for 1992 was 7.1 inches (18 centimeters) above the annual average of 40.9 inches (104 centimeters). The onsite 1992 wind data and National Weather Service wind data collected at Buffalo airport did not compare well, thereby indicating that Buffalo airport is not representative for predicting conditions at the West Valley Demonstration Project.

The state of New York has adopted national ambient air quality standards. The West Valley Demonstration Project is in a Class II Prevention of Significant Deterioration area. The nearest Class I Prevention of Significant Deterioration area is the Edwin B. Forsyth National Wildlife Refuge, approximately 300 miles (483 kilometers) southeast of the site.

3.3.1.7 Water Resources. The West Valley Demonstration Project is located in the Cattaraugus Creek drainage basin, which is part of the 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 (WVNS 1992a). Cattaraugus Creek is used for swimming, canoeing, and fishing. Although limited irrigation water for nearby golf course greens and tree farms is taken from Cattaraugus Creek, no public water supply is drawn from the creek downstream of the site. The West Valley Demonstration Project has three National Pollutant Discharge Elimination System permitted outfalls that discharge to Erdman Brook (WVNS 1992a).

The West Valley Demonstration Project site has two aquifers, but neither is considered highly permeable. The Cattaraugus Creek Basin aquifer system is a sole source aquifer under Safe Drinking Water Act regulations (EPA 1994). Groundwater beneath the West Valley Demonstration Project is not used for process or drinking water. The site receives all of its water supply from surface water. Offsite water supplies north of the site and south of Cattaraugus Creek derive mainly from springs and shallow dug wells (WVNS 1992a).

More detailed aquifer characterization information can be found in the West Valley Demonstration Project Safety Analysis Report for Project Overview and General Information, WVNS-SAR-001 (WVNS 1993).

3.3.1.8 Ecological Resources. The West Valley Demonstration Project lies within the Humid Temperature Domain, Warm Continental Division (Bailey 1994). The West Valley Demonstration Project is in a transitional zone between the Appalachian Plateau to the south and east and the Great Lakes Plain to the north and west (WVNS 1992b). The West Valley Demonstration Project is equally divided between forest land and abandoned farm fields (WVNS 1993).

Native vegetation, removed by previous agricultural activity, is becoming reestablished and, if left undisturbed, will slowly revert by successional stages to a climax hardwood community (WVNS 1992b).

Terrestrial wildlife is abundant within the Western New York Nuclear Services Center and surrounding areas because of the mixture of open areas and forested lands as well as the Center's protected nature (WVNS 1992b). Fifty-four species of mammals potentially occur on the site (22 have been recorded onsite). The most common mammal is the white-tailed deer (*Odocoileus virginianus*), which is also the most abundant game species in the region. However, hunting is prohibited. Other common game and furbearer species include raccoon (*Procyon lotor*), muskrat (*Ondatra zibethica*), red fox (*Vulpes fulva*), gray fox (*Urocyon cinereoargenteus*), woodchuck (*Marmota monax*), mink (*Mustela vison*), beaver (*Castor canadensis*), eastern cottontail (*Sylvilagus floridanus*), red squirrel (*Tamiasciurus hudsonicus*), and gray squirrel (*Sciurus carolinensis*) WVNS 1992b).

The various old-field, deciduous, and coniferous woodlands, marshes, reservoirs, and streams within the Western New York Nuclear Services Center provide a diversity of habitats used by a wide variety of birds. Bird species at the West Valley Demonstration Project include permanent and summer residents, migrants, and visitants. The abundance of upland meadow ecosystem within the Western New York Nuclear Services Center provides a unique habitat for several New York protected birds (WVNS 1992b).

Aquatic communities at the Western New York Nuclear Services Center include common shiners, eastern blacknose dace, common white sucker, and bluegill sunfish (WVNS 1992b).

Total wetland area is approximately 35 acres (14 hectares). The general types of wetlands on the West Valley Demonstration Project can be described as palustrine, emergent, shrub/scrub, and forested (WVNS 1993a).

A riparian area on Cattaraugus Creek is recognized by New York State as Habitat Significant for Wildlife (WVNS 1992b; WVNS 1993). Canada geese and other waterfowl have been observed periodically using the onsite reservoirs during migration (WVNS 1992b).

3.3.1.9 Transportation. Transportation in the Western New York Nuclear Service Center vicinity is primarily by highway system. Roads in Cattaraugus County are considered rural roads, except for those in Olean and Salamanca, located 38 miles (61 kilometers) and 26 miles (42 kilometers), respectively, south of the Western New York Nuclear Service Center. New York State classifies rural roads as interstate, principal arterial, minor arterial, major collector, minor collector, and local. Rock Springs Road, next to the Western New York Nuclear Service Center on the west, is a local road that services as the site-access road and connects with U.S. Route 219 about 2.5 miles (4 kilometers) west of the Western New York Nuclear Service Center. Route 219 connects with Interstate 90 (the New York State Thruway) approximately 25 miles (40 kilometers) north and with Interstate 17 (the Southern Tier Expressway) approximately 29 miles (46 kilometers) south of the Western New York Nuclear Service Center (WVNS 1993a).

Rail service to the Western New York Nuclear Service Center is provided by the Buffalo & Pittsburgh Division of the CSX Railroad, located 0.6 mile (1 kilometer) east of the Western New York Nuclear Service Center. A rail spur connects the West Valley Demonstration Project to the CSX (WVNS 1993a).

The Buffalo International Airport is located approximately 31 miles (50 kilometers) north. A general aviation airport, Olean Municipal Airport, is approximately 20 miles (32 kilometers) southeast of the Western New York Nuclear Service Center (WVNS 1993a).

3.3.1.10 Public Health and Safety. Nuclear Fuel Services, Inc. developed an environmental surveillance program in March 1963 before beginning fuel reprocessing. The program was intended to establish onsite background levels of gross radiological activity in surface water and air. The West Valley Demonstration Project began groundwater monitoring in 1982 (WVNS 1994).

Fallout data show the environmental levels of deposition at West Valley to have been within the nationwide normal range of the Radiation Alert Network measurements. Gross beta measurements in air taken at West Valley also were within the normal range of such readings taken throughout the United States. Levels of airborne particulates and deposition beyond the Western New York Nuclear Service Center perimeter have consistently been indistinguishable from the natural background.

The calculated total dose associated with airborne and liquid effluents released from West Valley Demonstration Project for a 6-year period are presented below (WVNS, 1994). The annual doses for each year are only a fraction of the DOE public dose limit of 100 millirem per year.

Year	Maximum Individual at Site Boundary EDE	Collective Dose Within 50-Miles (80-km)
1988	0.11 millirem	0.031 person-rem
1989	0.08 millirem	0.065 person-rem
1990	0.25 millirem	0.058 person-rem
1991	0.06 millirem	0.015 person-rem
1992	0.05 millirem	0.011 person-rem
1993	0.03 millirem	0.072 person-rem

3.3.2 Fort St. Vrain

Between 1979 and 1989 a high temperature gas-cooled reactor was in operation at the Fort St. Vrain site. In 1989, the Fort St. Vrain reactor was permanently shut down. At that time the Public Services Company of Colorado, the owner of Fort St. Vrain, proceeded with plans to decommission the Fort St. Vrain powerplant. To facilitate the decommissioning, the SNF had to be removed from the reactor. However, implementation of an agreement between the DOE and the Public Services Company of Colorado which would have provided for the storage of Fort St. Vrain SNF at the INEL was blocked, requiring the Public Services Company of Colorado to provide storage for the SNF from the Fort St. Vrain reactor. The SNF from the Fort St. Vrain is being stored in an independent spent fuel storage installation located on the Fort St. Vrain site (FSV 1990b).

The Fort St. Vrain site is located in Weld County in northeastern Colorado, approximately 3.5 miles (5.6 kilometers) northwest of the town of Platteville, 0.5 mile (0.8 kilometer) west of the South Platte River, and 35 miles (56 kilometers) north of Denver. The Fort St. Vrain site consists of 2,798 acres (1,132 hectares). About 1 mile (1.6 kilometers) north of the northern portion of the site is the confluence of the South Platte River and St. Vrain Creek. St. Vrain Creek flows in a northerly direction and passes within approximately 0.75 mile (1.2 kilometers) west of the site at its nearest approach (NRC 1991c; PSC 1994).

3.3.2.1 Land Use. Most of the land in the immediate area of the Fort St. Vrain site is disturbed, agricultural land. Its agricultural value is enhanced by a number of irrigation ditches fed by surface water diversions from the South Platte River and St. Vrain Creek. The predominant use of the land, surface water, and groundwater is agricultural (NRC 1991c).

3.3.2.2 Socioeconomics. The immediate area surrounding the Fort St. Vrain Nuclear Generating Station site is rural, with many communities within commuting distance. The nearest community is Platteville. Larger cities in the vicinity include Boulder, Denver, Estes Park, Fort Collins, Greeley, Longmont, Loveland, and Lyons (NRC 1991a).

The population density in the vicinity of the Fort St. Vrain Nuclear Generating Station is low. The nearest residence is more than 2,600 feet (0.8 kilometer) north-northwest of the site. The number of residents living within 1 mile (1.6 kilometer) of the Independent Spent Fuel Storage Installation site (based on projections from 1980 census data) is 39; the projected figure for the year 2012 is 40. However, 1990 figures indicate populations are changing at a similarly low rate, less than 1 percent per year, and consequently the projections will not change significantly (NRC 1991a).

Based on the 1980 census, the population within a 5-mile (8-kilometer) radius of the site at that time was 3,148, with 1,662 residing in the town of Platteville. The projected population for the year 2012 (through the 20-year license) for this same area is 4,526, with 3,040 residing in Platteville (FSV 1990a).

At the present time there are approximately 230 personnel working at the Fort St. Vrain site. Of these approximately 16 full time equivalent personnel work on the Fort St. Vrain SNF storage facility (Holmes 1995).

3.3.2.3 Cultural Resources. There are no known archaeological, cultural, or historical resources within, adjacent to, or in the immediate vicinity of the Independent Spent Fuel Storage Installation site. The nearest landmarks fitting any of these designations are more than 2 miles (3.2 kilometers) from the site. They include (NRC 1991a):

- The Dent site, an archaeological excavation with mammoth remains left by prehistoric Indians, situated about 4.5 miles (7.2 kilometers) northeast of Fort St. Vrain

- The original Fort St. Vrain, located 2.5 miles (4 kilometers) northeast of the Independent Spent Fuel Storage Installation site

- Fort Vasquez, located 4 miles (6.4 kilometers) southeast of the Independent Spent Fuel Storage Installation, and listed on the National Register of Historic Places

- Fort Jackson, situated 8 miles (12.8 kilometers) southeast of the Independent Spent Fuel Storage Installation site.

3.3.2.4 Aesthetic and Scenic Resources. The topography at the Independent Spent Fuel Storage Installation site is flat. It is situated on the high plains, overlooked by the foothills of the Front Range, which rise about 20 miles (32 kilometers) to the west, and by the Front Range crest, which rises to 14,255 feet (4,345 meters) (Longs Peak) about 45 miles (72 kilometers) to the west. The Front Range crest due west of the Independent Spent Fuel Storage Installation site is the most easterly section of the continental divide in the Rocky Mountains. The divide runs along ridges at an altitude of approximately 12,000 feet (3,650 meters) to a high point of 13,327 feet (4,062 meters) (McHenry's Peak) (NRC 1991a).

3.3.2.5 Geology. 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 which began in the Late Cretaceous and continued into the Tertiary. In addition to the axes of the superimposed folds, two groups of high angle faults have been recognized: a series of faults along the mountain front that extend in a generally northwest-southeast direction from the Precambrian into the Paleozoic-Mesozoic sediments, and northeast-southwest-oriented faults observed primarily in coal mines located east of Boulder (NRC 1991a).

The Fort St. Vrain site has not experienced any observed earthquake activity (Seismic Zone 1). A field examination and photo interpretation of the area provided no evidence of recent movement along any of the known faults. The closest area of recent activity is about 25 miles (40 kilometers) south of the site. Between April 1962 and May 1967, there were approximately 1,130 earthquake events in this area with magnitudes ranging from 1.0 to 5.0 on the Richter Scale. The 5.0 earthquake produced ground accelerations in the Vrain Valley of 0.002 ± 0.001 g. An earthquake with a Modified Mercalli intensity of VII (slight to moderate damage to structures) occurred on November 7, 1882, and was felt throughout Colorado and Southern Wyoming. Due to the sparse population in the epicentral region, the assigned intensity may in actuality be an underestimate. A reasonable guess for its Richter magnitude is 6.5, implying that most of the strain energy released by earthquakes of Colorado in the last century was released in this one earthquake (NRC 1991a).

3.3.2.6 Air Resources. The general climate around the Fort St. Vrain site is typical of the Colorado eastern-slope plains region. The weather is generally mild. Most seasons are characterized by low humidity and sunny days, with occasional brief storms bringing precipitation to the area. Thermal radiation losses resulting from lack of cloud cover provide considerable variation in temperature from night to day. In this semiarid region, the precipitation averages 10 to 15 inches (25 to 38 centimeters) a year, mostly from thunderstorms in late spring and summer. Snowfall is significant; however, the snow cover is usually melted in a few days. Relative humidity averages about 40 percent during the day and 65 percent at night (NRC 1991a).

Meteorological conditions in the local area include a preponderance of stable meteorological conditions and rather low wind speeds. Wind speeds generally range from 1 to 7 miles per hour (0.45 to 3.2 meters per second) 80 percent of the time. Wind directions are rather evenly distributed, although there is a preponderance of winds from the southwest and northeast quadrants. Seasonally, winds tend to be strongest in the late winter and spring, the season with high chinook frequency, and again in the summer, when thunderstorms occur frequently. Strong winds, especially under chinook conditions, have been observed on various occasions in easter Colorado. The chinook winds are strongest immediately to the east of the mountain ridge and diminish rapidly over the plains with increasing distance from the mountains (NRC 1991a).

The region typically experiences five tornadoes per year per 10,000 square miles (25,900 square kilometers), with peak tornado activity occurring during the month of June. According to the National Weather Service, Weld County has had 117 tornadoes during the period 1950-1987. A study of tornadoes in the area concluded that 100 mile (160 kilometer) per hour winds should constitute maximum forces to be expected at Fort St. Vrain (NRC 1991a).

Northeastern Colorado has moderate thunderstorm activity. The region near Fort St. Vrain averages 50 days a year in which thunder and lightning occur. The majority of these thunderstorms are present from late spring through the summer (NRC 1991a).

3.3.2.7 Water Resources. The topography in the immediate vicinity of the site is relatively flat and water use is primarily agricultural. Its distribution is through the use of irrigation ditches. The nearest major surface water features are the South Platte River, about 0.5 mile (0.8 kilometer) east of the site, and the St. Vrain Creek, about 0.75 mile (1.2 kilometers) west of the site. Local surface water diversions from these rivers, which feed irrigation ditches to support agriculture, are somewhat closer, about 0.33 mile (0.5 kilometer) east and west of the site, and about 0.4 mile (0.64 kilometer) to the north. The net local topography, which controls the direction of surface runoff, slopes slightly to the northeast toward the South Platte River. This trend is interrupted by the irrigation ditches. There are no liquid discharges from the dry storage facility (NRC 1991a).

3.3.2.8 Ecological Resources. Wildlife indigenous to the area include several species of ducks and geese, the mourning dove, cottontail rabbit, fox squirrel, and to a lesser extent bobwhite quail, ring-necked pheasant, deer, and antelope. The most abundant fish species include the white sucker, carp, notropis, creek chub, and, to a lesser extent, several types of perch (NRC 1991a).

With most of the land dominated by agriculture, natural vegetation is minimal. Most of the trees found along roads, in hedgerows, and around farm houses are cottonwood. Trees found in the river area are primarily cottonwoods, willows, and Russian olives. Typical grasses and weeds found in river bottom areas include gnat heads, golden weed, snake weed, Smith grass, Indian grass, foxtail and big bluestem. The site does not have readily visible evidence of recent farming but is now overrun with plants which are typically indigenous to disturbed land; plant species include Russian thistle, cocklebur, Canada thistle, dandelion, and poor-man's pepper grass (NRC 1991a).

The only threatened or endangered animal species known to occur within the area of the project are the bald eagle and the peregrine falcon. However, this land has not been identified as a critical habitat for these or any other species. The black-footed ferret, also endangered, may be found as a transient within the region, but requires a permanent habitat which is occupied by prairie dogs. Prairie dogs are not present at the site (NRC 1991a).

3.3.2.9 Transportation. There are no airports within the immediate vicinity of the Independent Spent Fuel Storage Installation site. Stapleton International is about 30 miles (48 kilometers) south of the site. County roads with their associated rights-of-way are adjacent the exclusion area boundary or provide access to the generating station (County Roads 21, and 19 1/2, respectively). A railroad spur connects the site to the Union Pacific Railroad main line located about 2 miles (3.2 kilometers) to the west (NRC 1991a).

3.3.2.10 Public Health and Safety. Results from an Independent Spent Fuel Storage Installation Site Background Radiation Study, completed by Colorado State University in October 1990, including the mean integral exposure rate of 0.34 mR per day, were consistent with data acquired for the area during previous years of sampling by the Fort St. Vrain Radiological

Environmental Monitoring Program. With the exception of cesium-137, whose average surface activity concentration of 0.18 pCi/g is consistent with regional levels due to global fallout, no statistically significant concentrations of activation or fission products were detected (NRC 1991a).

The design of the modular vault dry store system is such that its operation does not result in any water or other liquid discharges, generate any chemical, sanitary, or solid wastes, or release any radioactive materials in solid, gaseous, or liquid form during normal operations. The primary radiological exposure pathway associated with the Independent Spent Fuel Storage Installation operation is direct irradiation of nearby residents and site workers. The highest dose to the nearest resident for any year is about 0.1 mrem. The highest collective dose commitment for any year to the population within 5 miles (8 kilometers) of the Independent Spent Fuel Storage Installation will not exceed 0.45 person-rem (NRC 1991a).

3.3.3 B&W Lynchburg

B&W Lynchburg maintains a large nuclear fuels research facility at its Mount Athos site. This site is about 925 acres (374 hectares) in area with the research facility within a 4-acre (1.6-hectare) fenced area. Numerous support facilities are located outside and adjacent to this fenced area. The research facility is in Campbell County, Virginia near the James River, approximately 4 miles (6.4 kilometers) east of the city of Lynchburg (NRC 1987).

Building A was constructed in 1956 and housed the Lynchburg pool reactor and the Critical Experiment Facility. This facility has been decommissioned (NRC 1987).

Building B contains a hot cell facility with its associated operations area, cask handling area, transfer canal and storage pool, and various laboratories associated with the examination of radioactive materials. It also houses a demineralizer for the cleanup of the pool water (NRC 1987).

Building C was used as a plutonium fuels development laboratory and for research and development of processes for other nuclear fuels. It is undergoing decommissioning (NRC 1987).

Building J and its Annex are used for solid waste storage. High, intermediate, and low-level wastes may be stored here. Irradiated fuel wastes are being stored until they are accepted by the DOE in accordance with the provisions in the Nuclear Waste Policy Act of 1982 (NRC 1987).

3.3.3.1 Land Use. Land use in Campbell and Amherst counties is dominated by farming and forestry. Although the site lies in an agricultural region, very few of the important agricultural characteristics attributed to the region occur within 5 miles (8 kilometers) of the site because of unfavorable terrain. The region is characterized by mixed land use consisting of small areas of farmland (crop and pasture) interspersed within large tracts of forested area (NRC 1986).

3.3.3.2 Socioeconomics. The Lynchburg Research Center 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 and Lynchburg is about 180,000 (NRC 1986).

The Lynchburg area's commercial and industrial interests provide a large percentage of the employment in the four-county area. Although farming and forestry activities dominate the land use in the region, they provide less than 1 percent of the economic activity and very little permanent employment. Other principal commercial, industrial, and population centers that may influence the four-county area or may be slightly influenced by B&W operations are Roanoke, Charlottesville, Richmond, and Danville (NRC 1986).

The Lynchburg Research Center has about 180 employees, and the other facilities on the B&W site employ about 2,200. The total employment on the B&W site is only about 3 percent of the 69,000 persons employed in the Lynchburg Standard Metropolitan Statistical Area. The B&W operation is an important, although not critical, source of employment in the Lynchburg region (NRC 1986).

3.3.3.3 Cultural Resources. A review of the *Federal Register* reveals that the only historic site on the National Register of Historic Places located within 5 miles (8 kilometers) of the B&W facilities is the 19th-century Mt. Athos Plantation, which is across the road to the east of the site.

There are numerous historic places between 5 and 25 miles (8 kilometers and 40 kilometers) from the B&W site, particularly in Bedford County and Lynchburg to the west. The best known historic site is the Appomattox Court House National Historic Park, about 15 miles (24 kilometers) to the east (NRC 1986).

3.3.3.4 Aesthetic and Scenic Resources. The topography of the plant site is generally rolling with gentle slopes. The nominal river elevation is 470 feet (143 meters) above mean sea level. The dominant topographic feature of the site is a hill located approximately at the center of the property, the crest of which rises to 693 feet (211 meters) above mean sea level. The site includes a large area of relatively flat floodplain adjacent to the river. The highest point in the vicinity of the site is the top of Mt. Athos, where the elevation is 890 feet (271 meters) above mean sea level (NRC 1986).

3.3.3.5 Geology. The James River Basin of Virginia includes portions of four physiographic provinces characterized by distinct land forms and physical features. These provinces, located west to east, are Valley and Ridge, Blue Ridge, Piedmont, and Coastal Plain. Western or inner Piedmont, where the B&W property lies, is an upland characterized by scattered hills, some of mountainous dimensions, lying eastward from the foot of the Blue Ridge (NRC 1986).

No important mineral resources have been identified at the B&W site, and U.S. Geological Survey topographic maps do not indicate any significant surface or underground mining activities within 5 miles (8 kilometers) of the site (NRC 1986).

The B&W site is located in a western part of the central Virginia cluster region which is classified as Zone 2 on the Seismic Risk Map of the United States. This zone corresponds to an intensity of VII according to the Modified Mercalli scale, which implies building damages to the extent of fallen chimneys and cracked walls. During the period 1758 through 1968, 121 earthquakes with epicenters in Virginia were reported. The largest earthquake was in 1897, with a probable epicenter in Giles County, approximately 100 miles (160 kilometers) west of the plant site. A maximum intensity of VIII was estimated in the epicentral region, but an intensity of only V-VI was estimated at the plant site. The second largest earthquake was in 1875, with a maximum epicentral intensity of VII more than 50 miles (80 kilometers) east or northeast of the site. The estimated intensity at the site was V. No other quakes have been recorded with intensities at the site greater than the 1875 or 1897 occurrences (NRC 1986).

3.3.3.6 Air Resources. 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. Extremes in weather conditions in the area are rare. The mean temperature is about 56.7°F (13.7°C), with normal average temperatures ranging from 76.3°F (24.6°C) in July to 38.5°F (3.6°C) in December. Rainfall amounts at Lynchburg can be expected to reach 40.3 inches (102.4 centimeters) in any given year. The monthly rates are nearly uniform except for a slightly higher rate during the summer months. Snowfall in the Lynchburg area generally occurs between the months of December and March. The mean yearly snowfall total is 19.4 inches (49.3 centimeters). Winds at Lynchburg are predominant from the southwest with a mean speed of 8 miles per hour (3.6 meters per second). Mean relative humidity values in Lynchburg at 7:00 am, 1:00 pm, and 7:00 pm are 78, 51, and 62 percent, respectively. Heavy fog (visibility of less than 1,320 feet or 400 meters) can be expected to occur at the site on the average of 40 days per year (NRC 1986).

Severe weather at the Lynchburg Research Center is generally limited to thunderstorms, with a low probability of tornadoes. Climatological data show that the mean number of thunderstorms occurring at Lynchburg is 22 per year. According to methods for estimating tornado occurrence presented by Thom, the probability of a tornado's actually striking the site is 3.0×10^{-4} per year, with a recurrence interval of 3,333 years (NRC 1986).

The B&W Lynchburg Research Center is located in the Central Virginia Air Quality Control Region, where the air is classified by the Environmental Protection Agency as "better than national standards" for total suspended particulates and sulfur dioxide. The City of Lynchburg also meets the national standards for total suspended particulates and sulfur dioxide. For carbon monoxide, nitrogen dioxide, ozone, and hydrocarbons, the Air Quality Control Region cannot be classified because data are not available (NRC 1986).

3.3.3.7 Water Resources. A relatively large forested floodplain exists between the normal elevation of the James River and the estimated highest flood state at the site. Since no Lynchburg Research Center structures are located in the floodplain, plant operation does not impact floodplain features (NRC 1986).

The James River is formed about 96 miles (154 kilometers) 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. On the basis of records for two U.S. Geological Survey gaging stations, one about 20 miles (32 kilometers) upstream and the other about 21 miles (34 kilometers) downstream of the site, the annual average flow rate of the river at the plant is estimated to be about 3900 cubic feet per second (110 cubic meters per second). The estimated water surface elevation at the site at the average flow rate is approximately 470 feet (143 meters) above mean sea level (NRC 1986).

Eleven great floods of the James River occurred at the plant site in 1771, 1795, 1870, 1877, 1889, 1913, 1930, 1936, 1969, 1972, and 1985. The 1795 flood had the highest flood state, which was 535 feet or 163 meters above mean sea level at Lynchburg and 494 feet (151 meters) above mean sea level at the site (estimated). The largest recent flood occurred in November 1985 and had a flood state of 534 feet (163 meters) above mean sea level at Lynchburg (NRC 1986).

The Standard Project Flood determined by the U.S. Army Corps of Engineers for the James River would produce a discharge rate of 10,705 m^3/S (378,000 cfs) and a flood state of 502 feet (153 meters) above mean sea level at the site (NRC 1986).

Because the elevation of the plant floors at the Lynchburg Research Center is 589 feet (180 meters) above mean sea level, which is 95 feet (29 meters) above the maximum historical flood state or 37 feet (26 meters) above the Standard Project Flood elevation, James River floods would not affect the research and development facility at the Lynchburg Research Center (NRC 1986).

Measurements in potable wells located in the river floodplain near the B&W Commercial Nuclear Fuel Plant in the northeast corner of the site indicate that the groundwater elevation ranges between 440 and 460 feet (134 and 140 meters) above mean sea level, which is 10 feet (3 meters) 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. B&W obtains about 100,000 gallons per day (380 cubic meters per day) from the above-mentioned wells for drinking and industrial uses. An average of 19,300 gallons per day (73 cubic meters per day) is used at the Lynchburg Research Center. Continuous pumping tests on these wells indicates a plentiful supply of groundwater. Therefore, it is not likely that the performance at nearby residential wells would be affected by B&W's operations (NRC 1986).

3.3.3.8 Ecological Resources. Natural climax vegetation in the region is classified as oak-hickory-pine (*Quercus-Caray-pinus*) forest. Dominants include white (*Q. alba*), post oak (*Q. stellata*), hickory (*Carya* spp.), shortleaf pine (*P. echinata*) and loblolly pine (*P. toeda*). Other common species include tulip poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), dogwood (*Cornus florida*), and several other species of oak, hickory, and pine (NRC 1986).

The great diversity of plants and vegetative communities in the site vicinity provide a wide variety of habitats for wildlife. There are approximately 24 species of mammals, 160 species of birds, 19 species of reptiles, and 17 species of amphibians expected to occur in the Lynchburg area. Species in the vicinity of the site that are economically important include game mammals, e.g., white-tailed deer (*Odocoileus virginianus*) and black bear (*Ursus americanus*), otter (*Lutra canadensis*), red fox (*Vulpes vulpes*), and beaver (*Castor canadensis*); and mourning dove (*Zenaida macroura*) and several species of water fowl (NRC 1986).

The aquatic biota of the James River in the vicinity of the Lynchburg Research Center is generally characteristic of that of a moderately polluted river. Examination of photoplankton communities downstream of the site at Cartersville shows reasonably diverse communities consisting of green, yellow-green (diatoms) and blue-green algae during the late summer.

Phytoplankton communities during the fall, winter, and early summer consisted almost entirely of a few species of yellow-green algae (NRC 1986).

Most of the fish in the James River in the vicinity of the Lynchburg Research Center are primarily members of the minnow, sucker, sunfish, perch, and catfish families. Species in these families range from common to uncommon. There is no commercial fishery in the vicinity of the Lynchburg Research Center site (NRC 1986).

Federally and state-listed threatened and endangered animal species whose present or former geographic ranges include central Virginia and the B&W site are the bald eagle (*Haliaeetus leucocephalus*), American peregrine falcon (*Falco peregrinus*), gray bat (*Myotis grisescens*), Indiana bat (*Myotis sodalis*), Virginia big-eared bat (*Plecotus townsendii virginianus*), and eastern cougar (*Felis concolor couguar*). There have been no reports of these species being observed on the site or its vicinity (NRC 1986).

There are no species of rare or endangered fish or mollusks known to occur in the James River in the vicinity of the site (NRC 1986).

3.3.3.9 Transportation. The site is bounded on three sides by the James River and on the fourth side by Virginia State Route 726. The site is serviced by a spur of the CSX Railroad, which runs through the B&W property. The site is also conveniently located for truck and automobile access, because only about 2 miles (3.2 kilometers) from the plant, State Route 726 connects with U.S. Highway 460, a major link between Roanoke and Richmond (NRC 1986).

3.3.3.10 Public Health and Safety. The total-body dose rate for the vicinity of Lynchburg is approximately 107 millirem per year. This dose rate includes 43 millirem per year from cosmic rays, 45.6 millirem per year from terrestrial sources, and 18 millirem per year from internal emitters (NRC 1986).

4. ENVIRONMENTAL CONSEQUENCES OF SPENT NUCLEAR FUEL MANAGEMENT ACTIVITIES

This section presents the projected impacts of implementing the programmatic alternatives for management of SNF for which DOE has accepted present or future responsibility. The SNF management activities evaluated in this section only include those actions identified by the originating sites to be implemented should the No Action Alternative be adopted, as described in Section 2. SNF management activities planned independently of this EIS are addressed only if they are directly affected or altered as a result of the programmatic SNF alternatives considered in this EIS. Only Alternative 1, No Action, has any potential for affecting some of the facilities addressed in this Appendix. Thus only the environmental consequences of SNF management activities at originating sites under Alternative 1 will be discussed here. For the other DOE alternatives, the environmental consequences of SNF transportation from originating sites are analyzed in Appendix I to Volume 1. The environmental consequences at the DOE facilities that receive the SNF originating from any facilities in this Appendix are addressed in Appendixes A, B, C and F.

4.1 No Action

4.1.1 DOE Experimental Reactors and Small-Quantity Storage

The DOE's reactors at the Brookhaven National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories would not be affected by the No Action Alternative through the year 2005. Between 2006 and 2035, however, implementation of this alternative might require modifications of SNF management activities at the reactor facilities.

4.1.1.1 Brookhaven National Laboratory. The High Flux Beam Reactor at the Brookhaven National Laboratory is planned to continue to operate for the foreseeable future. The presently planned installation of a storage rack in the existing wet storage facility, providing 162 additional storage locations, will be depleted in 1998. It is expected that the arrangement of the existing racks will be modified to provide additional storage capacity in the existing pool if SNF cannot be shipped at that time (Carelli 1993).

Fuel storage capacities at the Brookhaven National Laboratory High Flux Beam Reactor would be severely taxed if the No Action Alternative were selected. Selection of the No Action Alternative could result in the eventual shutdown of the High Flux Beam Reactor as a result of filling the existing SNF storage capacity. Implementation of the No Action Alternative would be expected to have no operational impact on the Brookhaven Medical Research Reactor (Carelli 1993).

There is no safety analysis or technical specification limit on the number of elements stored, so the proposed addition of a new storage rack should be accompanied by a new criticality analysis (DOE 1993c).

The fuel canal is unlined and there is no continuous and accurate way of measuring leak detection. However, alarms for high and low water level are in the control room and the water level is regularly monitored. Records are maintained for canal water additions, and thus any increased amounts of canal makeup water can be detected. The canal has been sealed against evaporation about every 5 years to measure leakage, and no leakage problems have ever been detected. Also, there are groundwater monitoring wells near the High Flux Beam Reactor that are sampled twice per year, and no significant amounts of radionuclides have ever been detected. No known damaged fuel is presently stored in the fuel canal (DOE 1993c).

The fuel canal water monitoring program is adequate to control corrosion and to minimize the release of fission products. In addition, corrosion surveillance coupon samples have been photographed and evaluated yearly since stored in the canal in 1977. These photographs have shown no corrosion damage (DOE 1993c).

In view of the absence of any substantive difference in SNF management operations attributable to the No Action Alternative, effluent releases and their associated doses would be expected to be the same as those currently being experienced there.

Potential impacts on the Nassau/Suffolk Aquifer System as a result of SNF management alternatives described in this EIS are expected to be small. If the fuel canal were to leak, ground water impacts would be expected, but monitoring measures would mitigate impacts by permitting early detection of leaks.

For the Brookhaven Medical Research Reactor, which has sufficient SNF storage capacity, the No Action Alternative would cause no environmental consequences--other than those that have already been addressed and accepted under the siting and operation approval process.

4.1.1.2 Los Alamos National Laboratory. The Omega West Reactor at Los Alamos National Laboratory is permanently shut down. It is being decommissioned. The SNF is in temporary storage at the Chemistry and Metallurgy Research complex. Although at present the stored fuel elements do not present a health or safety hazard, storage of fuel at the Chemistry and Metallurgy Research complex presents a potential radiological hazard at that facility. The Los Alamos National Laboratory does not have the capability to store, handle or monitor spent fuel for any extended length of time. The Rover casks contain no monitoring devices, and storage of spent fuel is not addressed in the current Chemistry and Metallurgy Research complex authorization. It is recommended that the fuel be relocated as soon as practical.

For the other Los Alamos National Laboratory facilities that have sufficient SNF storage capacity, the No Action Alternative would cause no environmental consequences--other than those that have already been addressed and accepted under the siting and operation approval process.

4.1.1.3 Sandia National Laboratories. Each of the reactors at Sandia National Laboratories is designed so that the uranium fuel source essentially lasts the designed life of the reactor. Consequently, none of the reactors require periodic refueling or discharge spent fuel. Therefore, the No Action Alternative would cause no environmental consequences--other than those that have already been addressed and accepted under the siting and operational approval process for these facilities at Sandia National Laboratories (DOE 1993d).

4.1.1.4 Argonne National Laboratory - East. Essentially all of the SNF at the Argonne National Laboratory site in Illinois is contained in the Alpha-Gamma Hot Cell Facility. The Alpha-Gamma Hot Cell Facility is an operating hot cell where fuel development programs have been conducted for 29 years. The SNF located there is a combination of material in process and the stored residues from past programs (DOE 1993d).

The condition of the stored SNF is generally good and would be an issue only if its physical and chemical state dictates that it must be treated before it will be acceptable at a long-term interim storage site or a final repository. Likewise, the physical condition of the facility is good, considering its 29-year age. The SNF is contained within the hot cell, which precludes its entry into the environment except under the most extremely low-probability events (DOE 1993d).

4.1.2 Domestic Research Reactors

In Section 2.2.1.2, it was noted that SNF storage facilities at 34 domestic research reactors would not be overloaded were the No Action Alternative (i.e., no off-site SNF transportation) to be implemented. For those sites, the adoption of the No Action Alternative would produce no incremental impacts on the environment.

This conclusion is supported by NRC determinations in a number of licensing actions related to requested increases in possession limits for U-235 in fuel at research reactor sites. In these licensing actions, the NRC has determined that there is no significant impact on the environment from normal operation or accidents associated with the increases in the possession limits for U-235 at those reactor sites. The possession or storage of fuel at the domestic research reactor sites is not considered by the NRC to be a significant activity as indicated by the following examples of their findings.

In 1993, the NRC performed a safety evaluation in response to the University of Missouri at Columbia request for a temporary increase in the license possession limit for U-235 from 45 to 60 kilograms. In regard to potential accidents the NRC determined: "There are no specific accidents in this type of research reactor associated with the storage of spent fuel in accordance with the Technical Specifications. The maximum hypothetical accident of complete fission product release of four fuel plates in the reactor core is not affected by increasing the amount of stored fuel. Because the fuel will be stored in accordance with the Technical Specifications, accidents previously evaluated are not changed and no new or different kind of accident is created. Therefore, the staff concludes that the temporary increase in the possession limit of U-235 is acceptable."

In regard to environmental considerations of this possession increase, the NRC stated: "The staff has determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and there is no significant increase in individual or cumulative occupational radiation exposure. Accordingly, this amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no Environmental Impact Statement or Environmental Assessment need be prepared in connection with the issuance of this amendment." (NRC 1993b)

In 1991, in performing a safety evaluation in response to an earlier University of Missouri request for a temporary increase in the license possession limit for a larger amount of U-235 from 60 to 75 kilograms, the NRC reached the same determinations and conclusions as in the 1993 licensing action. (NRC 1991b)

In response to the request from the Massachusetts Institute of Technology request in 1991 to extend a temporary increase in the possession limit of U-235 of 41 kilograms until January 1, 1994, the NRC performed an evaluation and made identically the same determination as that quoted above for the University of Missouri license amendment. (NRC 1991d)

The NRC, in its Environmental Assessment for the Training and Research Reactor of the University of Lowell, stated: "Accidents ranging from the failure of experiments up to the largest core damage and fission product release considered possible result in doses that are less than 10 CFR Part 20 guidelines and are considered negligible with respect to the environment.... The staff concludes that there will be no significant environmental impact associated with the licensing of research reactors or critical facilities designed to operate at power levels of 2 MWt or lower and that no environmental impact statements are required to be written for the issuance of construction permits or operating licenses for such facilities." (NRC 1985b)

In the Environmental Impact Statement for the University of Texas, TRIGA Mark II reactor, it was stated: "Storage, processing and disposal of fuel elements is not considered a significant activity of this facility." (NRC 1984)

Of the 11 domestic research reactors that are projected to exhaust their storage capacity, a few facilities indicated that they might take measures to physically expand their SNF storage capacity within their existing structures beyond what had been planned. Only one facility has indicated that it might elect to create an 18.6-square-meter (200-square-foot) storage area outside the existing structure. An addition of this small size would be expected to have a minuscule impact on the previously disturbed environment.

A small number of these facilities could request deferral of their directed conversion from highly enriched uranium fuel to low enriched uranium fuel. The environmental consequences of such an action would derive from extending the risks of theft or diversion of highly enriched uranium fuel which the U.S. Government has tried to reduce by mandating the conversion (Jentz 1993).

An unidentified number of the research reactors may elect to discontinue operation at some time during the next 40 years. Storage of the SNF onsite at a reactor facility that is undergoing decommissioning would interfere with the radiological surveys conducted to ensure that the reactor site is returned to the pristine conditions that existed before the reactor was constructed.

The consequences of premature shutdown of any of these reactors, attributable to implementation of the No Action Alternative, would include the loss of service which the reactors were scheduled to provide. These consequences of implementing the No Action Alternative could include, for example:

- Loss of education and training for some nuclear engineers and scientists

- Loss of trace analysis capability supporting solar cell material research, monitoring of atmospheric pollutants, detection of trace metals in foods, and analysis of criminal artifacts

- Loss of specific materials research capability relating to hydrogen in metals, metglasses, amorphous magnetic materials, and biomolecular polymers

- Loss of specific nuclear medicine and radiation therapy.

Any changes in radioactive (or other) releases or exposures to the public or to workers would be inconsequential. More detailed analyses of radiation exposures and other impacts would be provided in site-specific NRC licensing documents before implementation of any changes in these facilities that were made necessary by an SNF transportation moratorium.

4.1.3 Nuclear Power Plant Spent Nuclear Fuel

4.1.3.1 West Valley Demonstration Project. It has been determined that continued use of the SNF storage pool in the Fuel Receiving & Storage building at the West Valley Demonstration Project is not a viable option for extended periods of time. Therefore, alternative concepts for storing West Valley Demonstration Project SNF are being evaluated by the Project. The options being considered at West Valley include dry storage, wet storage involving refurbishing of a portion of the existing spent fuel storage pool, and continued use of the present facility.

Dry storage is projected to require a maximum area of 0.003 square kilometer (0.72 acre) (i.e., a square plot of land about 54 meters [177 feet] on each side). This area would include the actual storage facility, approach pads, and perimeter fence. The largest base pad required for any of the dry storage concepts would measure 9.1 by 15.2 meters (30 by 50 feet) and be between 0.61 and 1.22 meters (2 and 4 feet) thick (WVDP 1993).

The wet storage concept and No Action Alternative assume the continued use (either modified or as is) of the existing spent fuel storage pool. These options should have no measurable impact on the West Valley Demonstration Project site. The actions taken to transfer the spent fuel from the storage pool to the on-site dry storage facilities would not differ from those taken to transfer this SNF to the INEL or any other DOE facility. Therefore, there would be no additional environmental impact resulting from these fuel transfer activities.

Potential impacts on the Cattaraugus Creek Basin Aquifer System as a result of SNF Management alternatives described in this EIS are expected to be small.

Keeping the SNF in dry storage on-site would result in both on-site and off-site exposures that would not occur if the fuel were shipped off-site once it was removed from the storage pool. Storing the fuel dry in sealed containers would not result in the production of radioactive liquid or gaseous effluents or solid radioactive wastes. The source of the on-site and off-site radiation doses is direct radiation from the dry spent fuel storage facility. Estimates have not yet been developed for these doses, because a storage concept has not been selected.

The 125 fuel assemblies in the Fuel Receiving and Storage Facility have been in storage for over 20 years. Their total heat generation rate is less than 9 kilowatt and fission product inventory should have reached a near steady state condition. Conservative calculations in safety analysis report estimate that failure of all 125 fuel assemblies would result in an off-site dose of 42 mrem and an on-site dose of 2.1 rem (DOE 1993c).

Doses and solid waste generation volumes resulting from implementation of the No Action Alternative would remain the same as the current operation at the West Valley Demonstration Project. The calculated annual effective dose equivalent resulting from the total site operations including wet storage of SNF at the West Valley Demonstration Project are as follows: (WVNS 1994)

Maximum individual off-site dose from gaseous releases	1.6×10^{-4} mrem/year
Maximum individual off-site dose from liquid releases	1.1×10^{-2} mrem/year

4.1.3.2 Fort St. Vrain. The Fort St. Vrain facility has already constructed an Independent Spent Fuel Storage Installation for interim storage (with a 40 year design basis) of the SNF from the Fort St. Vrain power plant. Onsite storage will have no additional impact on the Fort St. Vrain site (FSV 1990a). However, under this alternative, Public Service Company of Colorado would not achieve its goal of becoming free of radioactive materials by 1998 under this option.

4.1.3.3 B&W Lynchburg Technology Center. The Lynchburg Technology Center received the SNF between 1980 and 1987 as part of a "high-burnup" research program sponsored by the DOE Office of Nuclear Energy. The experiments were completed in 1989 and the program was officially terminated in 1992. Since that time, the Lynchburg Technology Center has stored this fuel under contract to DOE (DOE 1993c).

The DOE-owned spent fuel rods that are stored in the spent fuel storage pool are intact and in good condition. Water quality is also good and is maintained by passing through particulate filters and resin beds. No chemistry controls have been needed. In addition, sludge is not present in the pool and biological contamination has not been observed (DOE 1993c).

There are no routine inspections of the condition of spent fuel rods that have been sectioned and placed in dry storage. However, some of the fuel stored in this facility was recently repackaged and moved; this fuel and its containers are known to be in good condition. Other evidence that the integrity of spent fuel storage containers has been maintained in good condition is routine monitoring of groundwater, direct radiation, and smearable contamination, all of which indicate that leakage of radionuclides is not occurring (DOE 1993c).

Groundwater and other radionuclide monitoring have not indicated any radionuclide releases from the SNF storage facilities at the B&W Lynchburg Technical Center. There is currently no reason to suspect that spent fuel storage containers will degrade in the near term in a manner that would result in a release of fission products. This facility is routinely inspected and relicensed by the NRC every 5 years. Hence, any developing storage problems would most likely be dealt with and corrected under the direction of the NRC (DOE 1993c).

4.2 Decentralization

The Decentralization Alternative is similar to the No Action Alternative except that limited off-site shipments would occur from university and domestic non-DOE research reactors. Impacts of transportation are described in Appendix I to Volume 1. Some DOE facilities would be upgraded/replaced and additional on-site storage capacity would be required at several DOE facilities. Essentially, there are no differences from the No Action Alternative, except impacts from transportation, facility upgrade, and new construction.

At Brookhaven National Laboratory High Flux Beam Reactor, some land disturbance might be anticipated from the installation of additional SNF storage capacity, whether wet or dry. However, any such disturbance is expected to occur in previously disturbed on-site areas.

4.3 1992/1993 Planning Basis

The 1992/1993 Planning Basis Alternative would permit the shipment of the SNF currently in storage or being generated at the originating sites. With the implementation of the 1993/93 Planning Basis Alternative, as in past practice, SNF would continue to be shipped from the originating sites to a DOE receiving site. The 1992/1993 Planning Basis Alternative would be expected to have essentially no incremental impact on the originating sites. Impacts of transportation are described in detail in Appendix I to Volume 1. The alternative of transporting SNF by barge from Brookhaven National Laboratory is also described in Appendix I to Volume 1.

4.4 Regionalization

The Regionalization Alternative would be the same as the 1992/1993 Planning Basis Alternative, except for the difference in destinations. Implementation of the Regionalization Alternative would permit the shipment of SNF from originating sites to regional DOE interim storage facilities. The Regionalization Alternative would be expected to have essentially no incremental impact on the originating sites. Impacts of transportation are described in detail in Appendix I to Volume 1.

4.5 Centralization

The Centralization Alternative would be the same as the 1992/1993 Planning Basis Alternative, except for the difference in destinations. Implementation of the Centralization Alternative would permit the shipment of SNF from originating sites to a central DOE interim storage facility. The Centralization Alternative would be expected to have essentially no incremental impact on the originating sites. Impacts of transportation are described in detail in Appendix I to Volume 1.

5.0 CUMULATIVE IMPACTS

This section describes the cumulative environmental impacts of the alternatives for generating and storing SNF at the originating sites addressed in this Appendix. The emphasis is on DOE SNF Alternative 1, No Action, under which all SNF would remain at the originating facility. For the individual originating facilities, the cumulative impact is defined as the sum of the incremental impacts of SNF management under the No Action Alternative and the impacts of the other operations at the facility's reactor(s) or other activities involving radioactive materials. For the other alternatives, the SNF cumulative impact at the originating facilities essentially would end with the removal of the SNF from the site. The cumulative impacts of intersite SNF transportation alternatives on transportation routes and affected communities are analyzed programmatically in Volume 1, Appendix I. The cumulative impacts at the DOE facilities receiving SNF are addressed in Appendixes A, B, C and F.

5.1 DOE Test and Experimental Reactors

Under the No Action Alternative, the cumulative environmental impacts at DOE test and experimental reactors are derived from past environmental impacts as obtained from annual operating reports, and estimated future impacts based on extrapolation to the year 2035 of past impacts.

5.1.1 Brookhaven National Laboratory

It is expected that the High Flux Beam Reactor and Brookhaven Medical Research Reactor would continue to operate, for all SNF management alternatives except No Action. If additional storage were to be required on-site to accommodate High Flux Beam Reactor SNF through 2035, current impacts would be somewhat increased by the impacts of building and operating an additional facility. Although the nature of that facility has not been determined, the resulting impacts are expected to be negligibly small. Should the facility propose substantial changes, appropriate NEPA documentation would be prepared in accordance with existing environmental regulations.

5.1.2 Los Alamos National Laboratory

Omega West Reactor at the Los Alamos National Laboratory is permanently shut down and is being decommissioned. The spent fuel is in temporary dry storage at the Chemistry and Metallurgy Research complex, and resulting impacts are negligible. The spent fuel is awaiting relocation. Cumulative impacts would not change under any alternative.

5.1.3 Sandia National Laboratories

The cumulative environmental impacts would not change from those currently experienced at Sandia National Laboratories from the operation of the reactors and storage of small quantities of SNF.

5.1.4 Argonne National Laboratory - East

The cumulative environmental impacts would not change from those currently experienced from the storage of small quantities of SNF.

5.2 Domestic Research Reactors

Under the No Action Alternative, the cumulative environmental impacts at domestic research reactors are a composite of past environmental impacts as obtained from annual operating reports, and estimated future impacts based on extrapolation to the year 2035 of past impacts. The following facility-specific cumulative environmental impacts have been selected as representative of all domestic research reactor facilities that could be affected by Alternative 1.

5.2.1 National Institute of Standards and Technology

Implementation of the No Action Alternative would result in the shutdown of the National Bureau of Standards Reactor in October 1996 due to the inability to store additional SNF. The environmental radiological impact of such action would be a reduction of radioactive releases and doses below those of full power operation. On-site SNF storage would meet existing facility design criteria. There would be no other change in the cumulative environmental impact except for the adverse socioeconomic impacts as a result of the loss of services and knowledge from reactor operations.

A scenario of continued operation, assuming timely reissuance of the operating license, including compliance with the National Environmental Policy Act, would bound the cumulative environmental impacts under any of the DOE-postulated SNF alternatives.

5.2.2 Massachusetts Institute of Technology

As with the National Institute of Standards and Technology, the Massachusetts Institute of Technology research reactor would be expected to shut down in response to the No Action Alternative because of limited SNF storage capacity. Thus, a scenario of continued operation, assuming timely reissuance of the operating license, would bound the cumulative environmental impacts under any of the DOE-postulated SNF alternatives.

5.2.3 Conclusion

For all domestic research reactors, the SNF management alternatives, including the No Action Alternative, would not increase the cumulative impacts of the originating sites above current values. Some of the facilities could not be able to continue normal operation under the No Action Alternative and could be forced to shut down due to the lack of SNF storage capacity. Reactors licensed by the U.S. Nuclear Regulatory Commission are not under DOE control, and additional storage space could be constructed under the No Action Alternative. However, except for the negative socioeconomic impacts attributable to the loss of services and knowledge resulting from such shutdowns, other site-specific cumulative impacts would not be increased.

5.3 Nuclear Power Plant Spent Nuclear Fuel

The implementation of any one of DOE's five SNF management alternatives would have no additional environmental consequences beyond those already evaluated for the Fort St. Vrain and B&W Lynchburg facilities.

The situation is similar for the West Valley Demonstration Project, except that the DOE has entered into an agreement with the New York State Energy Research and Development Authority which calls for the removal of SNF from the West Valley Demonstration Project. Implementation of the No Action and Decentralization Alternatives would result in SNF remaining at the West Valley Demonstration Project. If the fuel remains at the West Valley Demonstration Project, the SNF may be managed in a new dry storage facility. Once the SNF is in dry storage, there will be no releases of radioactive effluents and an indistinguishable direct radiation exposure to the environs in excess of that which would occur were the SNF to be moved as scheduled, and in the payment of storage costs by DOE to the State of New York.

6.0 ADVERSE ENVIRONMENTAL EFFECTS THAT CANNOT BE AVOIDED

Unavoidable adverse impacts addressed here are limited to those occurring as a result of DOE Alternative 1 (No Action) at the originating facilities discussed in this Appendix. All other alternatives consider normal shipment of SNF from the originating site, with only transportation routes and the receiving site possibly being subjected to unavoidable adverse impacts by transferred SNF. Any adverse impacts at the originating sites are thus precluded for all SNF transportation alternatives. Possible unavoidable adverse impacts on transportation routes are analyzed in Volume 1, Appendix I. Possible unavoidable adverse impacts at the DOE facilities that receive SNF are addressed in Appendixes A, B, C and F.

6.1 DOE Test and Experimental Reactors

The adverse effects that may be unavoidable caused by implementation of the No Action Alternative would be associated with the possible premature, long-term shutdown of the High Flux Beam Reactor at Brookhaven National Laboratory. The consequences of this shutdown would be cessation of site specific activities involving unique experiments. These experiments are needed for understanding materials structures, biological processes, and the behavior of super conducting materials. Shutdown would also cause the loss of jobs associated with these experiments and supporting site activities.

6.2 Domestic Research Reactors

The adverse effects that may be unavoidable at domestic research reactors caused by implementation of the No Action Alternative would be associated with the possible premature, long-term shutdown of several reactors. The consequences of these shutdowns, discussed in Section 4.1.2, would be cessation of site-specific research and education activities and could result in the loss of jobs associated with these activities at these sites.

6.3 Nuclear Power Plant Spent Nuclear Fuel

Implementation of the No Action Alternative could result in adverse consequences that may be unavoidable at West Valley Demonstration Project. Should this alternative be selected, the adverse impact that may be unavoidable would be continued on-site and off-site radiation exposures beyond the scheduled fuel removal date as a result of radioactive effluents and/or direct radiation.

Since the Public Services Company of Colorado has already responded to the No Action Alternative by licensing and constructing an independent spent nuclear fuel storage installation at its Fort St. Vrain site, no additional consequences or additional adverse consequences would be incurred there.

7.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The assessment of the activities undertaken at the SNF originating sites as a consequence of the implementation of all alternatives indicates that only minor irreversible and irretrievable commitments of resources would be required.

7.1 DOE Test and Experimental Reactors

If the Decentralization Alternative were to be implemented, the Brookhaven National Laboratory would expect to be required to identify some way to store the SNF generated by the High Flux Beam Reactor through the year 2035. Several scenarios are possible, but none has been decided upon at this time. One possible SNF management scenario is to install additional storage accommodations. Limited quantities of construction materials and fuel for construction equipment would be required if this scenario were selected.

Implementation of the No Action Alternative would not result in any irreversible and irretrievable commitments at the Los Alamos National Laboratory, Sandia National Laboratories or Argonne National Laboratory - East.

Implementation of any of the other proposed alternatives for SNF would not result in any additional irreversible and irretrievable commitments of resources at the DOE test and experimental reactors.

7.2 Domestic Research Reactors

There are no substantial new irreversible and irretrievable commitments of resources at the domestic research reactors with the implementation of any of the proposed SNF alternatives for generating and storing SNF. If, under the No Action Alternative, any NRC-licensed facility should elect to modify its SNF storage capabilities, a site-specific license amendment would be required. If the storage facilities were expanded, there would be a commitment of construction materials and fuel to operate construction equipment. The other DOE SNF alternatives would involve no commitment of resources at domestic research reactor facilities.

7.3 Nuclear Power Plant Spent Nuclear Fuel

Implementation of the Decentralization Alternative could result in irreversible and irretrievable commitments of resources at the West Valley Demonstration Project site. Should this alternative be selected, this commitment of resources would result from the construction materials and fuels used to provide alternative on-site SNF storage capability. The magnitude of these commitments cannot be quantified, however, until it is determined whether existing SNF storage capacity would be modified or a new SNF storage facility would be constructed and its type.

Implementation of any of the other proposed alternatives for SNF would not result in any additional irreversible and irretrievable commitments of resources at the commercial SNF storage facilities.

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